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CLEARING NEW LAND.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Publications,
Washington, D. C., March 29, 1902.

Sir: I herewith transmit, with the recommendation that it be published as Farmers' Bulletin No. 150, a paper on Clearing New Land, by Mr. Franklin Williams, jr., a farmer and horticulturist of considerable experience. Acknowledgments are due to Mr. G. B. Sudworth, Dendrologist of the Bureau of Forestry, who revised those portions of the bulletin relating to the characteristics of the various species of trees, and to Mr. W. A. Taylor, field expert of the Division of Pomology, for some practical suggestions.

The bulletin is especially adapted to the Middle and Southern States, where the problems it seeks to solve are frequently presented.

Very respectfully,

Geo. Wm. Hill, *Editor.*

Hon. James Wilson,
Secretary of Agriculture.

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CLEARING NEW LAND.

INTRODUCTORY.

The clearing of new land is an important factor in the agricultural economics of many farms, yet probably no feature of farm life is so little understood and so blindly pursued. This unfortunate condition is largely due to lack of information upon the subject. Almost every other field of farm operations has been more or less thoroughly covered by agricultural publications of one kind or another; but the writer has long looked in vain for any definite and authentic information upon the subject of clearing land. The suggestions contained in this bulletin, being the results of practical work carried on for years, will, it is hoped, be of service to those who have land to clear.

For years the writer has been constantly engaged in clearing land, usually covered with bushes and timber of various sizes, including most species of forest trees common to the Middle Atlantic States. The task has been slow, laborious, and expensive, but very necessary.

LARGE PROPORTION OF UNCLEARED LAND.

The conditions indicated prevail upon thousands of American farms in the earlier settled portions of the country. Especially is this true in the South, where large areas once devoted to the cultivation of cotton and tobacco have through changed conditions inevitably gone to bush and small timber. The middle West is the only section of the country that does not need the woodman's ax and mattock. There woodland lots are at a premium. True they have their heavy prairie sod to bring under subjection, but that does not compare with the task of making a way for the plow through brush and roots. The far West, however, has its share of bush land. The clearing of such tracts in that section has long been a regular occupation of Chinamen, who usually charge $18 or $20 per acre for such labor. New Englanders are not only annoyed by stones, but are frequently beset with scrub timber and old overgrown fields, yet it is in the South that the largest proportion of waste land is found. It is here that large farms with many wooded acres and only small parcels of cultivated land are seen. Throughout the South the proportion of bush and scrub timber land is astonishingly and deplorably large.

IMPORTANCE OF CLEARING LAND.

Land of this bushy character is neither tillable nor suitable for timber purposes. It is an eyesore to the community and an expense to the owner. It has no earning capacity. It is deadheading its way, and the way leads only to the impoverishment of the owner. If there is no intention of improving such land it would be wise to dispose of it. Holding it for higher prices is invariably a losing game. Taxes and loss of interest on purchase money usually more than offset any increase in value.

There is a notion which obtains among many persons that the ownership of land imparts respectability. The correctness of this idea is conditional. The possession of broad and productive acres, it is true, gives prestige as well as profit, but the ownership of nonproductive bushy land is discreditable. The character and thrift of the farmer may be justly estimated by the appearance of his land.

A good plan for the owner of unimproved land is to sell the surplus. Such a course will not only promote the owner's interest, but the common wealth of the community. "Loafer" land not only represents idle and taxable capital for the landlord, but the withholding of possible support from others.

If he is a benefactor of mankind who succeeds in making two blades of grass grow where only one grew before, how much more beneficent is the mission of making grass grow where only bushes were wont to thrive.

WHAT LAND SHOULD BE CLEARED?

The problem is not only how to clear overgrown land, but whether it will be profitable to do so. Manifestly much wooded land had better be left for timber and fuel purposes. Quantities of promising young timber are annually slaughtered. Indeed, the desecration of our forests amounts to almost a national calamity. Every farm should have its timbered tract, and that tract should be wisely conserved. The reckless use of an ax for a few hours will inflict damage that it will take nature years to repair.

Disposition of farm lands.—No field operation affords more opportunities for the exercise of intelligent discretion than farming, and no problem of farm life is more far-reaching in effects than the wise disposition of farm lands. To cut away young growth which would within reasonable time possess timber value is usually a mistake. To leave bush land idle when it will require a hundred years for it to develop into profitable timber is folly.

The timber consideration is not the only one that enters into the advisability of clearing land. The location of the tract, together with the density and size of the wooded covering, must be considered. The rpose for which the land is adapted and the probable income to be rived from it when cleared generally govern the advisability of aring it. Yet it is desirable to open up the home site, connect lds, etc., at an expense greater than any probable pecuniary return uld warrant. Farming has its æsthetic as well as its material conleration. The farmer who stops to figure whether an overgrown nce row would yield enough harvest to pay for its clearing will never ve an attractive farm, or extract from farm life the pleasure it is pable of affording.

For trucking or orcharding.—It is obvious that it may be found profitble to clear land for trucking or orcharding when it would not be rofitable to do so for general farm crops. In the former case a turn of $100 or more per acre may reasonably be expected, while the ross income from an acre of grass or grain will rarely exceed $15 r $20.

COST OF CLEARING.

In many sections farm improvements can be bought for less than st. Certainly in such cases it is cheaper to purchase improved land an to buy impoverished or wooded tracts with a view to their imrovement by clearing. If a living has to be earned upon it, poor or ul land is dear as a gift. Generally the expense of clearing will ceed the original cost of the land. The cost per acre will vary from 5 or $10, to $30 or $40, conditional upon kind, density and size of ooded covering. In many localities there is a fair demand for wood, e proceeds of which will help to defray the cost of clearing. In fact might be profitable in some instances to dispose of the wood to the est advantage and then to give away, if it can not be sold, the land ith all its stumps and roots and purchase improved land.

Fighting it out with the bushes.—However, this much can be said in avor of fighting it out with the bushes on one's own land. A farmer ay improve his farm gradually as time and means permit, each year dding a few acres of cleared land. This small annual expenditure of ime and means will scarcely be missed in the sum total of the year's ccounts, yet in a short while it will make a most creditable showing. To thus gradually improve the land, is within the reach of all. And hen there is a certain sentimental satisfaction in working out the alvation of one's own place. For who would not rather improve his wn wooded hills and swampy bottoms than exchange them for the ields of another. The love of one's native place is happily a virtue hat most men possess.

If for any reason it is decided to clear land, then the method to be mployed becomes all important.

METHODS OF CLEARING.

Pasturing.—In adopting a method of clearing one must be governed by various circumstances. For instance, if the wooded tract is adapted to pasture and stock are available, pasturing would undoubtedly be the cheapest means. If the timber consists of kinds that rot readily, it would be wise to simply cut away the wood and leave stumps and roots to decay for several years before attempting to cultivate. If the wooded growth is small, the mattock will usually prove the most satisfactory and expeditious means of removing the brush. Thus not only the location but the size and kind of timber enter into the problem of determining the wisest means for its destruction.

Nature of ground to be considered.—The nature of the soil is the next thing to be considered. For instance, if soft or marshy, the use of heavy machinery would be impracticable, and if stones are thickly embedded in it great difficulty would be experienced in keeping mattocks sharp. Whether the land is desired for immediate cultivation and a good yield is expected the first year or not, are also matters for consideration. It is evident that the wisest method to be pursued depends upon local conditions.

CLEARING BY PASTURING.

When circumstances permit, pasturing is undoubtedly the most economical way of clearing land. In fact, if the growth is large and the clearing is to be a profitable investment, pasturing is probably the best method that can be pursued.

The purpose of this method is to change the field from woodland to pasture and from pasture to cultivated ground. The stock will keep down new growth while stumps and roots decay.

Timber should be cut low.—In pursuing this course the timber should be cut low, leaving the stumps in the most favorable condition for rotting. The bush and trash should be burned. The stock ought to be allowed the run of only so large a tract as they can keep pretty well subdued. The quantity of sprouts and young bushes an animal will nip off will depend upon whether or not it has access to other vegetable matter.

It is desirable in late summer to go over the pasture lot and with an old ax remove the sprouts and bushes which the stock have failed to subdue. If this method is carefully followed for a few years, surprising results will follow. When the stumps of one tract are dead and decaying, another lot should be added to the pasture.

Sheep and goats are preferable, but any kind of stock is suitable for this kind of pasturing. Horses and cattle, and even hogs, will answer well for this purpose.

The Angora goat as a land clearer.—Recently the Angora goat has attracted considerable attention as a land clearer. While other animals upon new land will usually confine their browsing to buds and tender shoots, and then largely for want of something better, the Angora prefers brush to grass. It will not only eat leaves and tender sprouts, but it will bark bushes and saplings whose tops it can not reach. This girdling is very destructive to vegetable life. In the far west, especially in the States of Washington and Oregon, this goat is frequently used as a means for clearing brush-land. Where there are large tracts to clear, goat grazing is probably the cheapest and most satisfactory method to pursue.

Those desiring further information about the Angora goat are referred to Farmers' Bulletin No. 137, U. S. Department of Agriculture, or Bulletin No. 27, Bureau of Animal Industry of that Department.

It is wiser, however, in most instances, to use what stock and means we have at hand, as the value of land in most regions is not sufficient to justify unusual expense in its improvement.

CLEARING BY CUTTING AWAY TIMBER.

It is recorded of the ostrich that when frightened it will burrow its head in the sand and imagine that it is hidden from the outside world because its own view is shut off. So it is with men who cut away and burn the brush and imagine that they have cleared the land because it looked clean. This is usually a mistake. Such land is untillable, and from each stump a number of sprouts will start and soon innumerable new bushes will be making headway. In a few years the land so recently apparently cleared will be more unsightly and expensive to clear than it was originally. Of course if it is practicable to remove immediately all starting sprouts the stumps must soon die. All vegetation requires leaves as well as roots to survive.

Timber should be cut in late summer.—If, however, the cutting is relied upon it is wise to do it in late summer. In clearing hardwood it will not do to cut off and wait for stumps to decay; they should be immediately removed or some method pursued that will at least keep down the sprouts and prevent objectionable plant growth.

Usually in clearing land, as in everything else, that policy is best which leaves a finished work.

Clearing pine land.—However, in clearing most pine land the cutting method is the most expedient. The pine genus, excepting two or three species, is happily peculiar. Contrary to the rule in forestry, when the pine is cut off just above ground it does not throw up shoots. Consequently it soon dies, and if the stump be small it rapidly decays.

Many pine lands throughout the South may be cut off and safely left idle for several years with assurance that roots and stumps will rot.

The white pine is the chief exception to this rule. Pine soil is not so impregnated with objectionable growth in an embryo state, waiting for an opportunity to develop into bushes, as is hard-wood land.

This nonsprouting characteristic of the stump of most species of pine, together with the relative freedom of pine soils from foul growth the first years, renders southern pine land comparatively easy and inexpensive to clean, especially if the timber is not large. New pine land is much more amenable to cultivation than lands from which other kinds of timber have been removed by cutting. This is owing to the semi-taproot system of the pine and the brittle nature of its roots.

Yellow poplar.—The yellow poplar or tulip tree (*Liriodendron tulipifera*) is another tree species which, for purposes of clearing, should be classed with the pine. The rapidity with which the stumps and roots of this tree rot, renders the cutting method of clearing land an eminently wise one in disposing of this member of the forest family. Unlike the pine, however, the poplar stump will send up numerous and vigorous shoots. Hence these should be sprouted off or grazed back, and then in a few years the stump, however large, will be a crumbled mass of vegetable mold.

There are other species of trees which resemble the pine and poplar in the susceptibility of their stumps to decay, and to which the cutting method is consequently applicable. Large areas of southern river lands have cottonwood, soft maple (red or water maple), and sycamore, all of which rot fast, though the sycamore has great vitality. But these two species—the pine and yellow poplar—sufficiently illustrate the principle, and in the destruction of these the writer has served a full apprenticeship.

Alder.—Before leaving the discussion of this method of clearing, it might be well to briefly advert to the alder. It is usually found in dwarf-bush size and in clusters. Its habitat is lowlands and swampy bottoms. It is master of the land upon which it thrives, and its masses of interlocked roots present an impregnable obstacle to cultivation; yet if its vulnerable points are understood it may be quickly and easily disposed off. In August cut the alders off at or below the crown, leaving the brush where it falls. The following spring, after vegetation has started and the ground is thoroughly dry, burn the area over. If the cutting and burning have been thorough, the alders will never return to plague you. The next year the ground may be cultivated with comparative ease.

CLEARING WITH DYNAMITE.

Dynamite for large stumps.—In the removal of large stumps dynamite is serviceable and economical. While it will seldom blow the stump out of the ground, it will usually split it in several parts and lay bare the roots, thus enabling the grubber to take out the stump piece by piece, which is less laborious than removing the whole stump. When occasional stumps are scattered over the field or plantation, along the roadway, or near the buildings, their immediate removal is desirable and for this purpose dynamite is serviceable.

Too expensive for general use.—The cost of this explosive will not justify its use on stumps under 6 or 8 inches in diameter. It is too expensive for general use in clearing land. While it is undoubtedly the cheapest method for removing stumps of large size, it is a question whether it is advisable for general farming to clear land covered with many such stumps. The profits in such farming are not certain enough or large enough to warrant heavy expense in bringing new land under cultivation. When much of the timber is over 6 or 8 inches in diameter at base, and pasturing can not be conveniently resorted to, it is usually wise to utilize land so encumbered for its timber purposes.

The cost of dynamite will approximately vary from 10 to 20 cents

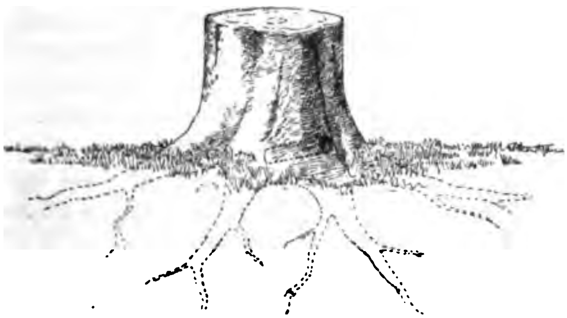

FIG. 1.—Showing dynamite cartridge in position.

per stump. It is readily seen that if there are some hundreds of these per acre the cost will be too great to justify clearing by this method land destined for general farming.

Experienced hands should be employed.—When using dynamite great caution must be observed, for it is very dangerous if carelessly handled. Also, if placed by inexperienced hands, much of it is likely to be misapplied. Hence, if contemplating its use, it will be safer and cheaper to employ experienced help.

As a warning to those handling this explosive, it might be well to state that dynamite consists of nitroglycerin mixed with a granular absorbent, and wherever there is nitroglycerin there is danger. It is made in different grades. These are determined according to the percentage of nitroglycerin they contain. The lower grades, those containing about 30 per cent nitroglycerin, are preferable for stump blasting because they explode with less suddenness and their tendency is more to upheave than to shatter.

Dynamite comes in cylindrical sticks of different sizes and lengths. The quantity to use in blowing out a stump depends necessarily upon the size of the stump. The charge, with cap and fuse attached, should be placed in a hole bored for the purpose as nearly as possible under the stump. The hole should then be filled with earth and gently tamped. Then the fuse may be lighted and the operator retreat beyond the range of flying fragments.

It is generally conceded by those familiar with dynamite that the most effectual destruction of the stump is achieved by boring into it as low down as possible, thus adding considerably to the force of the explosion (see fig. 1). This method, however, adds to the time and labor and hence to the cost per stump, while the more common method of digging down by the side of the stump and hollowing out a place under it where the charge is placed will generally split up the stump sufficiently to make its removal an easy matter.

CLEARING WITH MACHINERY.

Stump-pulling machinery.—There are many different makes of stump-pulling machinery upon the market. The promoters of these various grubbing devices claim great merit for their respective machines, but catalogue claims should be accepted with great caution.

In the neighborhood of the writer, and doubtless in many other neighborhoods, can be found such machinery in idleness because it was tested and found wanting. The difficulty with most stump-pulling machines is that if they are strong enough for the work desired of them they are too expensive, cumbersome, and unwieldy.

When these machines are once properly adjusted, their work, provided nothing breaks, will be satisfactory. But the labor of moving and the care of adjusting, together with the liability to breakage, more than outweighs the virtues of any stump-pulling machine known to the writer. Moreover, usually, when the timber is large enough and thick enough to suggest recourse to machinery for clearing, it will not pay to clear such land at all unless it can be devoted to some specially profitable crop.

However, it may be said of machinery cleared land that the clearing is thorough. The machine removes practically all the roots of any size from the ground, leaving the land in a good tillable condition.

When it is the intention to use a machine the timber should be cut away and removed and the brush burned. Such preparatory work will greatly facilitate the moving and operation of the machine. The stumps should be left high enough to conveniently loop with a chain, for it is much easier to get a secure hold above than below ground.

Best time to operate a machine.—The best time to operate a machine is immediately after a heavy thaw or rain. The stumps will draw much easier when the ground is soft and loose than when it is dry and hard.

CLEARING WITH HORSES AND CHAIN.

Pulling up saplings.—This method consists in pulling the young trees out of the ground. Where conditions are favorable it is surprising how rapidly this may be accomplished. Best results can be obtained where the growth consists of saplings, say 2 to 4 inches in diameter, which have a lateral root system such as possessed by the locust, maple, or dogwood. The ground should be soft and loose. The plan is simple. It consists in fastening one end of a long log chain to the trunk of the sapling as high above the ground as the flexibility of the

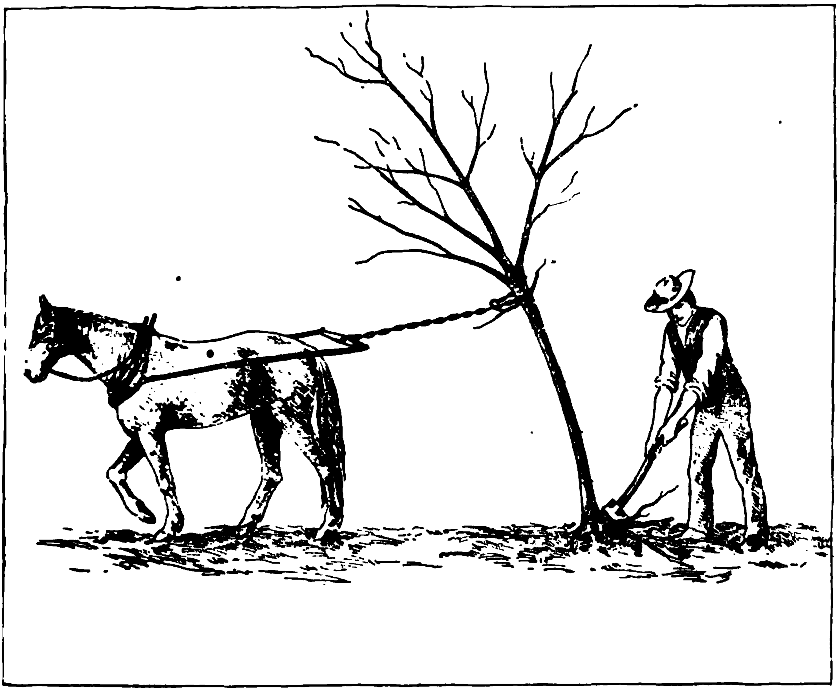

FIG. 2.—Uprooting sapling with horse and chain.

tree will permit and hitching a steady horse, or, if necessary, a team of horses (see fig. 2) to the other end of the chain. While the horses are pulling at the tree a man should be at its base with an ax and assist them by severing such roots as seem loath to give away.

Good and fast work.—In this manner, when the saplings are of the right size and kind, the ground in proper condition, the horses true and steady, the man with the ax alert and discreet, wonderfully good and fast work can be accomplished.

Stumps may also be pulled up with chain and horses. One end of a log chain should be fastened around one of the large roots of a stump, a team of horses being hitched to the other end. The chain is placed soften the subsoil and the wind with its swaying force will soon throw the tree. Indeed, when the side roots and the earth have been removed from around a tree, the prying force which the top will exercise upon the remaining roots will be irresistible. Each drop of rain and each puff of wind will contribute toward loosening and breaking those tap roots, which on account of their position almost defy the mattock. The assistance which nature is capable of affording in clearing away trees is wonderful. The spring season, when the ground is loose, the rains heavy, and the winds strong, is the most opportune time to pursue the above method.

Use sharp tools.—If a new mattock is needed do not be too economical to purchase it, and if it is dull do not imagine that you have not time to sharpen it. With a worn or dull hoe a man will pound more life out of himself than out of the bushes. A good plan is to have two hoes for each grubber, always keeping one in good condition. For sharpening hoes there is nothing so satisfactory as a steel file 12 or 16 inches in length.

Do not attempt too much continuous grubbing. It is very laborious work, and men will soon tire of it and become discouraged. A fatigued, disheartened laborer is never a success.

Grubbing at intervals.—Plan to do some weeks of grubbing in the fall before winter sets in, continue it from time to time through the winter as weather permits, and follow it up in spring with a few weeks more. In this manner a good deal can be accomplished without overtaxing your men at any one time.

Grubbing is slow and expensive, but when the land is needed it is time and means well spent. No farm is well ordered where there are foul fields and overgrown fence rows. No farmer commands the esteem of his neighbors when bushes are everywhere encroaching upon him.

Bush land is yielding no income. It is a boarder, and the owner pays the board bill in the shape of taxes, while the land is depreciating because it is growing all the time more expensive to clear.

METHODS OF CLEARING CONDITIONED UPON CHARACTER OF GROWTH.

Variation of root systems.—There is a marked variation in the root systems of different species of trees. The roots of some strike deep into the ground, while others extend out laterally; and still others traverse the ground in every direction. Some varieties are much more persistent in renewing themselves than others. The stumps of some kinds will survive for years, while those of other species will soon decay.

It is obvious that these varying characteristics of root and stump must affect the method of dealing with the different species of trees.

Classification of trees according to root characteristics.—In the United States there are about 500 species of indigenous forest trees. It would be beyond the limits and requirements of this article to attempt anything like a complete classification of all these numerous species. For our purpose we may classify trees according to their root characteristics and the durability of their stumps. To illustrate, we will indicate a number of a pronounced type belonging to these several classes.

TREES WITH A TAPROOT SYSTEM.

The hickory, black gum, and white oak will represent this system. They have a typical taproot. (See fig. 5.) Indeed, so pronounced are these characteristics that the root frequently holds its full trunk size for several feet under ground. Sometimes these large taproots break up into several smaller ones, but they invariably pursue a deep course downward. They send out to the side numerous small feeders, but exceptionally a lateral root of much size.

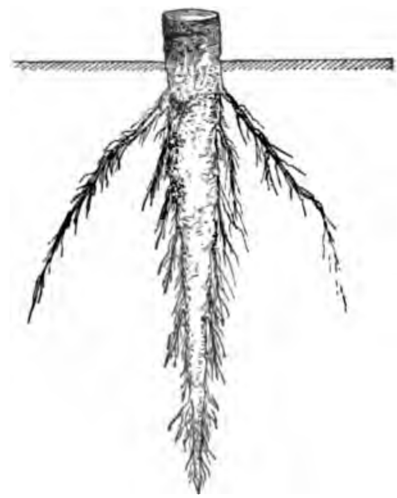

Fig. 5.—Stump with taproot.

Cultivation around stumps.—This is evidenced by the facility with which cultivation may be carried on around stumps having this root character. In plowing new ground the plowman is surprised to find with what ease he may pass some stumps, while it is necessary for him to bear his plow out of the ground or fight his way through a maze of roots as he approaches stumps of another species. Still further evidence of the varying root character of trees is manifested by the ability of some species to withstand wind storms, while others easily succumb. The forest may be full of uprooted trees, but the hickory, black gum, and white oak stand erect, resisting the force of wind and the ravages of time, until age has caused them to decay and crumble back to earth.

Stumps difficult to remove.—The taproot system of such trees makes it exceedingly difficult to remove their stumps. Roots of this character are very inaccessible to the mattock and resistant to force, whether applied by machinery or explosives. Hence, in clearing land covered with timber possessing this root system, either the method of pasturing or cutting back and cultivating should be pursued. The comparative ease with which the farmer may cultivate among stumps of this character and the extraordinary labor required to remove them, unite in suggesting the pursuance of one or the other of these methods.

TREES WITH A SEMI-TAPROOT SYSTEM.

This system embraces that numerous class of trees which throw out their roots in every direction. (See fig. 6.) The pines, poplars, and

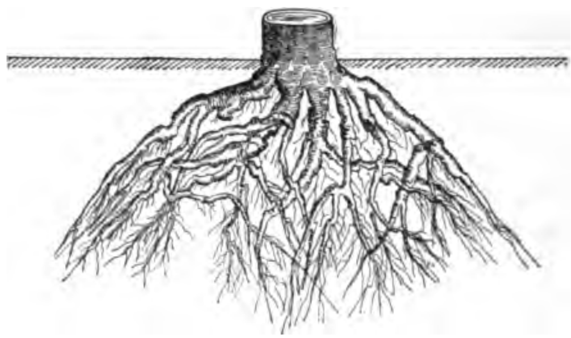

FIG. 6.—Stump with semi-taproot.

chestnuts are good specimens of this system and are widely distributed. In many sections of the Eastern States trees of this kind largely predominate upon most wooded areas. Not only does this class include the largest number of trees, but also the greatest number of species.

Stumps with a semi-taproot system are not as expensive to remove as those with the system previously described; but, on account of their surface root, plowing among them is much more difficult. However, removing stumps of this class is an unthankful and laborious task.

TREES WITH A LATERAL ROOT SYSTEM.

The varieties of this kind are much less numerous than those of the preceding classes. It embraces all trees whose roots are of a distinct surface character. (See fig. 7.) The elms, soft maple, locust, dog-

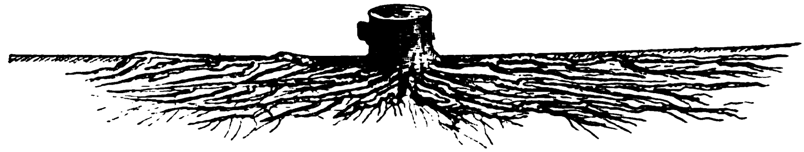

FIG. 7.—Stump with lateral roots.

wood, and alder are representatives of this class. These species do not always attain the size of trees, but their roots invariably belong to the lateral system. In fact, their roots all extend immediately upon or just under the earth's surface.

It is exceedingly difficult to plow among stumps having this lateral system of roots. Practically all their roots are within the reach and path of the plow. Happily, stumps of this class are comparatively easy to remove. Their roots are readily accessible to the mattock, or easily yield to the force of machinery or explosives.

TREES WITH AN INDETERMINATE ROOT SYSTEM.

There are several varieties of trees not only possessing a peculiar root system, but a wonderful capacity for reproduciug themselves. On account of their wide distribution, common occurrence, and annoying character it is deemed advisable to briefly advert to several leading specimens of this class.

Sassafras.—This is found most frequently in bush form. While it is occasionally observed growing to large size amid other forest trees, its favorite location is in old fields. Its chosen companions are hen grass, briers, and scrub pines. The growth for the first and second years is most vigorous; after that age very stunted.

The sassafras possesses a very singular root system. The roots strike perpendicularly into the ground for approximately 8 to 16 inches, then turn at right angles, rarely both ways, and pursue a horizontal course for about the same distance, when they split into numerous laterals.

Another and unfortunate peculiarity of the sassafras is the rapidity with which it reproduces itself. In this respect it resembles the asparagus vegetable. Indeed, after one has grubbed out this bush several times and observed how quickly and how numerously it reappears, he is forcibly reminded of the saying as to flies—for every one killed seven will return.

The usual custom of grubbing sassafras off several inches under ground serves only as a temporary expedient. While it will permit the plow to pass unmolested the first year, the next season and each succeeding one, the mattock will have to precede the plow.

Constant and careful plowing and cultivation, if maintained for several years, will gradually exterminate this bush; but due regard for the condition of the soil will usually not permit such treatment. The improvement of the soil also tends to subdue the sassafras. Rich land does not seem to be congenial to it. It thrives best upon poor lands that are left idle at intervals.

The most satisfactory method of dealing with sassafras, if it is large enough, is to pull it out root and branch. Any clamp device, adjusted to a strong handle 5 or 6 feet long, and in such manner as to give strong leverage, will answer. There are such implements upon the market. They are most serviceable, not only in clearing sassafras, but for all other kinds of small bushes. This device can be used only on bushes of medium size. If too small the bush will break, and if too large the clamp can not take hold or the man power at the other end will not be sufficient.

The sassafras may be exterminated by one grubbing, if the root is followed and cut beyond where it makes the turn or angle, but this method is laborious.

includes more or less of the kinds and varieties referred to above under the head of taproot, indeterminate root, and lateral root systems. Consequently it will be necessary for the owner to resort to more than one means to effect a complete clearing of this land. After what has already been said with reference to the matter, it is obvious that the mattock and the ax must be provided and considerable dependence placed on these tools. The first thing to be undertaken should be to cut down those trees of a sufficiently large growth to make serviceable timber for firewood or other purposes, whose stumps may be allowed to remain in the ground, either because of their tendency to quickly rot and decay or because of their deep taproots, making the removal of the stump difficult and costly, bearing in mind also that the taprooted stumps offer comparatively little obstruction to the plow. In the case of trees of medium growth, of which, owing to the nature of their roots, the stumps must be removed, it will be well to dig down around the base, making a trench, as it were, around the tree, severing with an ax all roots extending laterally from the stump: if these remained unsevered they would serve to keep the tree upright. The trees thus treated will, for the most part, succumb to winds and storms, pulling up the stumps with them as they fall.

The next process will be to tackle the young saplings, as previously described, by means of a chain and team, pulling them out of the ground, stumps and all. Attention is called to the fact that where the stump has to be removed by pulling, whether in the way just described or by the stump puller, it is important to select for the purpose a day succeeding a wet spell or a thaw, when the earth is soft and wet for a considerable depth below the surface, a condition which will greatly facilitate the operation of stump pulling. As the work progresses it may be necessary from time to time to again resort to firing, burning worthless timber and litter, the timber designed for lumber or fuel having been previously removed and piled for future use.

At this time we have our lot pretty well cleared of standing timber, save such as has been left for the influence of wind and weather, and work must now be undertaken on such stumps as it has been found expedient to leave in the ground up to this time, but which from their position or nature it will be necessary to remove before undertaking to plow the land. In these cases the method indicated in fig. 3 may be adopted, or the stump puller, if available, may be called into service. Possibly in a few cases, probably exceptional on this lot, recourse may have to be had to dynamite. Toward the spring those trees which have been dug around and which have succumbed to winter storms will in their turn have to be removed. By pursuing systematically the course above set forth on a lot of the character indicated, the owner will doubtless have it in proper condition for the plow by the spring following the year in which he began the clearing.

CULTIVATION OF NEW LAND.

The quantity of roots remaining in the ground after it has been cleared is always surprising. No matter what clearing method has been pursued or how carefully it has been done, the plow will discover an aggravatingly large number of roots. When stumps are pulled out by machinery many more roots are removed than by any other method. But even in machinery-cleared land the ground will still be full of roots, mostly small, it is true.

In plowing new land a good, steady, strong span of horses is of the first importance. Horses that are fast or fractious will not answer. They will fret the plowman, break the plow, and bruise their shoulders. With a spirited team, even though nothing is broken or injured, it is hard to do good work. If the plow is drawn rapidly it is quite impossible to guide it closely and avoid stumps and roots.

After the winter season of comparative idleness horses should not be put to plowing new land. Their shoulders have grown tender from disuse and should be first gradually toughened in old land; moreover, some of their accumulated energy should thus be worked off.

Oxen preferable to horses.—For plowing new ground oxen are preferable to horses. They are steadier and stronger. Formerly in breaking new land it was a common occurrence to see several yoke of oxen attached to one strong plow; and they did yoeman service. Now, in this age of hurry and rush, the slow, plodding ox has been forced to give way to the faster horse, and when new ground is to be plowed unfortunately the ox is seldom at hand.

There are several patterns of plows made especially for new-ground work. These grub plows, however, while strong and handy, are not essential. Any standard plow with a good cutter properly and securely adjusted will do good work.

Cut roots that stop the plow.—When plowing new land always have a mattock conveniently fastened to the plow handles, and cut all roots that do not break. When the plow becomes "hung" in roots it is better to cut it loose than to back and pull out. The root that stops the plow will interfere with cultivation, and the same root, unless severed, will occasion this annoyance for several successive seasons. In plowing new land it is well "to make haste slowly." Leave no skips. Turn a continuous furrow. The time saved in cultivating the crop, together with the increased harvest, will more than pay for the pains taken.

The second season the plow furrows should be run at right angles to those of the first. If these two plowings are thoroughly done, the ground will be completely broken and subdued.

If the land is very stumpy it will be quite difficult to level down for planting purposes. When the stumps are too thick for the old-fashioned A harrow to be used a heavy brush or cultivator, run opposite to the way the land was plowed, will answer fairly well. When the land is not too stumpy or the stumps are cut very low the spring-tooth harrow will do excellent work. The teeth will bound over stumps and roots that are fast and comb out a great many that are loose or broken. If the roots are plentiful, and they usually are, many of them will have to be removed. With an improved adjustable spring-tooth harrow, many of the loose roots may be combed out and windrowed and then burned or hauled off.

New land should be cultivated for successive seasons.—In bringing new land under cultivation, cultivate for several successive seasons or until all roots are thoroughly broken and all foul vegetation completely destroyed. If cultivated for only one year and then seeded down or left idle any number of roots and small bushes will revive and start into renewed life.

CROPS ADAPTED TO NEW LAND.

New land, because of the large quantity of vegetable matter it contains, is exceedingly loose. The leaf mold also gives the soil a dark color and fertile appearance. Humus or decomposed vegetation is an essential element in productive soils. It imparts a wholesome physical character and furnishes properties that enable it to retain heat, moisture, and plant food. But soils may contain too much organic matter, especially if it is not well decayed, hence virgin soil is usually not sufficiently productive at first for best crop results. Ordinarily, however, on new ground in the South each succeeding harvest will exceed the preceding one until the third or fourth year is reached. So that, in the long run, this excess of vegetable trash on recently cleared woodland tracts will, by its fertilizing value, and adding humus to the soil, more than compensate for the immediate loss in the earlier years.

Corn is a good crop for new land.—New land is so aerated that usually crops growing on it suffer much for lack of moisture. It will generally produce a good growth of stalk, but the yield of grain will be poor. This is especially true of corn. If not overtaken by a severe drought the fodder will likely grow to good size, while the ears will be small and faulty. Corn, however, is a good crop for new land, not that it is especially adapted to such land, but because it is the easiest of all crops to cultivate on rough and rooty soil. The cultivation that corn requires is the very kind most desirable for new land. After several corn crops have been removed the land should be in good condition for any grass, cereal, or vegetable.

Oats should not follow corn on new land, or for that matter should not be seeded to any foul land, for they, especially spring oats, are the foulest crop upon the farm. The early spring preparation of the ground required for sowing oats serves as an excellent inducement to the vigorous growth of weeds, briers, and bushes; and the inability to cultivate oats during the growing season will enable this foreign matter to again secure a foothold.

Clover well adapted to new land.—Among the grasses, clover seems best adapted to new land. Indeed, upon such soil it will invariably thrive, while upon old neighboring fields it may be difficult or impossible to secure a stand. In seeding new land to clover select the largest and most vigorous variety. The denser the growth the more difficult it will be for foul matter to secure a lodging; and the higher the clover stands the more shade it will afford, and this will facilitate the decay of roots and stumps. In fact, a most excellent treatment for new-ground pine land is to stir the surface with a harrow or cultivator and seed it to the large sapling clover. The clover will serve a most useful twofold mission. It will add nitrogen and humus to the soil and greatly assist in rotting the roots and stumps by the shade and contiguous decaying matter it affords.

Fruits of all kinds do well upon cleared woodland, provided, of course, that the location and mechanical condition of the soil are suitable. But it is not wise to plant trees on such land until it has been thoroughly plowed and is in a condition to be conveniently cultivated. In planting an orchard upon stumpy land, stumps should not be allowed to remain in proximity to the newly set trees. The stumps will not only interfere with cultivation but greatly endanger the trees by bruises from horse or plow.

Strawberries make a satisfactory growth.—Among small fruits the strawberry thrives especially well on recently cleared land. Upon such soil it makes a most satisfactory growth and fruitage, and much less labor is required to keep the weeds and grass down, as the ground is not impregnated with foul seed. This immunity of new ground, compared to old land, from weed and grass infestation is a most important factor not only in strawberry culture but in all gardening or trucking operations.

New ground is desirable for trucking.—For vegetable growing new land is very desirable, not only because of its comparative freedom from foul growth, but because such soils contain a large supply of organic nitrogen, the most necessary and expensive of vegetable fertilizers. It is light and porous, thereby enabling the tender sprout after germination to more readily push its feeble form through the earth's surface. Upon old land frequently a crust will form on the surface or the soil become baked, thereby preventing seed from coming up, but no trouble of this character is experienced with new ground. The physical condition of such soils greatly encourages the development of those tuberous vegetables that grow by a process of expansion under ground.

These are some of the properties of new ground that render it desirable for trucking. Potatoes, both sweet and Irish, will certainly thrive on this soil. They will yield well, be symmetrical in form, clear in color, and very free from scab. The tomato is another vegetable most congenial to new ground; upon such land it is relatively free from blight and less liable to be choked or smothered by a late summer grass, which so frequently appears upon old land after the size of the vines prevents cultivation. Neither should tobacco be omitted in enumerating crops adapted to new land.

Indeed, there is no question about the profitable cultivation of new land. The problem is when and how to clear it. When once the clearing has been completely accomplished the yield from such lands will be more satisfactory than the harvest from old fields. In fact, in many instances it would be wise and economical for the farmer to plant his old worn and washed fields to forest and clear other land for cultivation.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 154.

THE HOME FRUIT GARDEN:

PREPARATION AND CARE.

BY

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Horticulturist, Bureau of Plant Industry.

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1905.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
Washington, D. C., April 30, 1902.

SIR: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin the manuscript of an article on "The Home Fruit Garden: Preparation and Care," prepared by L. C. Corbett, Horticulturist of this Bureau.

The article appears in the Yearbook of the Department for 1901, but it is believed to be of the popular style and of sufficient value to warrant its republication in the Farmers' Bulletin series. It has been slightly revised for this purpose, and will be found to contain much general information in regard to the laying out and care of a small fruit garden. No attempt is made to fully cover the cultivation of various fruits, a subject treated in Farmers' Bulletins already available and in others to be hereafter published.

Very respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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ILLUSTRATIONS.

THE HOME FRUIT GARDEN: PREPARATION AND CARE.

INTRODUCTION.

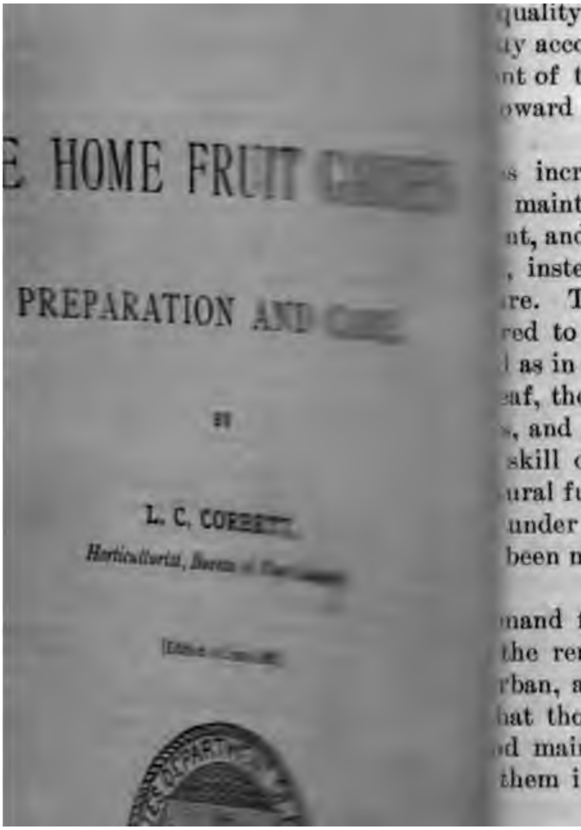
A fruit garden consists of an assemblage of fruit-bearing trees and shrubs, maintained for the purpose of supplying the family with fruits. In its general purposes, then, the fruit garden is intended to accomplish results similar to those of the vegetable garden. In distinction from an orchard, the fruit garden is more restricted in area; it is intended for home rather than market purposes, and consequently comprises a much greater variety of fruits.

Considering the general desire for and appreciation of fruits by people of all classes, it is amazing that even those who have suitable situations and facilities for raising them, and who can not purchase them because of remoteness from markets, have not established home fruit gardens.

With the growth of the commercial fruit interests of the United States the home fruit garden has been lost sight of. Only a few years ago the owners of home gardens not only led in the production of fruits, but were our authorities as to how and where to grow them. To-day these gardens, while no less numerous or important, are overshadowed by the orchards where fruit is grown for commercial purposes.

RELATION OF THE HOME GARDEN TO THE FRUIT INTERESTS.

While both the home garden and the orchard are essential to the good of the community, they bear very different relations to the fruit interests of the country as a whole. The home garden is always the forerunner of commercial development, and even in those localities where climatic and soil conditions are adverse to conducting such industries on an extensive scale the home fruit garden of the enthusiastic amateur is certain to be found. All the success attained to-day by the fruit interests of the United States has grown out of the persevering efforts of a few men whose home fruit gardens served not only as testing stations for determining the fitness of given sorts for new and untried localities, but they were the propagating grounds from which sorts of the highest quality and greatest commercial value originated.



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INFLUENCE OF AMATEUR FRUIT GROWERS UPON COMMUNITIES.

The testing of varieties in new localities and the development and dissemination of new sorts by the amateur is an important work, but the greatest good accomplished by him is to be found in the wholesome influence which he exerts on the community in which he lives. A community is certain to profit æsthetically as well as financially from the influence of such growers, and it is to them that we owe our appreciation for high quality. A discriminating taste developed in a neighborhood creates a demand which it pays well to gratify, and the amateur who grows fruits for quality will find a ready market in such a section.

CHANGED CONDITIONS OF FRUIT CULTURE.

Until within comparatively recent times the introduction of foreign species worthy of cultivation in this country was largely confined to horticulturists, who maintained private fruit gardens or nurseries. In fact, previous to the establishment of the State experiment stations by Congress in 1887, an important function of the work of the nurseryman was the introduction and testing of new sorts, both of foreign and domestic origin. While the commercial dissemination and popularization of fruits is at present almost exclusively in the hands of the nurseryman, the introduction of foreign species and varieties, as well as the testing of both foreign and domestic sorts, has fallen largely into the hands of the Department of Agriculture and the experiment stations. The general perspective of fruit culture in America has been greatly changed during the last twenty-five years, and many of the lines of work carried on in private fruit gardens have been absorbed wholly or in part by other forces; yet the profitable occupation of fruit growing, to say nothing of the highly interesting work of plant breeding, is ever open to the amateur.

ADVANTAGES AND PLEASURES OF THE HOME FRUIT GARDEN.

The inhabitants of this country are notably a fruit-loving and fruit-eating people. Notwithstanding this, however, fruit culture has grown to be classed among the specialties, and few persons who consume fruit are actual growers. The possibilities in fruit culture upon restricted areas have been very generally overlooked, with the result that many persons who own a city lot, a suburban home, or even a farm, now look upon fruit as a luxury. This can all be changed, and much of the land which is now practically waste and entirely unremunerative can be made to produce fruits in sufficient quantity to give them a regular place upon the family bill of fare and at the same time add greatly to the attractiveness of the table and healthfulness of the diet. The home production of fruit stimulates an interest in and a love for natural objects which can only be acquired by that familiarity with them which comes through their culture. The cultivation of fruits teaches discrimination. A grower is a much more intelligent buyer than one who has not had the advantages of tasting the better dessert sorts as they come from the tree. If every purchaser was a good judge of the different kinds of fruits, the demand for fruits of high quality, to produce which is the ambition of every amateur, as well as of every professional fruit grower, would become a reality. But until some means of teaching the differences in the quality of fruits can be devised the general public will continue to buy according to the eye rather than by the palate. The encouragement of the cultivation of fine fruits in the home garden will do much toward teaching buyers this discrimination.

Pleasant and healthful employment.—Besides increasing the fruit supply and cultivating a taste for quality, the maintenance of a fruit garden brings pleasant and healthful employment, and as one's interest in growing plants increases, this employment, instead of proving a hardship, will become a great source of pleasure. The possession of a tree which one himself has planted and reared to fruit production carries an added interest in its product, as well as in the operation by which it was secured. The unfolding of the leaf, the exposure of the blossom buds, the development of the flowers, and the formation of the fruit are all processes which measure the skill of the cultivator, and when the crowning result of all these natural functions has been attained in a crop of perfect fruit, the man under whose care these results have been achieved will himself have been made happier and better.

To those familiar with the facilities at command for the culture of fruit and the general interest in the subject, the remarkable absence of successful fruit gardens about city, suburban, and country residences can be explained only on the ground that those who would be most likely to give attention to their care and maintenance have no object lessons or literature at hand to guide them in laying out such gardens.

THE CULTIVATION OF A HOME FRUIT GARDEN.

Fruit for the family table.—Most persons engaging in the cultivation of a home fruit garden will have as their chief aim the production of fruit for the family table and the pleasure it affords; others will go a step farther and find an added source of pleasure in the problems of cross-pollination and the production of new forms. In a majority of cases, however, the aim will be the one first mentioned, and it is to assist such that the suggestions contained in this paper are offered.

In order to prove a source of constant pleasure and gratification a fruit plantation must claim the attention of its owner from early spring

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ılly grown is suited to a loose, sandy soil, and it seems desirable to l to the collection a plant, such as plum, which naturally requires a ıvy, retentive soil, it would undoubtedly be better to change the ıracter of the plant by grafting it upon a stock adapted to sandy l conditions than to attempt to modify the soil to suit the plant. is change can be effected by using a peach stock for the plum. We e therefore two alternatives—either the soil may be modified to t the plant or the plant may be adapted, by working it upon a suit-e stock, to the soil. Such modifications in plants are not always ily accomplished, and with many plants there is no alternative but use them on their own roots. In this latter case the soil itself must made to conform to the demands of the plants. The soil, in addi-n to being heavy and retentive, may also be cold and wet. In such e the addition of sand will not entirely overcome the difficulty.

Sand will lighten and facilitate natural drainage, but if the soil be luly moist the only safe and satisfactory remedy lies in thorough lerdrainage. This can be accomplished in two ways: Drains may dug and a stone conduit built to allow the superfluous water to escape, what is better, agricultural tile may be laid in the bottom of the nch. If the soil is very stiff and retentive, the tiles should not be l over 2½ or 3 feet deep and about 1 rod apart. If the soil is porous, drains may be placed farther apart and buried deeper. A double rpose is served by underdraining. The superfluous water which ıded to make the land cold, sour, and "late" is removed, thus making soil warmer and earlier; and by the admission of air the acidity is wly overcome. The processes of oxidation and nitrification are also orded better conditions for action, and while drainage adds nothing the soil in the way of plant food, the mechanical operation of noving water and admitting air is quite as marked in its effects as a eral dressing of manure, for the store of plant food which was with-ld from the plant is allowed to become available. There is little ınder in the light of these facts that early agricultural writers pro-unded the axiom "Tillage is manure."

PLANTING.

Preparation of plants.—It is impossible to give explicit directions r the many plants which may be selected for planting in fruit gar-ns in the various sections of the United States, and general state-nts only can be made. At planting time all broken or decayed ots should be cut away, leaving only smooth-cut surfaces and healthy od to come in contact with the soil. If a large part of the root area the plant has been lost in transplanting, the top should be cut back proportion to the roots remaining. By so doing the demand made the top when the plant starts into growth can be met by the root.

Setting the plant.—The holes in which trees, vines, or shrubs are to be set should be ample, so that the roots of the plant may have full spread without bending them out of their natural course. The earth at the bottom of the holes should be loosened a spade depth below the line of excavation. The soil placed immediately in contact with the roots of the newly set plant should be rich top soil, free from sod or partially decayed organic matter. Firm the soil over the roots by trampling, as this brings the soil particles together and at the same time in close contact with the surface of the roots. A movement of soil water is thus set up and the food supply of the soil brought immediately to the use of the plant. When the operation of transplanting is complete, the plant should stand 1 or 2 inches deeper than it stood in the nursery. Every precaution above enumerated will make for the success of the plant and calls for careful attention.

PRUNING.

While pruning has to be modified to suit the style of training employed with any given plant, each species of plant bears its fruit in a peculiar manner, which renders the maintenance of wood of a certain age and character necessary in order to secure a crop of fruit.

Apple and pear.—In the case of the apple and the pear the fruits are borne upon "spurs" of the previous year's growth only, these spurs appearing on wood one year or more of age. Heading in or shortening each shoot of the season's growth, therefore, must be done with care in order not to reduce the bearing wood beyond a profitable limit. With these two plants, however, the bearing shoots are not those making the most vigorous growth at the ends of the branches, but they are usually more obscurely located upon the sides of the branches, and make a much smaller growth, for which reason they have been termed spurs.

Peach and Japanese plum.—With the peach, however, it is the wood of the last season's growth upon which the fruits are directly borne, and with them heading in may be successfully employed to limit the quantity of fruit borne by the tree. Japanese plums bear on both year-old wood and spurs; pruning may, therefore, be used to thin the fruit, the same as in the case of the peach.

Quince.—The quince bears its fruit at the extremity of new shoots of the present season's growth, in which respect it differs from both its close relatives, the apple and the pear; but as these shoots arise from wood of the previous season's growth, pruning must be so adjusted that the fruit crop will not be reduced.

Grape.—The grape bears its fruit on shoots of the season, which in turn usually arise from canes of the previous year's growth. Old wood on the grape is therefore of little value; hence the development of so many systems of training which maintain only a single permanent trunk, from the top of which the bearing canes are renewed each year. The so-called "renewal," "high renewal," "Kniffen," "Munson," and various overhead systems of training all possess this feature in common. In fact, it is the only economical way in which to handle native kinds. For the fruit garden, however, where the vines are desired for covering arbors, pruning must be modified so as to secure a screen from the new growth as early in the season as practicable. For this purpose a modification of the "horizontal-arm" system of training will be found most advantageous. By planting the vines closely and carrying up single trunks to a fixed height, and from the top of the stalk carrying out horizontal arms along which "spurs" are maintained, a short growth from each spur will be sufficient to give a uniform and sufficiently dense canopy of leaves for the arbor.

Raspberry and blackberry.—Raspberries and blackberries both bear their fruits on short shoots which arise from canes of the previous season's growth. While these shoots are usually axillary shoots, the fruits are always terminal. In the case of the grape, which bears its fruit upon annual shoots arising from canes of the previous year, the fruit is produced at a node, and takes the place of a leaf; several fruit clusters may therefore arise from a single shoot of the grape.

Currant and gooseberry.—In the case of the currant and gooseberry the fruits are produced on both old and new wood; the fruits appear as axillary growths from the shoot itself, and wood 3 years or more of age is unprofitable and should be cut away.

Strawberry.—Strawberries are rarely produced in profitable quantities by plants more than 1 year old. Plants over 2 years of age should be rooted out to give room for new ones.

Orange.—The orange bears its fruit in much the same way as does the peach. New growth must therefore be maintained to insure a supply of fruit. But as the orange is evergreen, pruning can not be confined to a single season, as in the case of deciduous trees possessing a regular and marked period of rest.

PROTECTION.

The interest of a fruit garden may be greatly enhanced by growing therein plants not adapted naturally to the climatic region in which the garden is located, as, for instance, the growing of figs as far north as the latitude of Philadelphia. The summers of the region are sufficiently long and warm to induce a strong growth in the fig, but as the fruits normally require a long period in which to mature, the plant becomes useless as a fruit producer unless sufficient protection is afforded to carry over winter the immature fruits set the previous fall. This can be successfully accomplished in several ways. The most hardy sort should be selected, in addition to which the fruiting shoots may be wrapped in matting, covered with straw, and the fruits thus successfully protected; or, if it seems desirable, temporary sheds may be built over the plants, and these thatched with straw or fodder sufficiently to protect them from frost. Then, again, semihardy sorts may be tipped over by cutting the roots on one side, bending the branches close to the soil, pinning them down, and then covering the whole plant with matting and earth or a straw thatch and earth. At the extreme northern limit of fig culture it has been found that the covering of earth is preferable to any other method, while at the South, where only slight protection is necessary, bending down and covering with pine boughs or thatching with cornstalks has proved most successful.

By the use of one or the other of these methods of protecting plants the peach has been grown and successfully fruited in the southern central part of South Dakota, along the Missouri River.

Besides these protective devices, sheltered places, where growth is retarded in spring, may be taken advantage of in order to hold back such early blooming plants as apricots, Japanese plums, etc. Apricots planted and trained on the north wall of a building are frequently sufficiently retarded at blooming time to insure a crop, while if planted in the open and trained as a "standard" the fruit crop will be killed by late spring frosts.

For commercial purposes the use of most of these protective measures is precluded on account of expense. The commercial grower can not indulge in such expensive devices unless he has the assurance of obtaining a fancy price for his product. In a home fruit garden, however, it is different. The expense of protecting a half dozen plants is trifling, and many amateurs will incur it for the sake of the novelty of securing fruits naturally adapted to other climatic regions.

METHODS OF ADAPTING PLANTS TO CONDITIONS.

DWARFING AND GRAFTING.

In order to secure satisfactory results from a limited area devoted to fruit culture one must know the form of plant and method of pruning, training, and culture best suited to the space at command.

The fact that trees can be grown as *dwarfs* as well as *standards* will enable one to utilize a space which had previously been considered unsuited for the development of a tree. The cultivator's art has developed many devices which may be used to make plants conform to the conditions in a fruit garden.

Value of dwarf trees.—The modifications which plants undergo are sufficient to convince one of the great possibilities which await those who choose to make use of all the available methods to secure a large return from a limited area. It is well known that, in proportion to size, dwarf trees are more fruitful than standards; that they come into bearing sooner, and are therefore of special value for use in limited inclosures or fruit gardens.

Dwarfing is accomplished by budding or grafting robust growers on slow-growing stocks, and most tree fruits lend themselves to this treatment. While the dwarf pear is undoubtedly the most familiar example of a dwarf tree in the United States, there are stocks upon which apples, cherries, plums, and peaches can be grown with the same general result. Besides this method of modification, there are other methods quite as important to the owners of small areas. Standards may be grown as "bushes" or as "pyramids," thus making it possible to grow them much closer together. Pruning and training, used in combination, have shown the possibilities of restricting plants to the "espalier," "cordon," and other styles of training employed in growing fruits against walls. These methods not only allow plants to be grown more closely than is common in orchard practice, but they allow the grower to take advantage of locations and conditions under which trees could not develop normally. The side of a building may be utilized as a support to an apricot, nectarine, pear, or grape, the last named being the only one normally adapted to such a position.

FIG. 1.—Strawberries and currants between grapevines.

Varieties increased by grafting.—Besides the advantage of dwarfing, grafting may be turned to good account to enable the owner of few trees to increase his sorts beyond the limits of the trees he possesses. By grafting, the list of varieties can be increased at will. There are single trees known which bear as many as 150 varieties of apples. While a tree of this kind possesses little commercial value, it is of interest in proving what can be accomplished by grafting.

COMBINING PLANTS OF VARIOUS HABITS OF GROWTH.

Some combinations.—In addition to the advantages to be gained from restricting the growth of plants by training and dwarfing, some of the methods of training offer adaptations which allow of combining plants of various habits of growth, to the advantage of the grower and with little or no disadvantage to the plants. To illustrate this, currants may be combined with grapes, as shown at the left in fig. 1; apples with currants or raspberries, as in fig. 2; grapes and strawberries, as shown at the right in fig. 1.

The advantages of these methods become apparent at once when the object is the most economical utilization of a limited land area.

Besides the special adaptations afforded by dwarfed trees and by special combinations of low-growing and high-growing plants, certain well-known systems of pruning and training allow additional liberties to the skillful planter, as, for instance, the grapevine, which readily lends itself to arbor training, may be utilized for screening tender or shade-loving plants. The style of training the grape shown in fig. 3 is more desirable in many cases than a more perfect arbor. Strawberries adapt themselves readily to such situations if the shade is not allowed to become too dense. Among flowering plants none will thrive better under such conditions than pansies and violets, and among garden vegetables lettuce and radishes may be successfully grown under such a canopy, as they will be out of the way before a dense shade is formed by the grapes. Asparagus can be successfully grown under a shade of this character, as it will, because of its early habit, make a large share of its growth before the tardy grape will have produced a shade dense enough to interfere with the young, tender shoots.

FIG. 2.—Raspberries between apple trees.

Vines as a cover for walks and for shade.—The vine may be utilized as a cover for walks and drives or as a canopy over small outbuildings. A cozy summer veranda may be covered by grapevines, thus securing the double advantage of a cool, shady nook during summer and a supply of fruit in autumn. Fig. 4 shows a porch shaded in this way. In one garden a small ash house was made to support an Isabella vine, and this vine in 1891 produced 300 clusters of grapes. The small inclosure in which this vine grew, only 25 feet wide and 80 feet deep, also supplied foot room for 15 other grapevines, several dozen strawberry plants, a row of currants, and a limited supply of vegetables and annual flowers, besides a few square yards of beautiful

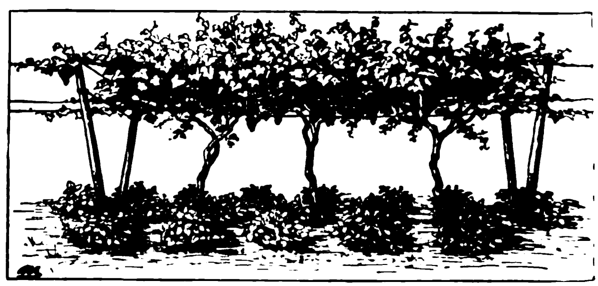


FIG. 3.—Strawberries under grapevines.

turf. The plan of this garden (fig. 5) shows the arrangement of the plants. The grapevines are trained to the high, tight, board fence which separates the lot from that of the next neighbor. The currants

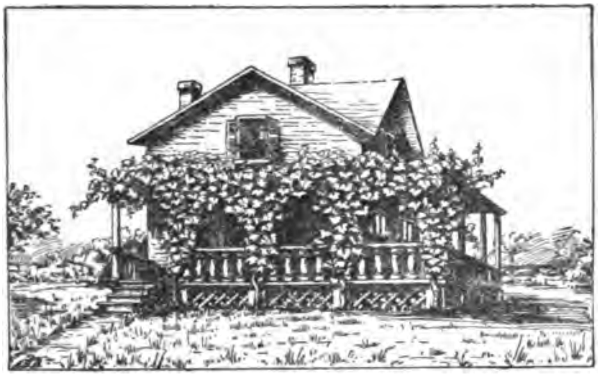
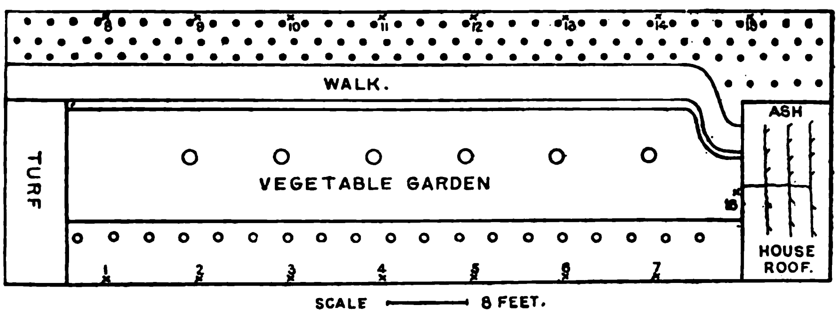


FIG. 4.—A vine-clad porch.

re planted near one side of the inclosure, while the main walk occupies a corresponding position on the opposite side. The area between he walk and fence on one side is given up to strawberries, while that



G. 5.—Plan of a back yard 25 by 80 feet in extent; ×, grapes; •, strawberries; o, currants, ◯, dwarf pears.

etween the walk and currant bushes on the opposite side forms the ower and vegetable plat.

COMBINED FRUIT AND VEGETABLE GARDEN.

Where there is more land at one's disposal there may be both a fruit arden and a vegetable garden. An area of 60 by 80 feet set apart as fruit garden will accommodate 442 fruit-bearing plants of the kinds esignated (p. 14), while an area of 40 by 80 feet will be sufficient for uite a variety of vegetable plants. On these areas, planned as shown fig. 6, fruit and vegetable plants may be grown as shown on the ext page.

FRUIT-BEARING PLANTS THAT CAN BE GROWN ON AN AREA OF 60 BY 80 FEET.

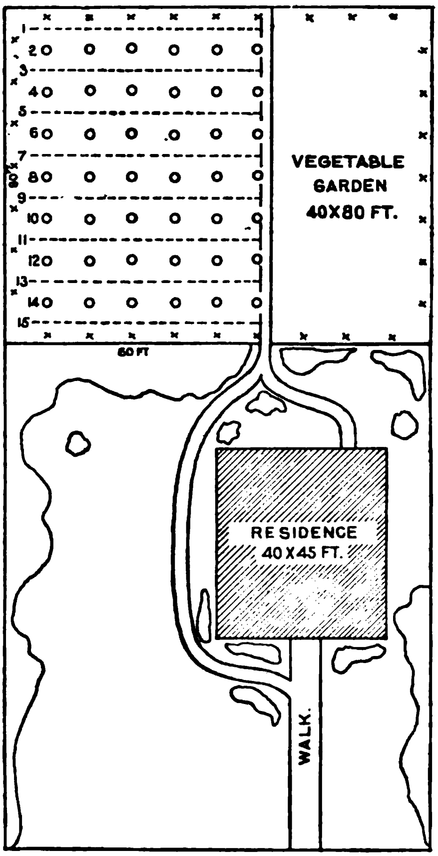
Thirty-two grapevines, dispersed at intervals of 10 feet around the entire gard·

Three rows, each containing 6 trees dwarf pears, 18 specimens in all (rows Nos. 10, 14).

One row, 6 specimens, peaches (row No. 4).

One row, 6 specimens, cherries (row No. 8).

One row, 6 specimens, dwarf apples (row No. 6).



SCALE. ⊢——⊣ 20 FEET.

FIG. 6.—Plan for a suburban place.

One row, 6 specimens, plums (row No. 12).

One row, 20 specimens, blackberries (row No. 1).

Two rows, 40 specimens, blackcaps (rows Nos. 3 and 5).

Two rows, 40 specimens, red raspberries (rows Nos. 7 and 9).

Three rows, 300 specimens, strawberries (rows Nos. 11, 13, and 15).

VEGETABLE PLANTS THAT CAN BE GROWN ON AN AREA OF 40 BY 80 FEET.

One row, ½ row rhubarb, ½ row asparagus (occupying 4 feet).

One row, salsify (1½ feet).

One row, parsnips (1½ feet).

Two rows, beets (3 feet).

One row, eggplant—plants set 18 inches apart—2 dozen (3 feet).

Two rows, tomatoes—plants set 2 feet apart—2 dozen (6 feet).

One row, summer squash, 12 hills feet apart (3 feet).

Two rows, cucumber, 24 hills, 3 feet apart (1 foot).

Two rows, early cabbage, 4 dozen plants, set 18 inches apart (4 feet).

Two rows, late cabbage, 4 dozen plants, set 18 inches apart (4 feet).

One row, early celery, 6 dozen plants set 6 inches apart (2 feet).

Eight rows, peas, plant in double rows, 4 inches apart; follow by 6 rows late celery, 36 dozen plants (16 feet).

Two rows, lima beans, 4 dozen hills, 18 inches apart (4 feet).

Six rows, bunch beans; in succession sow seeds in drills, placing seeds about inches apart in the row; follow by late cabbage, turnips, or spinach (12 feet).

Two rows, radishes, 4 sowings, planted in double rows 6 inches apart (3 feet).

Two rows, lettuce, two sorts, adapted for early and late use (3 feet).

One row, parsley and peppergrass (1½ feet).

The space occupied by the last three plants may be given over to winter squashes by planting these before other crops are off the ground.

As before mentioned, the general plan will serve as a guide to planting in any portion of the United States, but the sorts chosen must be suited to that particular section of the country in which the work is to be executed.

As will be seen by fig. 6, this garden is planned to utilize the space to the best possible advantage. In order to secure large returns, the soil must be kept cultivated and well enriched; walks, if any are to be maintained as permanent features, should only exist where necessary for ease and comfort in getting about. A permanent walk should divide the fruit garden from the vegetable garden. This is best made of gravel or some other loose material, which will preserve a dry passageway without preventing the rain from penetrating the soil beneath it, as the fruit trees which stand beside it will need the moisture which it gathers. On account of the small area occupied and the close planting necessary to secure the result desired, the culture of such a garden must of necessity be done by hand. If the grapevines are trained on the high renewal system, they will serve both as a screen for the rest of the garden and as a source of fruit supply. A good wire fence should, however, be constructed on the line between adjoining properties, and the grape border planted not farther than 2 feet from the boundary fence.

ALLOTMENT OF FRUITS FOR GARDENS OF DIFFERENT SIZES.

The following lists of varieties, while made for northern Ohio, are presented more as a guide to the proportionate allotment of plants of various species in a home fruit garden than as a guide to varieties suited to such a garden. As has already been pointed out, the selection of sorts for a fruit garden is a local as well as personal matter. Varieties give their best products only in certain more or less restricted areas, so the list of fruits in one section will naturally differ widely from those in another. Then, too, the personal likes of the planter will modify the list in each garden, even though the conditions be such as to admit of a duplicate set in each.

VARIETIES OF FRUITS FOR HOME GARDENS OF DIFFERENT AREAS.

FRUIT GARDEN NO. 1 (ABOUT 2 ACRES).

APPLES (22 TREES).—*Summer:* Two Early Harvest, 2 Red Astrachan, 1 Golden Sweet, 1 Pumpkin Sweet, 1 Maiden Blush. *Winter:* Two Grimes Golden, 2 Baldwin, 2 Rhode Island Greening, 2 Belmont (White Pippin), 1 Fallawater, 1 Fameuse (Snow Apple), 1 Tolman Sweet, 1 Roxbury Russet. *Crab:* One Hyslop, 1 Transcendent, 1 Yellow Siberian.

PEACHES (25 TREES).—*Early:* Four Yellow Rareripe, 4 Early Crawford, 4 Elberta, 2 Alexander, 2 Canada Early, 1 Lewis. *Late:* Four Late Crawford, 2 Stephens Rareripe, 2 Golden Drop.

PEARS (10 TREES).—Four Bartlett, 2 Koonce, 2 Duchess, 1 Kieffer, 1 Seckel.

CHERRIES (10 TREES).—Four Allen, 2 Black Tartarian, 4 Early Richmond.

PLUMS (10 TREES).—Two Green Gage, 2 French Damson, 2 Lombard, 2 Mar.. 2 Willard.

QUINCES.—Fifteen Champion.

APRICOTS.—Five Montezumet.

NECTARINES.—Five Boston.

GRAPES (100 VINES).—Twenty-five Concord, 25 Campbell's Early, 25 Niagara, 25 Brighton.

RASPBERRIES (150 BUSHES).—Fifty Gregg, 25 Marlboro, 50 Cuthbert, 25 Golden Queen.

BLACKBERRIES (100 BUSHES).—Fifty Agawam, 50 Taylor.

CURRANTS (100 BUSHES).—Fifty Victoria, 25 White Grape, 25 Black Champion.

GOOSEBERRIES (75 BUSHES).—Twenty-five Downing, 25 Industry, 25 Columbus.

STRAWBERRIES (400 PLANTS).—One hundred Brandywine, 100 Glen Mary, 100 Warfield, 100 Gandy.

FRUIT GARDEN NO. 2 (FOR MEDIUM-SIZE PLACE).

APPLES (10 TREES).—Two Baldwin, 2 Grimes Golden, 1 Fallawater, 2 Red Astrachan, 1 Bonum, 1 Bough Sweet. *Crab:* One Transcendent.

PEACHES (10 TREES).—One Alexander, 2 Rareripe (Yellow), 2 Early Crawford, 4 Late Crawford, 1 Stephens Rareripe.

CHERRIES (5 TREES).—Two Early Richmond, 2 Black Tartarian, 1 Allen.

PLUMS (5 TREES).—Two Green Gage, 2 Lombard, 1 Willard.

PEARS (5 TREES).—Two Bartlett, 1 Duchess, 1 Kieffer, 1 Seckel.

QUINCES.—Five Champion.

APRICOTS.—Two Montezumet.

NECTARINES.—Two Boston.

GRAPES (50 VINES).—Twenty-five Concord, 10 Niagara, 15 Brighton.

RASPBERRIES (70 BUSHES).—Twenty-five Gregg, 10 Marlboro, 25 Cuthbert, 10 Golden Queen.

BLACKBERRIES (50 BUSHES).—Twenty-five Agawam, 25 Taylor.

CURRANTS (45 BUSHES).—Twenty-five Wilder, 10 White Grape, 10 Black Champion.

GOOSEBERRIES (30 BUSHES).—Ten Downing, 10 Industry, 10 Columbus.

STRAWBERRIES (200 PLANTS).—One hundred Brandywine, 100 Gandy.

FRUIT GARDEN NO. 3 (FOR CITY LOT).

APPLES (4 TREES).—One Red Astrachan, 1 Golden Sweet, 1 Baldwin, 1 Fallawater.

PEACHES (4 TREES).—One Early Canada, 1 Yellow Rareripe, 1 Early Crawford, 1 Late Crawford.

PEARS (2 TREES).—One Bartlett, 1 Duchess (Dwarf).

PLUMS (2 TREES).—One Wilder, 1 Lombard.

QUINCES.—Two Champion.

APRICOTS.—One Montezumet.

GRAPES (10 VINES).—Five Concord, 5 Niagara.

RASPBERRIES (20 BUSHES).—Ten Gregg, 10 Cuthbert.

BLACKBERRIES (20 BUSHES).—Ten Taylor, 10 Agawam.

CURRANTS (10 BUSHES).—Five Victoria, 5 White Grape.

GOOSEBERRIES.—Five Downing.

STRAWBERRIES.—Fifty Brandywine.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 155.

How Insects Affect Health in Rural Districts.

BY

L. O. HOWARD,
Entomologist and Chief, Bureau of Entomology.

(Revised Edition.)

WASHINGTON:
MENT PRINTING OFFICE.
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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., April 7, 1908.

SIR: I have the honor to transmit herewith a revision of Farmers' Bulletin No. 155, entitled "How Insects Affect Health in Rural Districts," and recommend its republication in the present form. The article was originally prepared by me for the Yearbook for 1901, in which it appears under a different title, but in view of the very general interest in the subject it has seemed desirable to republish the matter for wide distribution to farmers, to whom the information contained in the article is especially pertinent.

Respectfully,

L. O. HOWARD,
Entomologist and Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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OW INSECTS AFFECT HEALTH IN RURAL DISTRICTS.

INTRODUCTION.

In very many parts of the country the farming population has to ontend with at least two diseases which are preventable. These are alaria and typhoid fever. Both of these diseases are transferred r may be transferred by insects—malaria by certain mosquitoes and yphoid fever by the common house fly, or certain other flies.

CITY AND COUNTRY CONDITIONS COMPARED.

While it is true that both malaria and typhoid prevail in large cities, it is none the less true that they may with a certain degree of accuracy be termed country diseases, that is to say, rather specifically, diseases of the farm and the small village. Malaria, in fact, has been called by medical men a country disease. Swampy regions do not occur in cities, or, at all events, only in the suburbs, whereas they occur commonly in the country. Open streams with side pools of still water are found only in the country, and it is in such small, still pools, and in more or less permanent but small accumulations of water, that the malarial mosquito breeds. This mosquito, therefore, does not accommodate itself well to city conditions, but it is found almost everywhere in the country, except possibly in very dry localities and at certain high elevations. Even in dry regions it sometimes abounds, especially where there is a definite rainy season, or where the land is irrigated. Irrigating ditches are prolific breeding places for mosquitoes, including the malarial kind. Malaria in cities, as a rule, is found only with persons who have contracted it in the country or in the suburbs, although with some cities having marshy places on their borders a malarial belt may exist, the extent of which depends upon the direction and force of the prevailing summer breezes, especially the night breezes. For example, such a condition as this accounts for the prevalence of malaria in certain portions of the city of Washington before the reclamation of the Potomac Flats, which lie to the south of the city, the prevailing night breezes of the summer being southern.

SOURCES OF TYPHOID FEVER.

Cities well supplied with water from a reservoir, especially a filter reservoir, which possess a modern sewage system, and in which water-closets are universal, derive typhoid fever only from the following sources: Country milk contaminated through vessels washed in water infected with typhoid germs, the return of people in the autumn from the less sanitary country, and lack of care in the disposal of the discharges of persons who have contracted typhoid from either of the first two sources.

In the country, however, conditions are different. Each country house or each house in a small village has its own water supply, usually in the shape of a well; there are few water-closets, and excreta are deposited in the open or in box privies; drainage from these box privies or from the open deposits containing virulent typhoid germs may enter the streams, or the germs may be carried by underground drainage directly into the wells from which drinking water is gained; or, exposed as these box privies or open deposits usually are, certain flies may alight upon the excrement and carry the germs directly to the food supply of the houses; or certain flies may breed in this excrement and fly, fairly reeking with disease-bearing filth, to the kitchens and tables of nearby houses. When we consider that active typhoid germs may be given out for some time by persons who have not developed typhoid fever sufficiently so that it may be recognized, and that they may also be given out for some time after patients have been apparently cured of the disease, it is perfectly obvious that in the country the lack of care with which excreta are deposited readily accounts for outbreaks of typhoid fever from any of the causes mentioned.

METHODS OF PROTECTION FROM TYPHOID AND MALARIA.

Of course it will be said that the entire water supply of a city may become contaminated at or immediately above its reservoir supply. This contamination is from country sources and might be obviated either in a general manner by the establishment of a reservoir filtering plant, or in a special manner by individual householders by the constant and thorough use of house filters. In cities possessing a common water supply and modern sanitary plumbing there is no excuse for the presence of typhoid in the household. Even the city water must be filtered, which can be done by the use of any one of the cheap filters now on the market; the milk which is drunk by children must be sterilized, and the excreta of persons returning to the city after contracting typhoid fever in the country, must be disinfected with the utmost care. These three measures, systematically followed will result in the abolition of typhoid fever within the city boundaries.

So much for cities. In the country the matter is somewhat more difficult, and immunity from malaria and typhoid depends largely upon the individual householder. Such immunity may be obtained, but only as a result of intelligent care.

Let us briefly consider what the farmer or the resident of a small village must do to bring about protection.

MALARIA.

The old idea that malaria is caused by breathing the miasma of swamps has been exploded. Malaria is contracted only through the bites of mosquitoes of the genus Anopheles. The cause of human malaria is the growth and development within the red blood cells of a very minute parasitic organism belonging to the lowest group of the animal kingdom—the group Protozoa, or one-celled animals, which includes those minute creatures known as Amœbas and others, and which live in the water or in damp sands or moss, or inside the bodies of other animals as parasites. This parasite reproduces in the body by subdividing, eventually bursting the red blood cells and entering the blood serum as a mass of spores. Broadly speaking, when the blood of a human being is sucked into the stomach of a mosquito of the genus Anopheles the malarial parasite undergoes a sexual development and gives birth to a large number of minute, spindle-shaped cells, known as blasts, which enter the salivary glands of the insect and are ejected with the poison into the system of the next person bitten by the mosquito. If this person happens to be nonmalarious the malaria has thus entered his system and malarial symptoms result.

So far as present knowledge goes this is the only way in which people become malarious. In order to avoid this result it is necessary to avoid the bites of malarial mosquitoes, and it therefore becomes important to know the differences between the malarial and the more harmless mosquitoes, and the conditions under which the malarial forms breed.

Malaria-bearing mosquitoes.—There are very many mosquitoes which have not yet been proven to carry any disease. In fact, the majority of mosquitoes are supposed to be harmless except for the irritation caused by their punctures. The commonest of all forms belong to the genus Culex. These include the mosquitoes most commonly breeding in rain-water barrels and chance transient pools. Fig. 1 shows the difference between a harmless mosquito of the genus Culex and the malarious mosquito of the genus Anopheles. It will be noticed that Culex has clear wings, while Anopheles has wings which are more or less spotted. It will be noticed further that while the palpi (which are the projections either side of the beak) are very short in Culex, they are long—nearly as long as the beak—in Anopheles. Further,

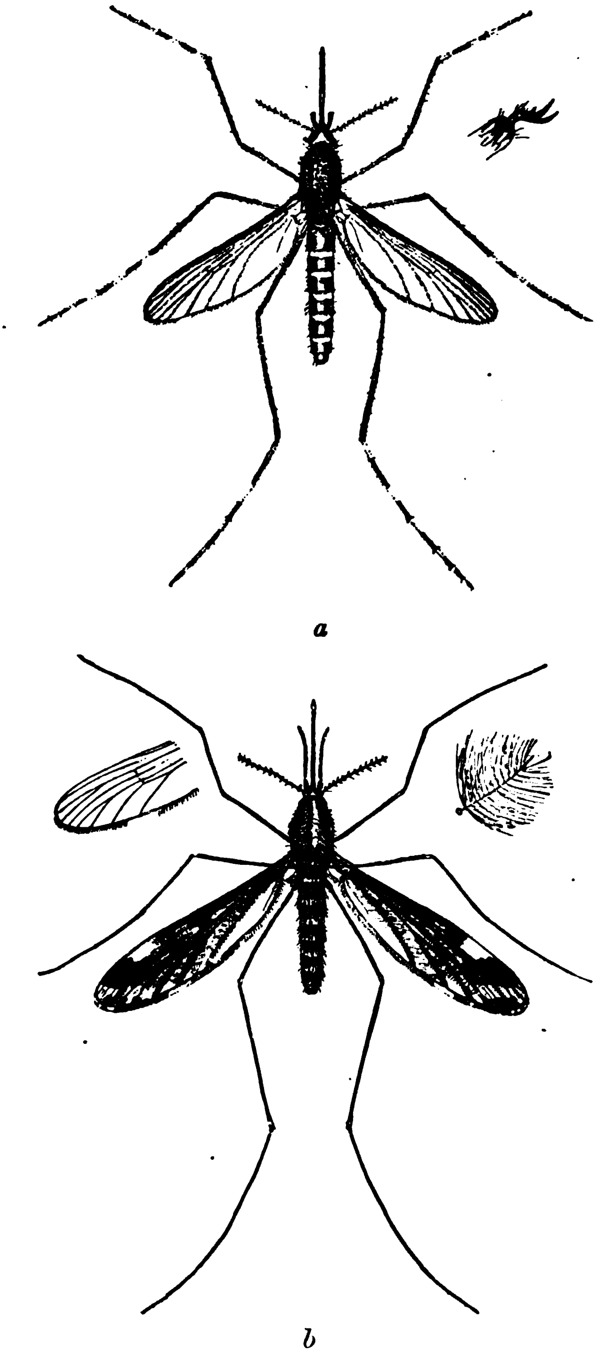

FIG. 1.—Adults of Culex and Anopheles: *a*, *Culex sollicitans*; *b*, *Anopheles punctipennis*. Enlarged (author's illustration).

it has been observed that when Culex is resting upon a wall it appears more or less humpbacked, that is to say, the head and the beak are not in the same plane with the body and wings, but project at an angle toward the surface of the wall, the body and wings being parallel with the wall. With Anopheles, however, the head and beak are in practically the same plane with the body, and the body itself is usually placed at an angle with the wall, and especially when resting upon a horizontal wall, such as the ceiling of a room, the body of Anopheles is at a very great angle with the surface. We have in this country three species of the malarial genus Anopheles, namely, *Anopheles maculipennis* (illustrated in fig. 2), *Anopheles punctipennis* (shown in fig. 1, *b*), and *Ano-*

pheles crucians (shown in fig. 3). The former two are found nearly all over the country, but the last is a more Southern species, although it has been found as far north as the south shore of Long Island.

As to the early stages, the eggs of Anopheles may be at once distinguished from the eggs of Culex by figs. 4 and 5, those of Culex being laid in the raft-shaped mass on end and those of Anopheles being laid singly upon the surface of the water, always lying upon their sides. The larvæ of Culex, commonly known as wigglers, are

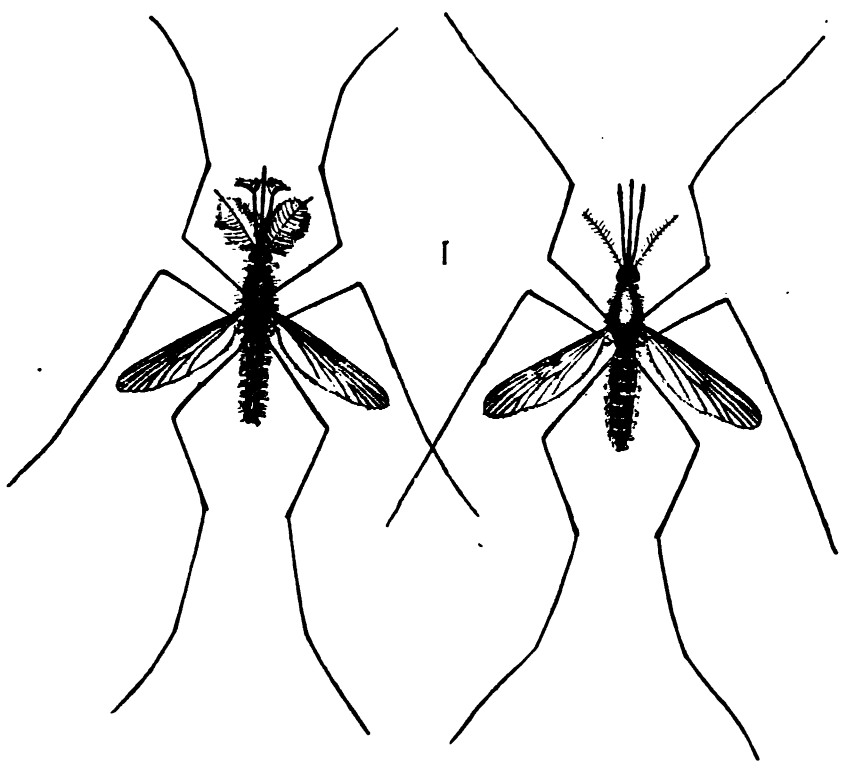

FIG. 2.—*Anopheles maculipennis:* Male at left; female at right. Enlarged (author's illustration).

familiar to almost everyone, and are the common wigglers found in horse troughs and rain-water barrels, which wriggle around in the water, returning at frequent intervals to the surface to breathe, and when at the surface hanging with simply the tip of the tail extruding, the rest of the body being held below the surface at a great angle. What we have called the "tail" is simply the breathing tube, which, with the common Culex wigglers, is long and more or less pointed. With the malarial mosquitoes, however, the wiggler, or larva, is of somewhat different shape, as shown in figs. 6 and 7, and when resting at the surface, which it does most of the time, it lies with its body parallel with the surface, and not hanging down, as does the Culex wiggler. The pupæ of both forms are shown in fig. 8, and need not be described.

Breeding places of malaria-bearing mosquitoes.—The breeding places of the harmless mosquitoes are more numerous and more varied than the breeding places of the malarial mosquitoes. Anopheles, however, are found under many diverse conditions. They are found, as stated, in still side pools of small streams, in the swampy pools at the margins

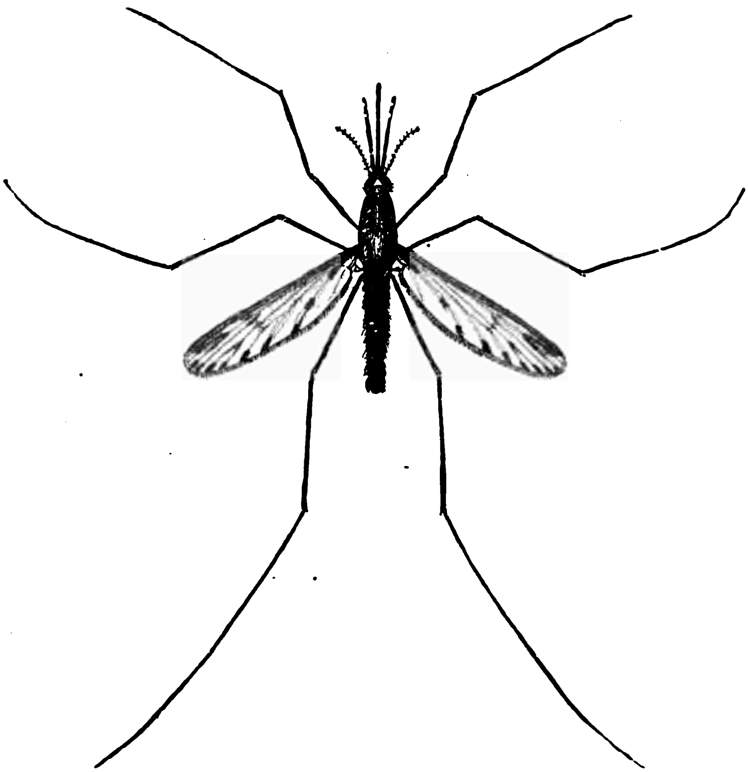

FIG. 3.—*Anopheles crucians*. Enlarged (author's illustration).

of larger ponds, in stagnant water in ditches, in the beds of old canals, in the still water at the sides of springs, and occasionally, though rarely, in old horse troughs. They are perhaps more frequently found in such situations as described when a certain amount of green scum has accumulated, and it is upon the spores of the water plants constituting this green scum, as well as upon other very small objects floating on the surface of the water, that they principally feed.

Measures to be taken to prevent malaria.—To prevent malarial mosquitoes from breeding in a given vicinity, one should be prepared to recognize their larvæ when they are seen, and to distinguish them from other mosquito larvæ; then a most thorough search for all possible breeding places should be made within a radius of a mile. This distance is mentioned, since it seems rather definitely proven that the Anopheles mosquitoes do not fly for great distances. After the breeding places are found they should be drained or filled in with earth, or they should be rendered uninhabitable to the Anopheles larvæ by covering the surface of the water with a thin film of kerosene oil, or by introducing certain fish which feed upon the larvæ, such as top minnows, sticklebacks, young sunfish, or goldfish.

FIG. 4.—Eggs of Anopheles. Enlarged (author's illustration).

Pending the result of such exterminating measures, all houses in malarious localities should be carefully screened to prevent the entrance of mosquitoes. After screening, thorough search should be made in the house for mosquitoes which have already gained entrance. Such as are found roosting upon the walls should be captured by placing an inverted vial over them, or they may be stupefied by burning a small amount of pyrethrum powder upon a tin dish cover. Persons wishing to avoid malaria should not sit out of doors the bites of mosquitoes at night. Persons having malaria should be carefully screened at night to prevent them from being bitten by mosquitoes, which, becoming thus infected, would become potential carriers of the disease. Such patients, systematically treated with quinine, the dose being always given at the beginning of the chill, will soon be rid of the disease. The time of the dose is important, and the reasons for the time have been abundantly proven by the study of the life of the parasite in the blood cells.

All of this advice is given only after abundant demonstration of the efficacy of the methods. These measures have been followed with success in the most malarious localities in the world, and with this knowledge there is no good reason why an individual should contract

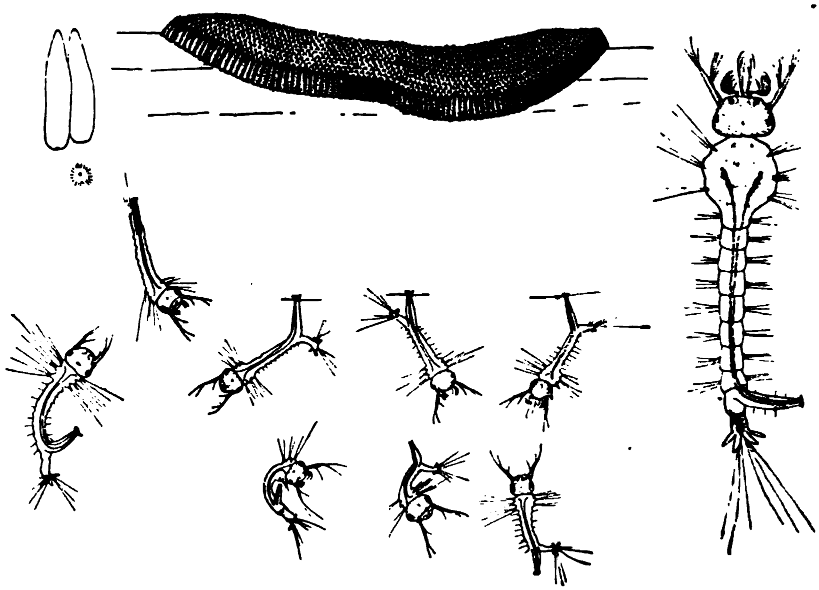

FIG. 5.—Eggs and larvæ of Culex. Enlarged (author's illustration).

malaria in his own home, no matter how much malaria exists around him.

Of course, however, there may be occasions where it is almost impossible to avoid contracting the disease. For example, the writer was once waiting for a night train one evening in a small Western town where there were irrigating ditches near the station. In these ditches malarial mosquitoes were breeding profusely, and the insects abounded in the station waiting room and on the platform. Nothing but a gauze covering would have kept them away, and several bites were inflicted on the hands and neck. Fortunately, none of the individuals could have bitten a malarial patient, as the disease was not transmitted.

TYPHOID FEVER.

It is not the writer's intention to go further into the causation of this disease than he has already done in his introductory remarks. He wishes, however, to point out as forcibly as possible the danger of its spread by insects and the methods of avoiding this danger.

House flies and breeding places:—The principal insect agent in this spread is the common house fly (fig. 9), and this insect is especially abundant in country houses in the vicinity of stables in which horses are kept. The reason for this is that the preferred food of the larvæ of house flies is horse manure. House flies breed in incredible numbers in a manure pile largely derived from horses. Twelve hundred house flies, and perhaps more, will issue from a pound of horse manure. Ten days completes a generation of house flies in the summer. The number of eggs laid by each female fly averages 120. Thus, under favorable conditions, the offspring of a single over-wintering house fly may in the course of a summer reach a figure almost beyond belief. With an uncared-for pile of horse manure in the vicinity of a house, therefore, flies are sure to swarm. Their number practically will be limited only by breeding opportunities. They are attracted to, and will lay their eggs in, human excrement. Under favorable conditions they will breed, to some extent, in this excrement. They swarm in kitchens and dining rooms where food supplies are exposed. They are found commonly in box privies, which sometimes are not distant from the kitchens and dining rooms. Therefore, with an abundance of flies, with a box privy near by, or with excremental deposits in the neighborhood, and with a perhaps unsuspected or not yet fully developed case of typhoid in the immediate neighborhood, there is no reason why, through the agency of contaminated flies lighting upon food supplies the disease should not be spread to healthy individuals. That it is so spread is not to be questioned. That under the unusual conditions of the army concentration camps

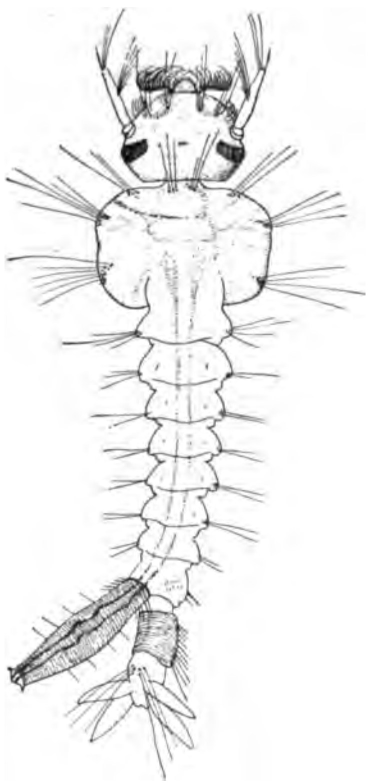

FIG. 6.—Full-grown larva of Culex. Enlarged (author's illustration).

in the summer of 1898 it was so spread to a shocking extent has been demonstrated by the army typhoid fever commission. And the remedy is plain. It consists of two courses of procedure: (1) Proper care of excreta; (2) the destruction of flies.

Measures to be taken to prevent typhoid fever.—On many farms where intelligent people live the old-fashioned box privy has been done away with, and there has been substituted for it some form of earth closet. Where a good earth closet is in operation, and the inhabitants of a farm appreciate the importance of using no other, and where in case of illness the excreta of patients are promptly disinfected, flies breeding in the neighborhood will have practically no opportunity to become contaminated with typhoid germs, except in the unlikely event (which future investigation may possibly show) that other animals than man are subject to this disease. The proper maintenance of an earth closet will add somewhat to the work of a farm, but this extra work will pay in the long run. While it is true that a box inclosure if its contents are covered with lime every three or four days, will answer the purpose, a much better plan would be to use a large metal vessel, the surface of the contents being covered with earth after each operation, and which may be removed, emptied, and replaced daily. Care should, of course, be taken to empty the contents of the vessel in a pit constructed in some well chosen spot, from which the drainage would not be dangerous.

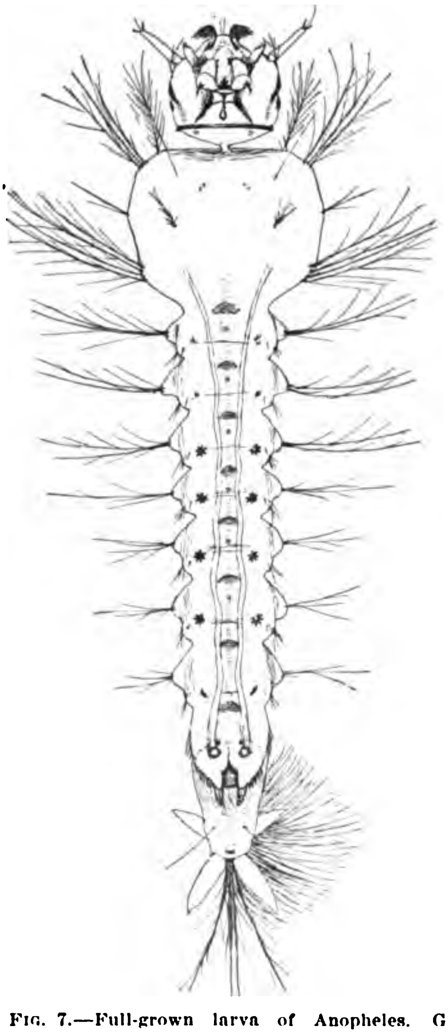

FIG. 7.—Full-grown larva of Anopheles. Greatly enlarged (author's illustration).

With regard to the abolition of flies, the best measures will again naturally involve some trouble and expense. In a thickly settled country it will become necessary for some such measure to be generally adopted in order to be perfectly effective, but in an isolated farm-

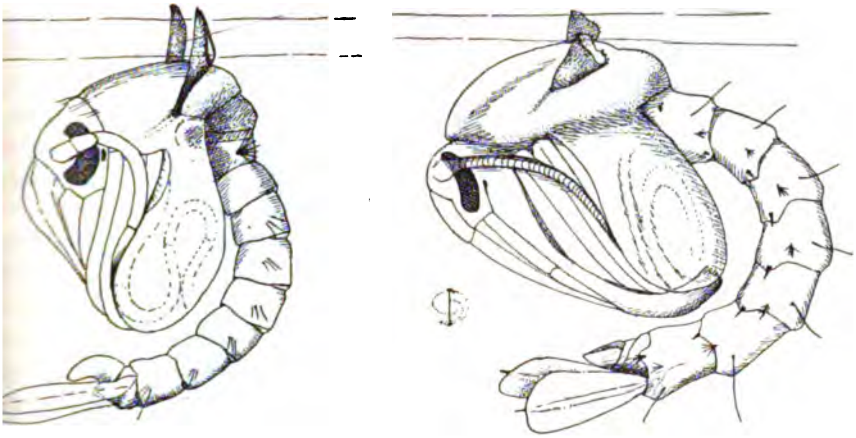

FIG. 8.—Pupa of Culex (at left) and Anopheles (at right). Greatly enlarged (author's illustration).

house the number of house flies may be greatly reduced by individual work. All horse manure accumulating in stables or barns should be collected, if not daily, at least once a week, and should be placed in either a pit or vault or in a screened inclosure like a closet at the side or end of the stable. This closet should have an outside door from

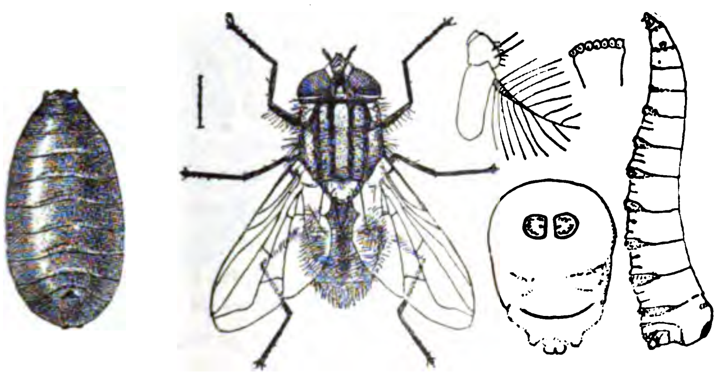

FIG. 9.—Common house fly (*Musca domestica*): Puparium at left; adult next; larva and enlarged parts at right. Enlarged (author's illustration).

which horse manure can be shoveled when it is needed for manuring purposes. Each day's or each week's accumulations, after they are shoveled into the closet or pit, should be sprinkled over the surface with chloride of lime, and a barrel of this substance can conveniently be kept in the closet. If this plan be adopted (and these recommendations are the result of practical experience), house flies will have almost no chance to breed, and their numbers will be so greatly reduced that they will hardly be noticeable. Many experiments have been made in the treatment of manure piles in order to kill the maggots of the house fly, and the chloride-of-lime treatment has been found to be the cheapest and most efficacious.

It has been stated above that the closet for the reception of manure should be made tight to prevent the entrance or exit of flies. A window fitted with a wire screen is not desirable, since the corroding chloride fumes will ruin a wire screen in a few days.

Fruit flies.—While extended investigations have shown that the common house fly is the fly most to be feared in guarding against typhoid, on account of the fact that over 99 per cent of the flies found

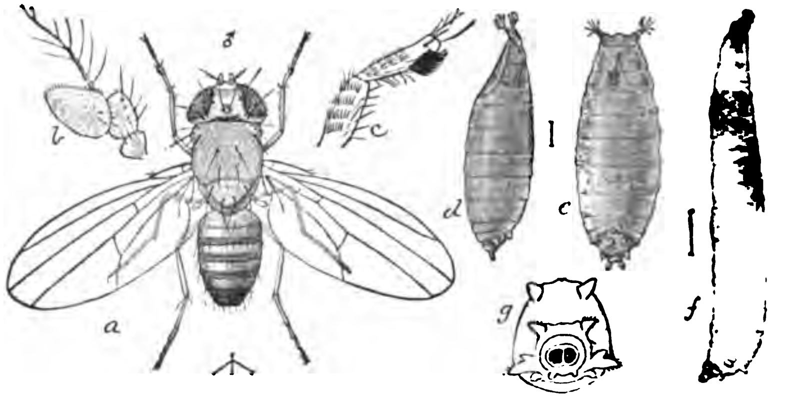

FIG. 10.—*Drosophila ampelophila*: *a*, Adult; *b*, antenna of same; *c*, base of tibia and first tarsal joint of same; *d*, puparium, side view; *e*, puparium from above; *f*, full-grown larva; *g*, anal spiracles of same. Enlarged (author's illustration).

in kitchens and dining rooms and attracted to food supplies are house flies, there are a few others which are attracted to and which may breed in human excrement that also have to be guarded against, and as these do not breed in horse manure the treatment just described will not be effective against them. The care of human excrement, however, will prevent the carriage of typhoid germs even by these species. The little fruit flies of the genus Drosophila (fig. 10), which breed in overripe or decaying fruit, are the principal species in this category. Therefore, fruit storehouses or fruit receptacles should be screened, and overripe fruit should not be allowed to remain in dining rooms or kitchens for any length of time.

OTHER DISEASES CARRIED BY INSECTS.

While in malaria and typhoid we have the two principal diseases common to the United States which may be conveyed by insects, t[illegible]

untries a disease known as
is, which somewhat resem-
ertain forms of leprosy, is
erred among human beings
tain mosquitoes. There is
reason to suppose that the
of the bubonic plague may
nsferred from sick people to
y people by the bites of fleas

FIG. 11.—Cat and dog flea. Enlarged (original).

l). The so-called Texas fever of cattle is unquestionably trans-
by the common cattle tick (fig. 12), and this was the earliest of
arly demonstrated cases of the transfer of disease by insects. In
a similar disease of cattle is transferred by the bite of the
biting fly known as the tsetse fly (fig. 13) and the so-called

made. Even the common bedbug (fig. 15) is strongly suspected in this connection.

YELLOW FEVER.

One of the most important of these disease-transfer relations of insects which has been demonstrated is the carriage of yellow fever by certain mosquitoes. The cause of yellow fever has always been a mystery, and indeed it is a mystery to-day in a measure, since, although undoubtedly a disease of parasitic origin, the parasitic organism itself has not yet been discovered. During the summer and autumn of 1900 and spring and summer of 1901 the work of a commission of surgeons of the United States Army demonstrated in Cuba beyond the slightest possible doubt that yellow fever is not conveyed by infected clothing of yellow-fever patients or by contact

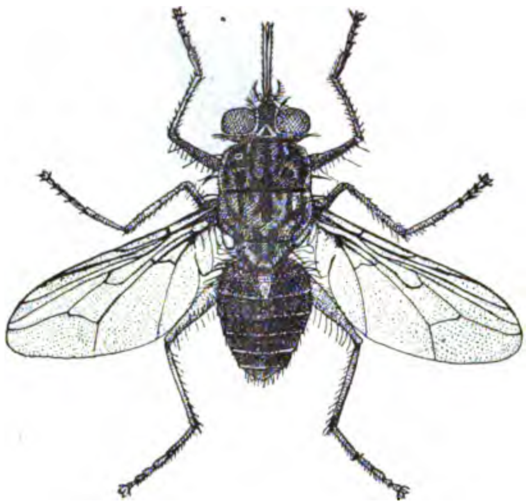

FIG. 13.—Tsetse fly. Enlarged (original).

FIG. 14.—Black gadfly. Enlarged (original).

FIG. 15.—Bedbug. Enlarged (after Marlatt).

with such patients or by proximity to them, but that it is conveyed by the bite of a certain species of mosquito known as *Stegomyia* *calopus* (fig. 16), which abounds in regions where yellow fever is possible. The bite of this mosquito, however, does not convey yellow fever to a healthy person until twelve days have elapsed from the time when the same mosquito has bitten a person suffering with the disease. It follows from this fact that by keeping yellow-fever patients screened from the possibilities of mosquito bites we can prevent the yellow-fever mosquito from becoming infected. It follows further that by preventing healthy people from being bitten by mosquitoes we can keep them free from the disease even where infected mosquitoes exist. And it follows still further that by the adoption of remedial measures looking toward the destruction in all stages of the yellow-fever mosquito we may reduce to a minimum the possibilities of the transfer of the disease. After demonstrating the fact, the medical officers of the Army in Cuba put these measures into effect, and the results were most gratifying. The health of Havana immediately improved, and the general health of Cuba and the industrial conditions dependent upon better sanitation have continually gained since.

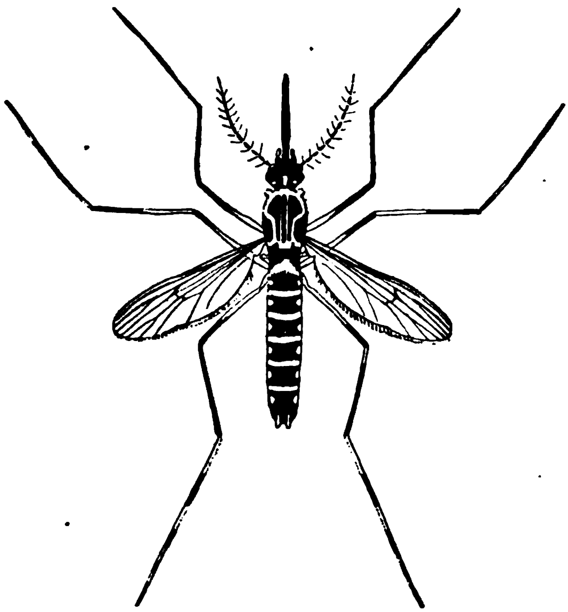

FIG. 16.—*Stegomyia calopus.* Enlarged (author's illustration).

The New Orleans outbreak of yellow fever in the summer of 1905 was quickly stopped by antimosquito measures, and it is conceded that more than 4,000 lives were saved in that city during that season by the intelligent application of measures based upon the discovery of the United States Army surgeons in Cuba in 1900 and 1901.

O

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 157.

E PROPAGATION OF PLANTS.

BY

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HORTICULTURIST, BUREAU OF PLANT INDUSTRY.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1902.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Washington, D. C., July 15, 1902.

Sir: I have the honor to submit a paper on the Propagation of Plants, prepared by L. C. Corbett, Horticulturist of this Bureau, and to recommend its publication as a Farmers' Bulletin. This paper is a revision and enlargement of a paper on Nursery Hints, prepared by the same writer while horticulturist of the West Virginia Experiment Station, and published as a bulletin of that station.

The treatment of the subject is brief, simple, and practical, rather than complete and technical. It is believed that its publication as a Farmers' Bulletin will tend to assist and encourage farmers in the propagation of plants for their own use, especially small fruits, grapes, and orchard fruits.

Very respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE PROPAGATION OF PLANTS.

INTRODUCTION.

The propagation of plants is their reproduction by natural or rtificial means. A knowledge of these means is of great importance to agriculturists of all classes, and especially to those engaged in the various branches of horticulture. There are, for instance, so nany benefits to be gained by the local production of nursery stock hat fruit growers of a developing region can not afford to neglect his art. The introduction of dangerous pests can be avoided, scions nd buds from trees thoroughly acclimated can be obtained, the oung stock will not be forced to suffer the shock of long transportaion and a change of climate, and last, and by no means least, the rchardist can have his trees grown from scions or buds from his avorite trees.

MEANS BY WHICH PLANTS ARE REPRODUCED.

The means by which plants in nature reproduce their kind are eeds, spores, rootstocks, stolons, suckers or root sprouts, bulbs, orms, and tubers.

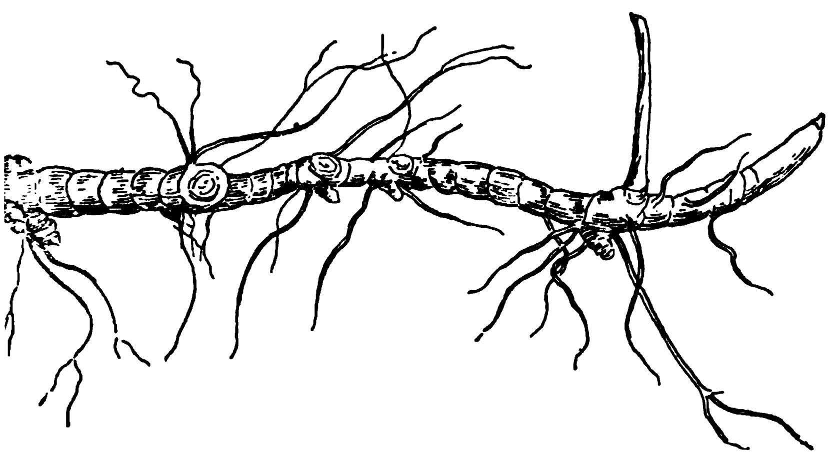


FIG. 1.—A rootstock.

By these means nature has provided for the perpetuation of species, r the continuance of general types. But man endeavors to reproce the peculiar desirable qualities found in a single individual, and multiply the number of individuals possessing these qualities. erefore, in addition to using the natural means of reproduction, man has developed several artificial means of reproducing plants, of which the principal are cuttings, layering, grafting, and budding.

Rootstocks.—Many species of plants, including a number of common grasses, spread by means of vigorous, fleshy rootstocks (fig. 1), which push out laterally in all directions from the parent plant, developing

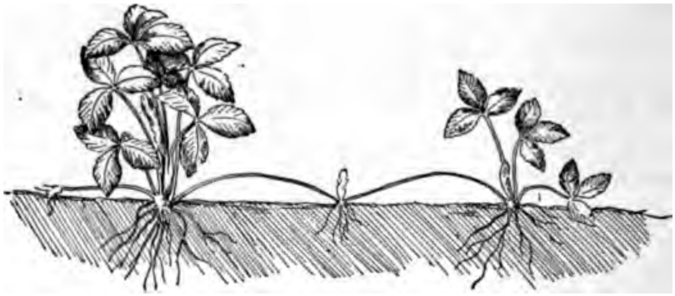


FIG. 2.—Reproduction by means of stolons.

rootlets and throwing up the stems of new plants at intervals. Johnson grass and Bermuda grass are excellent examples of plants which spread in this manner.

Stolons.—Some plants throw out trailing branches or runners which take root at their ends or at joints, thus producing new plants (fig. 2). The strawberry is an excellent example of this class. Black raspberries reproduce in a very similar way, as the tips of the drooping canes readily take root when they touch the ground.

FIG. 3.—A bulb.

Suckers and root sprouts.—Many plants reproduce by means of suckers and sprouts sent up from lateral roots.

Nursery practices are greatly facilitated by this natural tendency in plants which reproduce their kind true to variety, as do the red raspberry and blackberry and some plums.

In general, seedlings and all plants that have been grown from cuttings will come true from root sprouts if they reproduce in that way. Outside the bush fruits, however, this method of reproduction should be discouraged rather than encouraged. Nothing is more annoying to the orchardist and fruit grower than the persistent sprouting of some plants.

Bulbs and corms.—A bulb (fig. 3) is a short rudimentary axis encased in more or less close-fitting fleshy leaves or bulb scales, in which is stored up nutriment to be used in subsequent growth. It is, in fact a more or less permanent and compact leaf bud throwing out roots from its lower portion. Bulbs usually form at or just beneath the surface of the ground. They may be divided into two general classes,

(1) those composed of scales which are more or less narrow and loose, as in the lily, and (2) those composed of more or less continuous and close-fitting layers or plates, as in the onion. Bulbs often divide naturally into two or more parts, or may be so divided artificially, each of which parts serves the purpose of a complete bulb in propagation. Small bulbs or *bulbels*, sometimes called "daughter" bulbs, develop around the large or "mother" bulb, and are used in propagation. Bulbs are often caused to produce these bulbels artificially by wounding or mutilating them. A *bulblet* is a small bulb borne entirely above ground in the axil of a leaf or at the top of a stem, as in case of the "sets" of the onion.

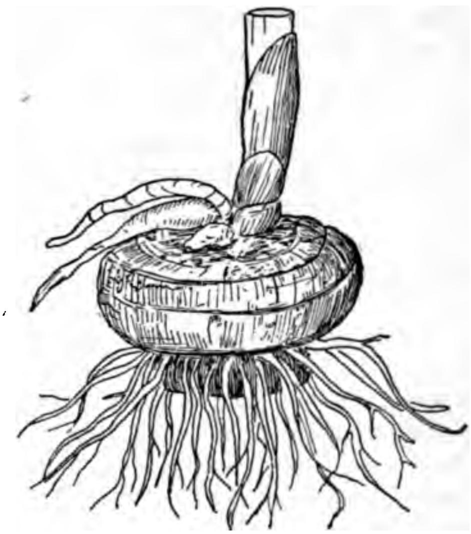


FIG. 4.—A corm.

A *corm* resembles a bulb in appearance (fig. 4), but differs from it in being solid throughout. Small corms, or *cormels*, are developed in very much the same manner as are daughter bulbs. Examples of corm-producing plants are the indian turnip, crocus, gladiolus, and caladium.

PROPAGATION BY MEANS OF SEEDS.

In a state of nature most species of plants depend mainly on seeds for the reproduction of their kind. Almost all plants which reproduce by other means also produce seeds. As a rule plants produce annual crops of seeds which, when mature, fall from the parent plant to the ground, often being carried in their descent considerable distances by the wind. Seeds are also carried by running water and by animals. A single plant produces a large number of seeds, sometimes an enormous number, so that the loss of a very large percentage by various natural means will not endanger the perpetuation of the species.

As seeds are the main dependence of plants in nature, so are they man's chief reliance in agriculture. The principal food crops of the world are grown from seeds planted by man.

The simplest and most common method pursued by the agriculturist is to prepare the soil and place in it the seeds of the future crops just where they are expected to grow and produce mature plants. This is the method employed in growing cereals, cotton, most forage crops, and many truck and garden crops as well as ornamental plants.

With many cultivated plants, however, the seeds are planted in a bed, cold frame, hotbed, or greenhouse, and the plants, on reaching proper size, are transplanted to field or garden.

Nearly all orchard trees come from seeds originally planted in nursery beds and later, after being budded or grafted, transplanted to the orchard. They are in fact usually transplanted once or more before being finally put out in the orchard.

Seeds are sometimes soaked in water to soften the seed coats and start the process of germination. Seeds of many forest and fruit trees require special treatment to insure prompt germination. This treatment, known as stratification, consists in placing layers of seeds alternating with layers of sand in a shallow box. This box may be buried or it may be set in a sheltered place and covered with leaves or straw to the depth of a foot. The object is to soften and decay the hard covering without starting germination. Freezing is beneficial in case of walnuts, hickory nuts, peach pits, and the like, as it helps to crack the shells. Hence such seeds are sometimes stratified in boxes placed in sheltered spots on the surface of the ground, or they may be merely placed in a pile on the ground with a slight covering of leaves or straw.

A special point to be guarded against in stratification is alternate freezing and thawing. When once frozen the seeds should not thaw out until settled weather has arrived. Repeated freezing and thawing while in a moist condition is destructive to most seeds.

Seeds receiving this treatment should be planted immediately upon being removed from stratification and before signs of growth appear. A few hours' exposure to wind and sun may prove disastrous.

Spores are not true seeds, but they are the means of reproduction of a great number of species, such, for instance, as ferns and the various fungi. Mushrooms are the most important class of cultivated plants which depend on spores for reproduction.

CUTTINGS AND THEIR USE IN PROPAGATION.

A cutting is a detached portion of a plant inserted in soil or in water for the purpose of producing a new plant. Cuttings may, for convenience of treatment, be divided into three classes, (1) hard-wood cuttings, (2) herbaceous or soft-wood cuttings, and (3) root and tuber cuttings.

HARD-WOOD CUTTINGS.

A hard-wood cutting is a cutting from the ripened wood of a deciduous plant of the present or a previous season's growth.

The cultivated plants most commonly propagated by the use of hard wood cuttings are grape, currant, gooseberry, and cranberry (a ıs). Many ornamental shrubs, such as privet, tamarisk, ;ea, etc., as well as some trees, such as the willows, poplars, ıe conifers, can also be propagated in this way. From a com- standpoint this method of propagation is one of the most ınt.

Forms of Hard-wood Cuttings.

le cutting.—The most common form of hard-wood cuttings is ıually employed in propagating the grape and current (fig. 5, *a*). , cutting consists of a straight portion of a shoot or cane nearly m in size throughout and containing two or more buds. At the end it is usually cut off just below a bud, because roots develop

ɪG. 5.—Cuttings; *a*, simple cutting; *b*, heel cutting; *c*, mallet cutting; *d*, single-eye cutting.

t readily from the joints. At the top it is usually cut off some ınce above the highest bud.

he heel cutting.—A cutting of this form (fig. 5, *b*) consists of the ɪr portion of a branch, containing two or more buds, cut off from parent branch in such a manner as to carry with it a small portion ıat branch forming the so-called "heel."

ıe mallet cutting.—A cutting of this form is produced by severing parent branch above and below a shoot, so as to leave a section of ı the base of the cutting (fig. 5, *c*).

ıe principal advantage in the use of heel and mallet cuttings lies ıe greater certainty of developing roots. The principal drawback ıat only one cutting can be made from each lateral branch.

ngle-eye cuttings.—When it is desired to make the largest number uttings from a limited supply of stock, cuttings [illegible] ing but one bud each (fig. 5, *d*). Such c [illegible] started under glass with bottom heat either in greenhouse or hotbe They may be set either in horizontal position with the bud on t upper side or perpendicularly. In either case the bud is placed abo an inch below the surface of the ground in soil which should be ke uniformily moist.

Treatment of Hard-wood Cuttings.

Cuttings are usually made with two or more buds. The cuttin are made while the wood is dormant during the fall or early wint As fast as made they are tied in bundles of 25 or 50 (butts all one wa and buried bottom end up in a tren and covered to a depth of 2 or 3 inch with sand or mellow soil. This pr tects the top buds from freezing a gives the butts the benefit of t warmth of the sun in the spring, th stimulating root development. C tings may also be kept over winter a cool cellar buried in sand, sawdu or moss.

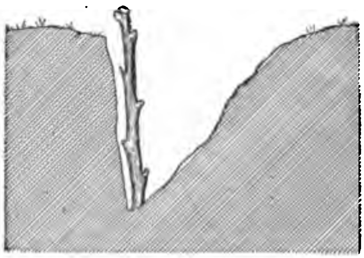


FIG. 6.—Cutting set in trench.

The following spring the bundles are taken up and the cutting about 3 inches apart in a trench with only the topmost bud or tw above the surface of the ground (fig. 6). The soil is then replaced in the trench and thoroughly packed. In planting, the cuttings should be exposed to light and air as little as possible.

After being planted the cutting should develop roots and put forth leaves, and by the next fall or spring it should be ready to put out in the permanent plantation.

HERBACEOUS OR SOFT-WOOD CUTTINGS.

This class of cuttings is exemplified in the "slips" used to increase the numbers of house plants. Many greenhouse plants, including roses, carnations, geraniums, chrysanthemums, fuchsias, begonias, and the like, are propagated in this way. This method of propagation can be employed in the winter time under glass. Near the large cities the propagation of orna plants for use on lawns or in parks, yards, and gardens has bec important and remunerative business.

FIG. 7.—Leaf cutting leaf.

Herbaceous cuttings may be made from the leaf or stem.

Leaf cuttings.—These are commonly employed in multiplying hoyas, begonias, and other plants having thick fleshy leaves containing a large quantity of plant food either in the body of the leaf or its larger ribs. Such cuttings may be made from parts of a leaf (fig. 7), or a whole leaf may be employed (fig. 8). In either case a leaf which has

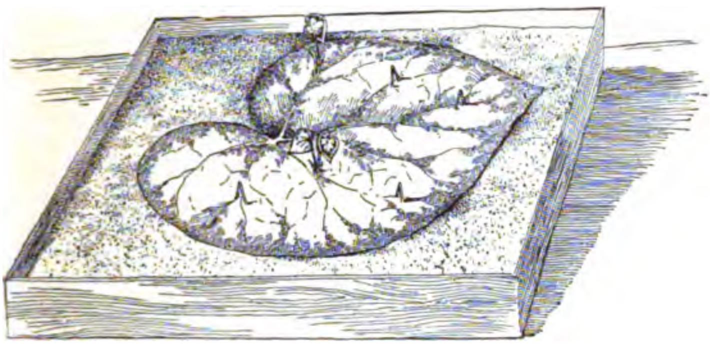


FIG. 8.—Leaf cutting—whole leaf.

ached its full development, and is in a vigorous, healthy condition, is sential. A suitable bed for the propagation of leaf cuttings may be ide by filling a shallow box with fine clean gravel or sand. Soil ntaining considerable organic matter is to be avoided, also sand conning much clay. Material prepared artificially by crushing sandstone is often used. During winter months a few degrees of bottom heat will be found useful with leaf cuttings of most plants, and some can not be induced to strike root without it.

FIG. 9.—Stem cutting or "slip."

Stem cuttings.—A stem cutting or "slip" is a portion of a branch containing two or more nodes with leaves attached (fig. 9). Stem cuttings of coleus, geranium, and allied plants strike root very easily. As a general rule, in preparing slips the leaf area ld be reduced to a minimum in order to lessen evaporation of the ture contained in the cutting, and thus prevent wilting.

thods and conditions.—Depth of the sand to be used in the propag bed varies with the plants to be propagated, but usually an of broken stone or coarse gravel overlaid with 1½ to 3 inches of will be found amply sufficient for all soft-wood cuttings.

A confined atmosphere over the tops is especially required in propagating plants which have leaves that are thin and are liable to wilt easily; also for herbaceous cuttings which require a long period in which to form roots, and those from soft wood which suffer from exposure. Such a close atmosphere can be secured by means of a sash supported by a tight frame. The simplest device for use in a small way is the bell glass. Single cuttings may be covered with inverted glass jars.

If the trouble known as "damping off" develops in connection with this work, the sand should be removed, the inside of the box or frame should be scrubbed and whitewashed, and fresh sand should be put in.

TUBER CUTTINGS AND ROOT CUTTINGS.

Tuber cuttings.—Tubers (fig. 10) are thickened portions of either roots or stems in which starch is stored up. Irish and sweet potatoes are familiar illustrations of tubers. Roots do not commonly arise from the tubers themselves, but from the bases of young shoots or sprouts. When these sprouts have developed roots, they may be removed from the tuber cutting and planted, and the cutting will then send out new sprouts. This practice is sometimes employed with new

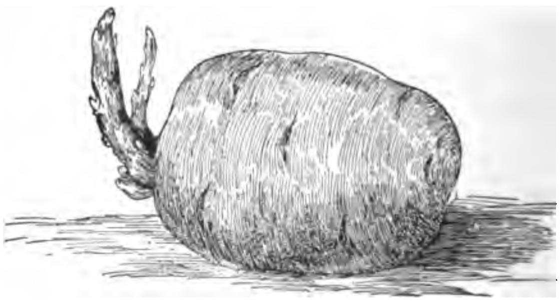


FIG. 10.—A tuber—Irish potato.

varieties of Irish potatoes in order to secure a maximum yield from small stock of seed potatoes.

In cutting Irish potatoes, there should be at least one eye on each piece; but in cutting such tubers as sweet potatoes, which have no eyes it is only necessary that each piece should have upon it a portion of the skin or epidermis from which adventitious buds may develop.

Tuber cuttings may be planted in hotbeds for the production of plants, which are then set out in the field or garden; or, as is customary with Irish potatoes, the cuttings may be planted in furrows in the field or plot which is to produce the crop.

Root cuttings.—Short cuttings of the roots may be used in the propagation of many plants, especially those which show a natural tendency to sucker. Rootstocks (fig. 1) of Johnson grass, Bermuda, and some other grasses can be cut into short pieces and used in setting fields with grass. With root cuttings of many plants bottom heat is useful. The root cuttings of the blackberry do well with ordinary outdoor treatment.

Horse-radish is propagated by root cuttings. The small lateral roots may be cut off and cut into pieces 4 inches in length and planted. Care should be taken to place them in the ground either horizontally or right end up. In order to avoid mistakes in placing the roots in the ground, cuttings may be made with a slanting cut at the base and a square cut at the top.

LAYERING.

A layer is a branch so placed in contact with the earth as to induce t to throw out roots and shoots, thus producing one or more independent plants, the branch neanwhile remaining ttached to the parent plant. Layering fre-quently proves a satis-factory method of mul-iplying woody plants vhich do not readily ake root from cuttings.

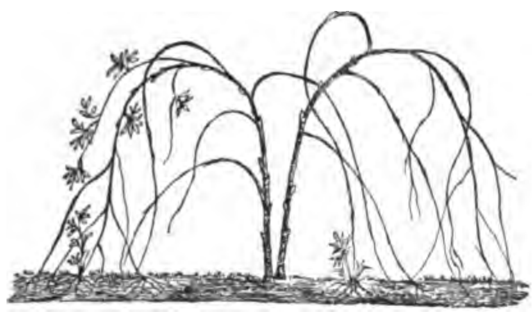


FIG. 11.—Tip layering.

Tip layering.—The tip f a branch or cane is ent down to the ground nd slightly covered with soil, when it will throw out roots and develop

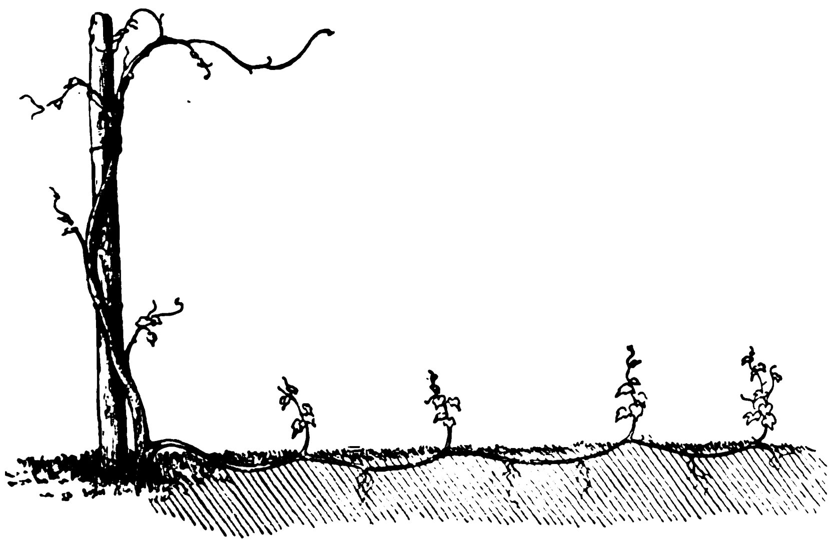


FIG. 12.—Vine layering.

iew plant (fig. 11). Many plants can be propagated in this way. e black raspberry is a familiar example.

Vine layering.—A vine is stretched along the ground and buried oughout its entire length in a shallow trench, or it may be covered in certain places, leaving the remaining portions exposed. Roots will be put forth at intervals and branches thrown up. Later the vine may be cut between these, leaving a number of independent plants (fig. 12). The grape can be easily propagated in this way.

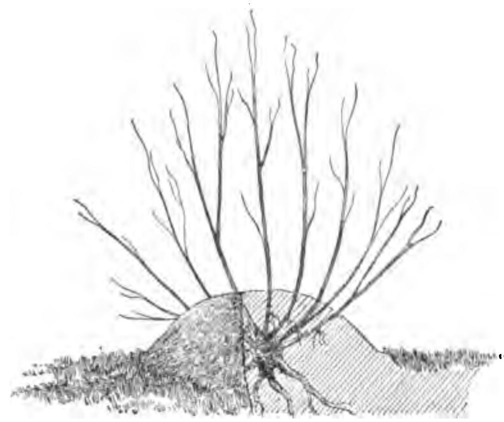


FIG. 13.—Mound layering.

Mound layering.—Plants which stool, sending up a large number of stems or shoots from a single root, are often layered by mounding up the earth so as to cover the bases of these stems and cause them to throw out roots (fig. 13). Each may then be removed from the original root and treated as an independent plant. A plant is often cut back to the ground to make it send up a large number of shoots to be layered in this way.

GRAFTING.

Were all forms of the art of grafting and budding to be taken from the horticulturist to-day, commercial fruit growing in its high state of perfection would decay with the orchards now standing.

Importance of grafting.—All the common pomaceous fruits (apples, pears, and quinces), the stone fruits (peaches, plums, cherries, and apricots), and the citrus fruits (lemons, limes, and oranges) are now multiplied by grafting or budding. The progress in plant breeding and the great rapidity with which new sorts are now disseminated could not be obtained without the aid of budding or grafting. Under existing conditions it is not necessary for the originator of a new sort of apple to give any thought to the question of fixing that type so it may be reproduced from seed; the method of reproducing the sort does not enter as a factor into his efforts to secure the desired variation. Grafting or budding has settled that long ago; but were it otherwise horticulturists would be studying different problems, and the nurseryman would be more of a scientist than a manufacturer.

The scion and its treatment.—A scion is a portion cut from a plant to be inserted upon another (or the same) plant, with the intention that it shall grow. Except for herbaceous grafting the wood for scions should be taken while in a dormant or resting condition. The time usually considered best is after the leaves have fallen, but before severe freezing begins. The scions are tied in bunches and buried moist sand, where they will not freeze and yet will be kept cold enough to prevent growth. Good results often follow cutting scions in the spring just before or at the time the grafting is to be done. If cleft grafting is the style to be employed this practice frequently gives good results, but spring cutting of scions for whip grafting is not desirable, as not enough time is given for proper healing of the wound before planting time in the spring.

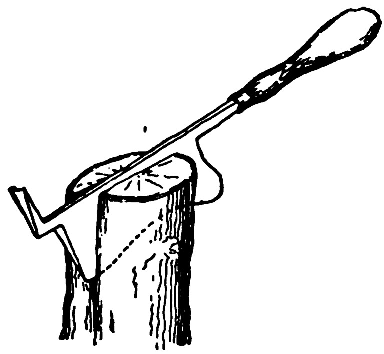
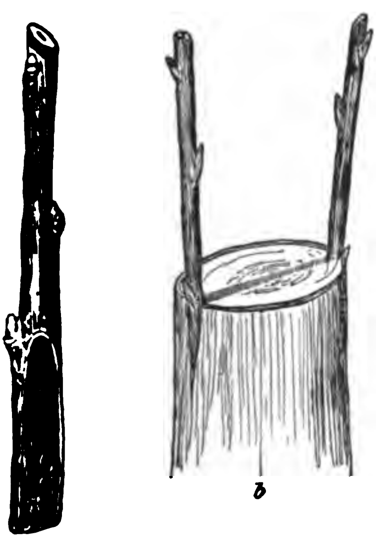


FIG. 14.—Grafting tool.

The stock and its treatment.—The stock is the plant or part of a plant upon which or into which the bud or scion is inserted. For best results in grafting it is essential that the stock be in an active condition, or so that active growth can be quickly brought about.

CLEFT GRAFTING.

This style of graft is particularly adapted to large trees when for any reason it becomes necessary to change the variety. Branches too large to be worked by other methods can be cleft grafted.



. 15.—Cleft grafting: *a*, the scion; *b*, scions inserted in cleft.

A branch 1 or 1½ inches in diameter is severed with a saw. Care should be taken that the bark be not loosened from any portion of the stub. Split the exposed end with a broad thin chisel or grafting tool (fig. 14). Then with a wedge or the wedge-shaped prong at the end of the grafting tool spread the cleft so that the scions (fig. 15, *a*) may be inserted (fig. 15, *b*).

The scion should consist of a portion of the previous season's growth and should be long enough to have two or three buds. The lower end of the scion which is to be inserted into the cleft should be cut into the shape of a wedge, ving the outer edge thicker than the other (fig. 16). In general, s a good plan to cut the scion so that the lowest bud will come just the top of this wedge (fig. 15), so that it will be near the top of the stock. The advantage of cutting the wedge thicker on one side is illustrated in figure 16, which shows how the pressure of the stock is brought upon the outer growing parts of both scion and stock, whereas were the scion thicker on the inner side the conditions would be reversed and the death of the scion would follow. The importance of having an intimate connection between the growing tissues of both scion and stock can not be too strongly emphasized, for upon this alone the success of grafting depends. To make this contact of the growing portions doubly certain, the scion is often set at a slight angle with the stock into which it is inserted in order to cause the growing portions of the two to cross.

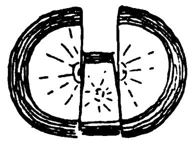


FIG. 16.—Cross section of stock and scion.

After the scions have been set the operation of cleft grafting is completed by covering all cut surfaces with a layer of grafting wax.

WHIP GRAFTING.

This style of grafting is the one almost universally used in root grafting. It has the advantage of being well adapted to small plants only 1 or 2 years of age, as well as the other great consideration that it can be done indoors during the comparative leisure of winter.

The graft is made by cutting the stock off diagonally—one long smooth cut with a sharp knife, leaving about three-fourths of an inch of cut surface, as shown in figure 17, *a*. Place the knife about one-third of the distance from the end of the cut surface, at right angles to the cut, and split the stock in the direction of its long axis. Cut the lower end of the scion in like manner (fig. 17, *b*), and when the two parts are forced together, as shown in figure 17, *c*, the cut surfaces will fit neatly together and one will nearly cover the other if scion and stock are of the same size. A difference in diameter of the two parts to be united may be disregarded unless it be too great. After the scion and stock have been locked together as shown in figure 17, *c* they should be wrapped with five or six turns of waxed cotton to hold the parts firmly together.

FIG. 17.—Whip grafting: *a*, the stock; *b*, scion; *c*, stock and scion united.

While top grafting may be done in this way, it is in root grafting that the whip graft finds its distinctive field. When the roots are into lengths of 2 to 5 or 6 inches to be used as stocks, the operation is known as piece-root grafting. Sometimes the entire root is used.

The roots are dug and the scions are cut in the fall and stored. The work of grafting may be done during the winter months. When the operation has been performed, the grafts are packed away in moss, sawdust, or sand in a cool cellar, to remain until spring. It is important that the place of storage should be cool, else the grafts may start into growth and be ruined, or heating and rotting may occur. If the temperature is kept low—not above 40° F.—there will be no growth except callusing, and the knitting together of stock and scion.

In ordinary propagation by means of whip grafts, the scion is cut with about three buds, and the stock is nearly as long as the scion. The graft is so planted as to bring the union of stock and scion not very far below the surface of the ground; but where the trees are required to be especially hardy in order to stand severe winters, and the roots used are not known to be so hardy as the plants from which the scions have been cut, a different plan is adopted. The scions are cut much longer and the roots may be cut shorter, and the graft is planted so deep as to cause roots to issue from the lower end of the scion. When taken up to be set in the orchard, the original root may be removed entirely, leaving nothing but the scion and the roots which have put forth from it. This is common practice in preparing nursery stock for planting in the northern part of the Mississippi Valley.

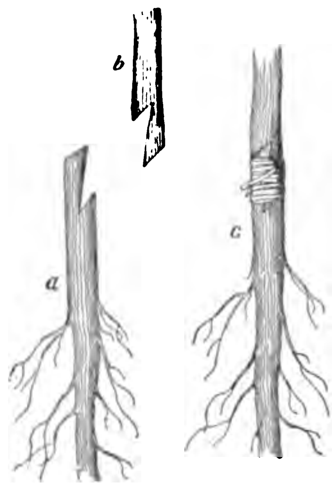


FIG. 18.—Veneer grafting: a, the stock; b, the scion: c, stock and scion united.

OTHER METHODS OF GRAFTING.

There are a great many other methods of uniting scion and stock, a few of which may be mentioned:

Bark grafting.—A branch is sawed off, as for cleft grafting, and the scions, instead of being inserted in a cleft, are cut very thin and slipped between the bark and wood, being inserted far enough to bring the growing parts together. The bark is then securely bound and wax is used as in cleft grafting. This is called crown grafting by the English and French. It is an excellent method for grafting larger limbs, as it injures the stock less than cleft grafting.

Splice grafting.—This is like whip grafting, except that no splgittin done, the sloping surfaces being simply placed together and tied.

Saddle grafting.—The stock is cut to a wedge shape and the lower end of the scion is split and set upon the wedge, the being tied and waxed.

Veneer grafting.—This method is illustrat

The top of the stock is removed with an cut. Then beginning at the highest porti the stock, cut a shaving which is thicke which can only be removed by a sloping the illustration. Cut the lower end of manner and bind the two firmly toge string. When this style of graft is us no wax is necessary, but when used wound should be well covered. This is adapted to use in either summer or

Shield grafting or scion budding.—Th thin, as in bark grafting, and is inser of the stock as a bud is inserted in th and is firmly bound in place with (figs. 20, 21).

Side grafting.—The scion is cut cleft grafting, a chisel or a thick kni the stock, and the wedge of the scio the incision. Waxed string and wa

GRAFTING W

A good grafting wax may be m gredients: Resin, 4 parts; beeswax seed oil, 1 part—by weight. If a parts of resin and 2½ of beeswax of tallow.

The resin an melted toge the liqui As so

a most convenient
with the stock the
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rieties.

September. The usual plan is for a man to set the buds and a boy to follow closely and do the tying.

The bud.—The bud should be taken from wood of the present season's growth. Since the work of budding is done during the season of active growth, the bud sticks are prepared so that the petiole or stem of each leaf is left attached to serve as a handle to aid in pushing the bud home when inserting it beneath the bark of the stock. This is what is usually called a shield bud and is cut so that a small portion of the woody tissue of the branch is removed with the bud. A bud stick is shown in figure 19. The operation of cutting the bud is illustrated in figure 20.

The stock.—The stock for budding should be at least as thick as the ordinary lead pencil. With the apple and pear a second season's growth will be necessary to develop this size, while with the peach a

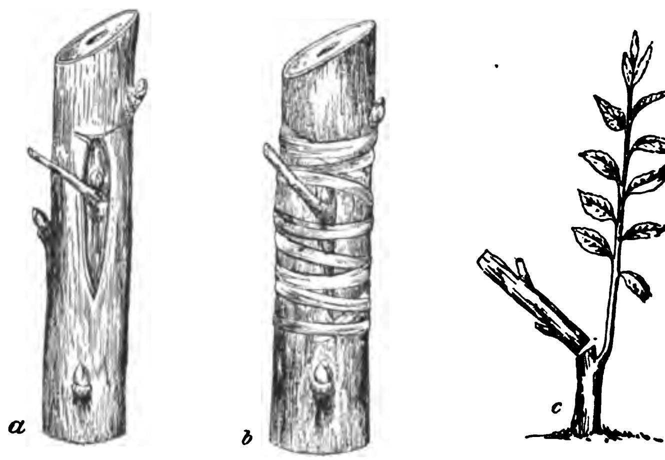

FIG. 22.—Budding: *a*, inserting the bud; *b*, tying; *c*, cutting off the top.

single season will suffice; hence peach stocks can be budded the same season the pits are planted. Consequently the peach is left until as late in the season as is practicable in order to obtain stocks of suitable size.

The operation.—The height at which buds are inserted varies with the operator. In general, the nearer the ground the better. The cut for the reception of the bud is made in the shape of a letter T (fig. 21, *a*). Usually the crosscut is not quite at right angles with the body of the tree, and the stem to the T starts at the crosscut and extends toward the root for an inch or more. The flaps of bark caused by the intersection of the two cuts (fig. 21, *b*) are slightly loosened with the ivory heel of the budding knife, and the bud, grasped by the leaf stem as a handle, is placed under the flaps and firmly pushed in place until its cut surface is entirely in contact with the peeled body of the stock (fig. 22, *a*). A ligature is then tightly drawn about, above and below the bud, to hold it in place until a union shall be formed (fig. 22, *b*)

Bands of raffia about 8 or 10 inches long make a most convenient tying material. As soon as the buds have united with the stock the ligature should be cut in order to prevent girdling the stock. This done, the operation is complete until the following spring, when all the trees in which the buds have "taken" should have the top cut off just above the bud (fig. 22, *c*).

Budding and grafting compared.—The removal of the top forces the entire strength of the root into the bud, and since the root itself has not been disturbed by transplanting a more vigorous growth usually results from the bud than from scions in whip or crown grafting.

The one objection to budding is that it causes an unsightly crook in the body of the tree unless the tree is planted deeply enough in the orchard to cover the deformity. In rigorous climates, where trees upon tender roots are likely to suffer from severe winters, a bud of a hardy sort upon a tender root is no hardier than the root, because budding leaves a portion of the stock exposed above the surface of the soil and thus precludes the possibility of the development of roots from the portion above the bud; while a piece-root-grafted tree with a long scion is practically the same as a tree propagated from a cutting, as the scion will strike root and the new plant will be upon its own root. In regions where severe winters do not enter as a factor there is undoubtedly a number of reasons why budding will be the most desirable method of reproducing horticultural varieties.

FARMERS' BULLETINS.

The following is a list of the Farmers' Bulletins available for distribution, showing the number and title of each. Copies will be sent to any address on application to any Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. The missing numbers have been discontinued, being superseded by later bulletins.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 172.

SCALE INSECTS AND MITES ON CITRUS TREES.

BY

C. L. MARLATT,

Entomologist in Charge of Experimental Field Work.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1903.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Entomology,
Washington, D. C., April 17, 1903.

Sir: I have the honor to transmit herewith for publication an account of the more important scale insect and mite enemies of citrus trees, prepared by Mr. C. L. Marlatt, entomologist in charge of experimental field work. This bulletin is a somewhat condensed revision of the article under the same title published in the Yearbook of this Department for 1900. The classes of insects mentioned are the most important enemies of the citrus fruits, and this Office is in receipt almost daily of inquiries concerning them. To meet the need for more widespread dissemination of information on the subject, this paper is recommended for publication in the Farmers' Bulletin series. The information conveyed will be of special service in California, throughout the Gulf region, including Florida, and in our new subtropical possessions.

Respectfully,

L. O. Howard,
Entomologist.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

ILLUSTRATIONS.

SCALE INSECTS AND MITES ON CITRUS TREES.[a]

INTRODUCTION.

The scale insects, or bark-lice, are the most important insect enemies of citrus, as they are also of most other subtropical plants. They are, as a rule, small and inconspicuous singly, but they multiply so rapidly that very soon an entire plant becomes infested—trunk, limbs, leaves, and fruit. The attacked tree is rarely killed outright, but its growth may be almost completely checked and its fruit rendered valueless.

Next in importance to the scale insects are the mite enemies of the orange and lemon, as represented by the mite which causes the rusting of the orange in Florida and the silvering of the lemon in California, and also the leaf mite, known from its coloring as the six-spotted mite of the orange. These mites occur with the scale insects, are subject to similar remedies, and may properly be considered in the same connection.

Of very great importance to the Florida grower of citrus fruits is the so-called white fly, the latter not being a scale insect in the ordinary acceptation, but in the essential features of life history and habits coming in the same category, and hence properly considered with the true scale insects.

There are many insect enemies of citrus plants other than the scale insects and mites, but, for this country, at least, these others, in the main, have no great economic importance, or are only very occasionally abundant enough to be especially destructive.

Occurring about the orange and other citrus trees will also be seen many other insects which play a beneficial rôle, preying upon or parasitizing the scale insects living on these trees. It is very important to make the acquaintance of these beneficial species, more particularly to avoid, whenever possible, killing them in the warfare waged against the injurious ones.

[a] No one can discuss the insect enemies of citrus plants without acknowledging indebtedness to the very comprehensive and valuable work, now long out of print, prepared by the late H. G. Hubbard and published by this Department in 1885, under the title "Insects affecting the orange." The practical side of Mr. Hubbard's work is especially to be remembered, and particularly that he devised kerosene-soap emulsion, which, with allied washes, has for many years been the leading means of controlling scale insects.

INFLUENCE OF CULTIVATION, PRUNING, AND CLIMATE.

With the orange and lemon as with other plants, negligent cultivation and improper care, or any unfavorable conditions of climate which weaken the vitality and vigor of the tree, encourage the presence and multiplication of the insect enemies. On the other hand, vigor of growth is repellent to insect attack; and it will be almost invariably found that the unhealthy tree is the one first severely infested with scale insects or mites. This does not mean that vigorous healthy trees will not be attacked, but such trees are less apt to be completely invaded. As a means of protection against scale insects, a proper system of cultivation and pruning is therefore highly important.

The value of pruning as a means of preventing scale-insect injury can not be too strongly urged. Scale insects thrive best where they are protected from direct sunlight and free movement of the air, hence trees of dense growth, unpruned, are almost certain to have their centers, at least, scaly. A well-pruned tree, in which free access is given to light and air, is much less apt to be badly attacked than a thick-headed tree, the interior of which is entirely shaded, thus furnishing the conditions most favorable for the well-being of scale insects.

The abundance or scarcity of scale-insect pests is very much influenced by climatic conditions. A moderate amount of moisture and warmth are the favoring conditions. On the other hand, a very dry climate accompanied during the summer season by excessive heat, will frequently destroy most scale pests, as will also a high degree of humidity with high temperature such as characterizes many areas within the Tropics, the latter condition developing fungous diseases which often keep most scale species well nigh exterminated. The favoring intermediate climate is illustrated by the citrus districts of Florida, Jamaica, and the West Indies, where scale enemies are more troublesome than they are in the drier climate of California. On the Pacific coast, also, the moister ocean districts are worse infested than the drier regions farther inland with greater elevation. Under the latter conditions the black scale, for example, has been almost entirely exterminated by a temperature holding for several days above a hundred degrees, and similar results have been noted with other species.

PERIODICITY IN SCALE INSECTS.

With most insects injurious to cultivated plants a periodicity is noted in their occurrence in injurious numbers. In the case of subtropical species, like the scale insects affecting citrus plants, this periodicity is not so marked as it is with insects in temperate latitudes. That there may be more or less well-defined periods of destructive abundance separated by periods of comparative scarcity is illustrated by the noted epidemic of scale infection referred to by Hubbard as prevailing throughout the entire orange, lemon, and olive districts along the shores of the Mediterranean from Italy to Spain during the first decade of the present century, which later subsided very largely of itself, efficient remedies at that date being practically unknown.

In this country, scale infestation varies considerably from year to year. The fluted scale, in California, increased enormously during the first ten or fifteen years and threatened the very existence of the citrus orchards. Thanks, however, to the Australian ladybird, and, doubtless also to many native predaceous and parasitic insects, it is no longer feared in California. The long scale in Florida, also, was much more injurious in the first years of its activity than it has been since. In 1896 the black scale was very abundant and destructive in the orange districts about Riverside, Cal. Partly owing to adverse climatic conditions and partly to natural enemies, this insect has almost disappeared from this district, which is now one of the least affected by scale insects.

These facts are cited to give the citrus grower whatever encouragement they may offer, but not with the idea of belittling the need of remedial operations.

NATURE OF THE INJURY OCCASIONED BY SCALE INSECTS.

The damage occasioned by scale insects is of several kinds. The first and principal injury is the extraction of the juices of the plant, the scale insect in its relation to its food plant being a mere pumping machine, which is continually absorbing the sap from its host. While the amount extracted by a single insect is very small, when multiplied by millions it greatly weakens the plant. With some species the excess is thrown off in the form of so-called "honeydew," which accumulates in drops and spreads out over the bark or leaf as a sticky liquid. This liquid attracts ants, which very often gives rise to the erroneous belief that the ants are depredating on the plant.

Another form of injury results from the honeydew excretion, which not only prevents normal respiration, but develops a black fungus covering the leaves, twigs, and fruit, and still further stifling the plant and reducing the marketable value of its products.

Associated with the damage due to the absorption of the juices of the plant by the scale insect is a diseased condition, particularly to be noted in the limbs, caused by the irritation excited by the beaks or by the injection of some poisonous liquid.

The extreme injury by scale insects arises from the further fact that they are active the year round in climates where citrus trees can be grown. Their most rapid breeding period is from May to August, but continues through October and November. In the winter or rainy season they are more dormant and breeding is at a much lessened rate.

THE NATURAL ENEMIES OF THE CITRUS SCALE INSECTS.

The natural predaceous enemies of scale insects of greatest importance are various species of ladybirds, as illustrated by the Australian ladybirds (figs. 21 and 29) imported to control the fluted and black scales, and a great many native species, which are very effective agents in the control of these and other scale pests. The work of ladybirds is especially important against the young of the armored scale and against the softer and freely moving scale insects which secrete no protective covering. Whenever, therefore, ladybirds of any species are found to be abundant on scale-covered trees, they may be safely recognized as friends and working in the interest of the grower. If they are very abundant, it may even be unwise to fumigate or spray. The black scale has been completely controlled on certain ranches in California by its imported ladybird enemy, and this control has been brought about by the entire cessation of all insecticide operations. Most of our ladybirds, however, will probably stand a spraying without being killed, and, as a rule, it is hardly worth while to take the risk of loss while waiting for them to do their work. The experience, however, on the Cooper ranch and in other localities in California has certainly demonstrated the advantage of giving natural enemies a fair chance.

The other important class of enemies of scale insects are the hymenopterous parasites. The recognition of these is not so easy, but if scales are found pierced with minute round holes, it is a safe indication that they have been parasitized, and that the parasites have escaped and are multiplying in the younger scale insects on the trees, and here again if the parasitism is found to be general, it may be inadvisable to spray or fumigate.

The other natural enemies of scale insects are not so important as those mentioned; still they are of service, and should be recognized. These include the larvæ of the lace-winged flies (*Chrysopa* spp.), which feed on the young of both the armored and the unarmored scales. There are also a few dipterous, or fly, parasites of scale insects, and the larvæ of several species of Lepidoptera are carnivorous and feed on the larger species of scale insects, such as the Lecaniums and wax scales.

A most desirable outcome would be to secure a complete and practical control of scale insects by their natural enemies; but, so far, this has been fully accomplished in the case of the fluted scale only. Very encouraging results have been secured, however, with other parasites, and the introduction of these is being actively prosecuted. Nevertheless, spraying and fumigation must be relied upon for some time to come, or at least until the natural enemies have been more fully studied and better means of successfully colonizing them devised. Climatic conditions also affect the activity of these enemies to such an extent that the same results may not be counted on in different localities.

In considering the agency of control afforded by the natural enemies the fact must not be lost sight of that these are dependent on the scale insects for their existence, and that, therefore, a fairly complete extermination of the host insects means a like extermination of its enemies. There is, therefore, a natural alternation or periodicity in the abundance of the scale insect and its parasites. A more even balance may be maintained to a certain extent by artificial introduction of the parasitic insect the moment the scale has begun to be abundant, in this manner assisting the early multiplication of the natural enemy. This is now the practice with the fluted scale in California, South Africa, and Portugal. To succeed in such efforts, it is necessary to have an efficient parasite or predaceous insect, and also regular breeding places where these may be secured when wanted. These conditions may be naturally supplied when a whole district, such as California, is under constant observation and the localities where the parasite and scale are occurring together are known, so that from such points the ladybirds or other enemies may be collected and shipped to the districts needing them.

THE DIRECT MEANS OF CONTROLLING CITRUS SCALE INSECTS.

Scale insect enemies of citrus trees are directly controlled in two ways: (1) By spraying the infested plants with some liquid insecticide, (2) by subjecting them to the fumes of hydrocyanic-acid gas, commonly designated as "gassing." Each of these methods of control has its place.

THE GAS TREATMENT.

The gassing method (figs. 1–6) is undoubtedly the most effective means known of destroying scale insects. It has been in general use

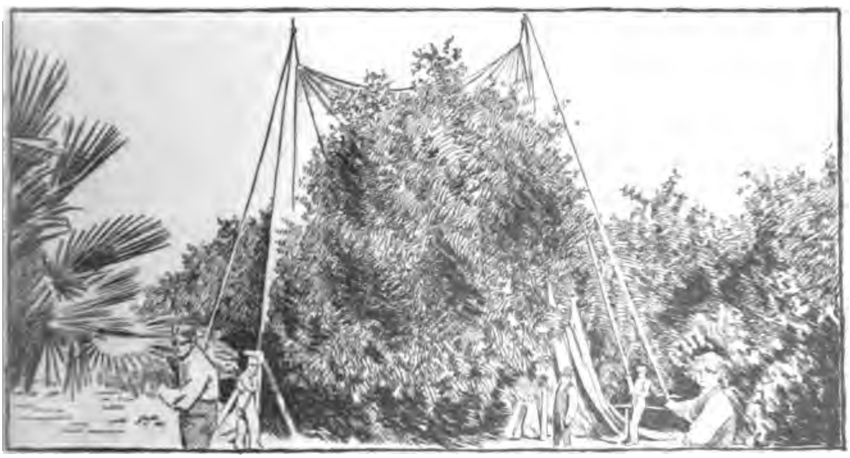


FIG. 1.—Method of hoisting tent over orange tree.

in California for fifteen years, and to a less extent elsewhere on citrus trees, and the methods are now thoroughly perfected and highly satisfactory. Gassing should undoubtedly be employed wherever the expense of the treatment, which is the one objection to it, is not an object as measured by the value of the crop protected. For most

FIG. 2.—Tent carried over tree by the falling of pulleys.

species of scale insects, one good gassing is worth as much as two or three sprayings, and, when done at the right season and properly, it very frequently will almost, if not quite, exterminate the scale insects from the treated trees, giving them comparative immunity

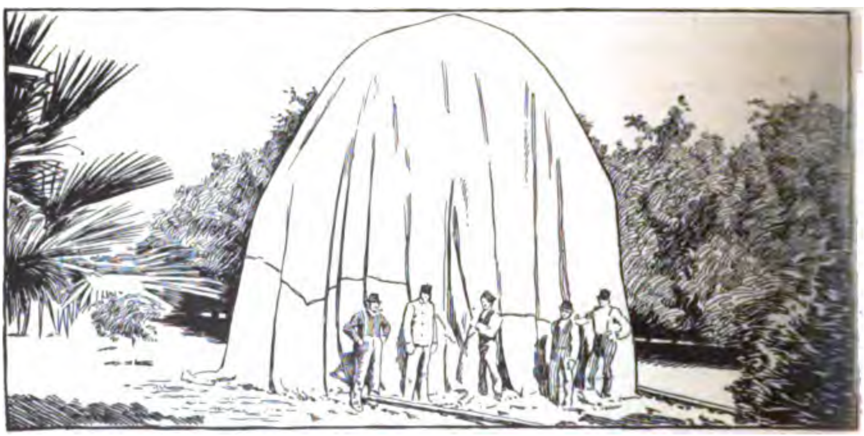


FIG. 3.—Tent in position for fumigation.

often for two or more years. The use of hydrocyanic-acid gas is, therefore, strongly urged wherever the conditions warrant it. Gassing is especially desirable for trees that have a dense habit of growth, such as the orange, which develops a large, thick head, the spraying of which thoroughly and completely is almost impossible, especially after the trees have attained any size. Furthermore, with gas there is no danger of spotting the fruit as may happen with improper spraying.

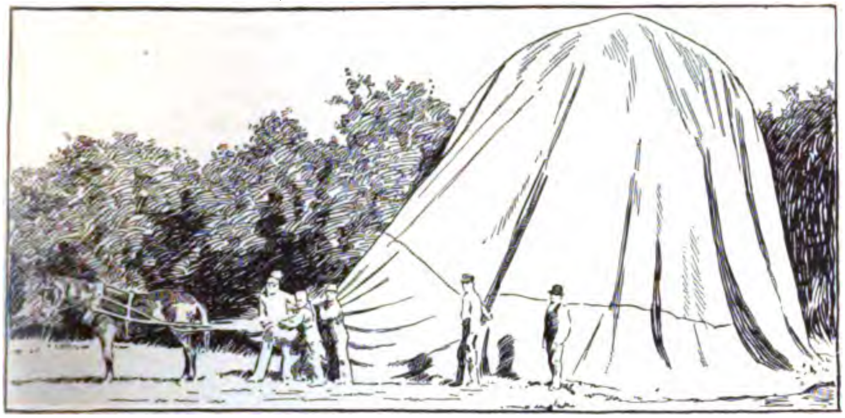


FIG. 4.—Removing tent by horse power.

The more straggling growth of the lemon makes gassing less necessary, notably where the open system of pruning is adopted.

Successful as gassing is, it is not effective in the same degree against all the scale insect enemies of citrus plants. It is especially valuable

FIG. 5.—Series of tents for continuous operations.

against the black scale and the red scale of California, but with such of the armored scales as are oviparous, or deposit beneath the old scales eggs which undergo a certain amount of incubation before hatching, gassing is not always effective. Under such circumstances the eggs may not be killed, rendering it necessary to make an additional treatment after a sufficient period has elapsed to allow all the eggs to hatch and the young to escape.

The black scale is especially adapted to control by gassing on account of its being, in the main, single-brooded. Applied late in October or early in November after all the young scales have hatched, badly infested orchards have been completely cleaned by a single treatment. Gassing in midsummer for this insect will be ineffective, because a large percentage of the old females at this period cover and protect unhatched eggs.

Gassing consists in inclosing a tree at night with a tent and filling the latter with the poisonous fumes generated by treating refined potassium cyanide (98 per cent strength) with commercial sulphuric

Fig. 6.—Tents, tackle, and chemicals loaded for transportation.

acid (66 per cent) and water. The treatment should continue from thirty to forty minutes, the longer time being preferable. The work is done at night to avoid the scalding which follows day applications, at least in bright sunlight.

The proportions of the chemicals as now employed in California are considerably in excess of the amounts recommended a few years since. The gas treatment was first chiefly used against the black scale, and at a season of the year when these scales were all in a young stage and easily killed. The effort is now made not only to kill the black scale, but also the red scale, and to do more effective work with both than formerly. The proportion of chemicals commonly employed in Los Angeles, Orange, and some other counties in southern California are indicated in the following table, published by the horticultural commissioners of Riverside County, Cal.:

Amounts of chemicals ordinarily used in gassing.

Height of tree.	Diameter through foliage.	Water.	Cyanide C. P. (98 per cent).	Sulphuric acid (66 per cent).
Feet.	*Feet.*	*Ounces.*	*Ounces.*	*Ounces.*
6	4	2	1	1
8	6	3	1½	1½
10	8	5	2½	2½
12	14	11	5	5½
16	16	17	8	9
20	16-20	22	10	12
20-24	18-22	30	14	16
24-30	20-28	34	16	18
30-36	25-30	52	24	28

The amounts here recommended are thoroughly effective for the black scale at the proper season, and generally effective also for the California red scale and other armored scales. Where the treatment is designed to be absolutely one of extermination, and the expense is not considered, from one-third to one-half more of cyanide and acid is employed, as indicated in the table following, furnished by Mr. Felix G. Havens, of Riverside, Cal.

The greater expense entailed by this larger quantity of chemicals is offset by the more effective results and the longer intervals between treatments:

Excessive amounts used for extermination.[a]

Height of tree.	Diameter through foliage.	Water.	Sulphuric acid (66 per cent.)	Cyanide C. P. (98 per cent).	Time to leave tent on tree.
Feet.	*Feet.*	*Ounces.*	*Ounces.*	*Ounces.*	*Minutes.*
6	3 to 4	3	1½	¾ to 1	20
8	5 to 6	6	2½	2	30
10	7 to 10	15	5 to 6	4 to 5	35
12	9 to 12	20 to 30	7 to 9	5½ to 7½	40
14	12 to 14	30 to 35	9 to 12	8 to 10	40
16	12 to 15	35 to 40	12 to 14	10 to 12	40
18	14 to 16	45 to 55	15 to 18	12 to 15	40 to 50
20	16 to 18	60 to 70	20 to 22	16 to 20	45 to 50
22	16 to 18	70 to 75	22 to 25	20	50
24	18 to 20	75 to 80	25 to 30	22 to 26	50
27	20 to 24	85 to 100	30 to 36	28 to 32	60
30	20 to 28	100 to 110	36 to 44	32 to 38	60

[a] A fumigation of the orangery of the Department of Agriculture demonstrated that half an ounce of cyanide to the hundred cubic feet kills the eggs, even of the black, purple, and other scales. The results are scarcely comparable to the proportions recommended in the tables on this page, for the reason that in these tables the amount of cyanide is greatly lessened with larger trees, and furthermore, that the orangery probably retained the gas more effectually than would be the case with cloth tents. Nevertheless, it is interesting to know that a comparatively inconsiderable strength of cyanide, when applied under the best conditions, will prove thoroughly effective against the eggs as well as the insects.

For small trees ordinary earthenware vessels may be used to generate the gas. For large trees requiring heavy doses tall wooden pails have proved more practicable, two generators being employed for the very largest trees. It is important that the water be put in the vessel first, and then the acid, and lastly the cyanide. If the water and cyanide are put in the vessel first and the acid poured in afterwards there is danger of an explosion, which will scatter the acid and burn the tents and the operator. In the spring, when the trees are tender with new growth, and in early fall, when the oranges are nearly grown and the skins are liable to be easily marred, and also with young trees, it is advisable to add one-third more water than ordinarily used, or use the cyanide in larger lumps. This causes the gas to generate more slowly and with less heat, and if the tents are left over the trees a third longer the effectiveness of the treatment will not be lessened.

The extremely dangerous nature of the gas must be constantly borne in mind and the greatest caution should be taken to avoid inhaling it. The person handling the chemicals should always have an attendant with a lantern, to hold up the tent and enable the cyanide to be quickly dropped into the generator and to facilitate the prompt exit of the operator.

As with spraying, the gassing is often done (and this is very desirable also) by individuals or companies who make a regular business of it, charging a fixed rate per tree, depending on size—from 10 cents to a dollar or more. Much of this work is also done under the direct supervision of the county horticultural commissioners, which gives a greater assurance of efficiency.

Practically, the only tent now used is the so-called "sheet tent," which is drawn up over the tree by means of pulleys (figs. 1–3). For very large trees, averaging 30 feet in height, it is sometimes necessary to employ two sheets to effect a complete covering.

Some of the tents employed are of great size, the one illustrated in the figures, from photographs secured by Mr. Havens, having a diameter of 76 feet. As described by Mr. Havens, it is constructed of a central piece 50 feet square, of 10-ounce army duck. Four triangular sidepieces, or flaps, of 8-ounce duck, 10 feet wide in the middle, are strongly sewed to each side of the central sheet, forming an octagonal sheet 70 feet in diameter. About the whole sheet is then sewed a strip of 6-ounce duck, 1 yard wide. The tent is handled by means of ropes and pulleys. A 1½-inch manila rope is sewed about near the edge of the central piece in an octagonal pattern. Rings are attached to this rope at each of the eight corners thus formed, and also on opposite sides of the outer edge. To these rings the pulley ropes are fastened and the tent is elevated over the tree and handled as indicated in the plates.

The treatment is made altogether at night, although it would be possible to treat trees also on a very dark or cloudy day. In California, however, at the time the gas treatment is made, such days are infrequent. About 50 trees of the largest size, 30 feet high or thereabouts, can be treated in a night with an equipment of twelve or fifteen tents (fig. 5). By the time the last tent is in place, the fumigation in the first is completed, and it can be taken down and moved forward, and so on with the others; thus the men at work handling the tents are kept continuously employed. Working in the same way with smaller trees, the number which can be treated in a single night is very considerable, it being possible to gas from 300 to 500 trees, averaging 10 feet in height, in eleven or twelve hours, employing 35 to 40 ring tents.

SPRAYS FOR CITRUS TREES.

It may often happen that gassing is impracticable or that the expense of the treatment is not warranted. This last may be the case where the rancher has not sufficient capital to keep up the heavy

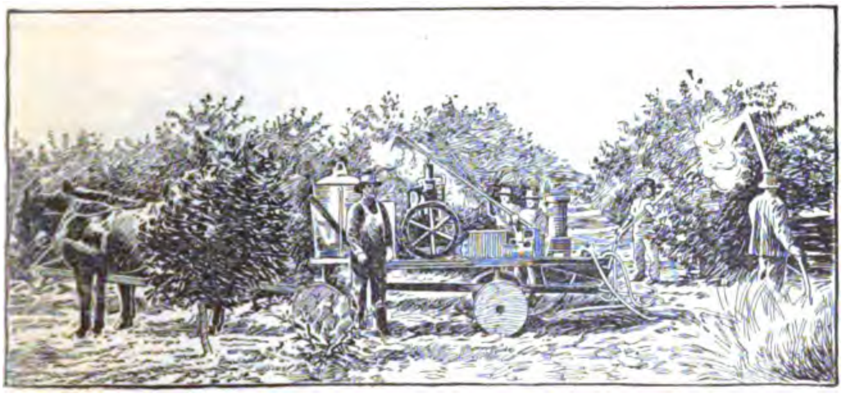


FIG. 7.—Gasoline-power spraying outfit with four lines of hose in operation.

outlay necessitated by the treatment of young stock which yields no revenue. Gassing is also difficult and less desirable where, as for the lemon in southern California, the low, open-center pruning is adoptted, the trees under this system of pruning often having an expanse of 20 feet, with a height of scarcely more than 6 feet. This open system of pruning and more straggling form of growth, on the other hand, makes the lemon easier to treat with liquid sprays, and under such conditions spraying will probably prove more practicable and profitable than gassing. Nevertheless, where lemon trees are of a form and size to admit of it, and the crop warrants the expense, gassing is always to be recommended.

The expense of spraying is not heavy, compared with that of gassing. In most of the citrus districts of California where spraying is practiced to any extent there are individuals who make a business of treating orchards at a charge of a cent a gallon for the liquid applied, or about double that price when they furnish as well as apply the insecticide. This work is now commonly done with a power apparatus (fig. 7),[a] and usually in a fairly satisfactory manner. The difficulty in depending on the public sprayer is that it is very often not available when much needed. For a large ranch the possession of a power spraying outfit will probably prove economical in the long run, and anyone contemplating securing one is referred to the general article on such machines, by Dr. L. O. Howard, in the Yearbook of this Department for 1896.

For the small rancher, having from 10 to 30 acres of orchard, it is not necessary to go to the expense of a steam or a gasoline spraying apparatus. There are a great many excellent force pumps on the market which may be easily equipped with suitable hose and nozzles, and which will do the work of spraying very satisfactorily. A hand force pump with suitable connections, which may be equipped for

FIG. 8.—Hand-power spraying outfit with two lines of hose in operation.

work at a cost of from $25 to $30, will meet all requirements. The pump for such an outfit should be capable of easily producing a pressure of 100 pounds, which will supply four cyclone nozzles attached to two lines of hose. With such an apparatus (fig. 8), the writer was able to spray easily 50 gallons an hour, or 500 gallons a day, working with three men, and this covers also the time lost in mixing the insecticide and refilling. The cost of applying the same amount of liquid by a contract sprayer would probably be a little less, but under personal supervision, the work will undoubtedly be better done and with less waste of material, and, of more importance still, at the time when most needed and when the greatest advantage will result.

Trees under seven years old will probably require from half a gallon to a gallon of spray per tree. For an orchard of 10 acres, or about 860 trees, the cost of spraying would be about $8 for the spray and

[a] From photograph furnished by F. Kahles.

as much more for the labor. In other words, spraying with the insecticides commonly employed, such as "distillate," kerosene emulsion, and resin wash, may be safely estimated to cost about 2 cents a gallon for the amount of liquid used, or not exceeding 2 cents per individual tree under seven years of age. On the other hand, gassing trees seven years old will cost from 12 to 15 cents per tree, or the equivalent of from five to seven sprayings. The advantage, therefore, of spraying, for the small owner, and for trees especially suited by form of growth or pruning to such treatment, is evident.

The oily washes are by far the best for use on citrus trees against scale insects. The attempt has been made in various places to substitute lye washes for the old standard kerosene washes, but the effect has, as a rule, been disastrous. Lye strong enough to kill scale insects applied to a tree, as demonstrated by Hubbard fifteen years ago, is very destructive to the tender growth of the tree, and the damage from the wash is often greater than that occasioned by the insects themselves. In California, the kerosene and resin washes formerly used have now given place, to a considerable extent, to a modification of kerosene emulsion known as "distillate." As now employed, the washes in the order of their popularity are: (1) Distillate; (2) resin wash; (3) kerosene emulsion. The probability is that distillate will ultimately supplant the other two on account of its equal, if not greater, efficiency and smaller cost.

Distillate.—This wash was originated by Mr. F. Kahles, and has found very general use in the Santa Barbara region, and also in the lemon districts adjacent to San Diego, as well as in other citrus districts in California. It is substantially an emulsion of crude kerosene, made in the same way as kerosene emulsion, except that a greater amount of soap and only half as much oil are used. Its cheapness results from the latter fact. In spite of this lessening of oil it seems to be, if anything, stronger than kerosene emulsion.

It is termed distillate spray, because the oil used is a crude distillate of the heavy California petroleum, or the crude oil minus the lighter oils.

The emulsion or "cream," as it is generally known, is prepared as follows: Five gallons, "28° gravity," untreated distillate; 5 gallons water, boiling; 1¼ pounds whale-oil soap. The soap is dissolved in the hot water, the distillate added, and the whole thoroughly emulsified by means of a power pump until a rather heavy, yellowish, creamy emulsion is produced. For use on lemon trees it is diluted with 12 parts of water, and with 15 parts of water for the orange. The "distillate cream" is prepared and sold by oil companies and private individuals at from 10 to 12 cents a gallon, making the dilute mixture, as applied to the trees, cost in the neighborhood of a cent a gallon.

Kerosene emulsion, made by the same companies, costs from 12 to 15 cents a gallon. In using these oil emulsions it is advisable to first break the water by the addition of a little lye, one-fourth pound being ample for 50 gallons of water.

Kerosene emulsion.—This wash, made according to the old formula (kerosene, 2 gallons; whale-oil soap, one-half pound; water, 1 gallon), is prepared in the same way as the distillate and used at the same strength. It does no harm to use double the quantity of soap indicated, securing in this manner a rather more stable emulsion. This emulsion, while perhaps somewhat less efficient than the distillate emulsion, is always available where the latter may not be in reach. It may be prepared on a small scale with an ordinary hand pump, but is best prepared in large quantities with a gasoline or steam-power pump to mix and emulsify it after the soap has been dissolved in the water by boiling.

The resin wash.—This wash is especially valuable against the California red scale. It may also be used against any other scale insect, including the black scale and the various armored scales affecting citrus trees. The wash is made as follows: Resin, 20 pounds; caustic soda (78 per cent), 5 pounds; fish oil, 2½ pints; water to make 100 gallons. Ordinary commercial resin is used and the caustic soda is that put up for soap establishments in 200-pound drums. Smaller quantities may be obtained at soap factories, or the granulated caustic soda may be used, 3½ pounds of the latter being the equivalent of 5 pounds of the former. Place these substances with the oil in a kettle with water to cover them to a depth of 3 or 4 inches. Boil about two hours, making occasional additions of water, or until the compound resembles very strong black coffee. Dilute to three times the final bulk with hot water, or with cold water added slowly over the fire, making a stock mixture to be diluted to the full extent as used. When sprayed the mixture should be perfectly fluid, and should any sediment appear the stock mixture should be reheated; in fact, the wash is preferably applied hot. This wash is more difficult to prepare than the emulsions referred to above, and is therefore much less employed.

CITRUS SCALE INSECTS: CLASSIFICATION AND CHARACTERISTICS.

For the purpose of this paper a very simple classification of citrus scale insects may be adopted, namely: (1) The armored scales, or those forming a protective covering scale and losing their limbs and the power of changing their situation as soon as they settle down to feed as newly hatched larvæ; (2) those species which secrete no covering shell or scale and retain their limbs and the power of moving about during most of their lives.

The species belonging to both groups are commonly called scale insects, although the term might seem properly to apply only to the first group; nevertheless, the old insects in the second group, when they become hardened, and, in fact, the younger stages also, greatly resemble scales; hence, the name may properly apply to them as well.

These insects all belong to the family Coccidæ of the order Hemiptera, or true bugs, being allied to plant-lice and other suctorial insects of this order. In the larval stage the scale insects, except in point of size, closely resemble the larvæ of the higher forms of Hemiptera, and are active and can run about on plants or may be carried from one plant to another by the wind, or by birds or other insects to which they may attach themselves.

In the case of the armored scales, as soon as the young have undergone their first molt they appear as mere sacks provided with long sucking beaks, but without legs or eyes, and are very much degraded structurally from the larval condition. The unarmored scales, while retaining their limbs throughout life, are not apt to move very much after they have once settled and begun to feed, except in the case of one or two species. The power of locomotion, however, is retained, and in the case of the fluted scale and mealy bug is often actively brought into play; the Lecaniums and wax scales are apt to migrate late in their lives from the leaves to the twigs. The female insects of both groups remain on the plants and never advance to a winged stage. The males of both groups, however, while paralleling the development of the females in the early stages, in the later stages transform to pupæ, and eventually emerge as minute, two-winged gnats. The life of the winged male is very short, and its sole function is to fertilize the eggs of the female. It is a very delicate creature, having no mouth parts, but in place of them a second pair of prominent eyes.

GROUP 1.—THE ARMORED SCALES.

The majority of the important scale-insect enemies of the orange belong to the group known as armored scales because the insects begin to excrete as soon as they thrust their beaks into the tissues of the plant a waxy covering which protects the growing insect and forms a definite scale-like shield entirely independent of the insect itself. This group includes the long scale, purple scale, the red scale of California and the red scale of Florida (an entirely distinct insect), the oleander scale, the chaff scale, and other less important species.

In general habits these armored scales are very similar. The eggs, which are developed in enormous numbers, may be extruded under the covering scale of the mother insect and undergo a longer or shorter period of incubation before hatching, or the young may be partly or fully developed within the body of the mother and emerge as active insects, or more properly shake off the egg envelope at the moment of birth, so that certain species appear to yield living young. The young of these different species of armored-scale insects very closely resemble each other, and can not be distinguished without careful microscopical study. While very minute, the young are yet visible to the naked eye, and during the breeding season may be seen, by sharp inspection, running about on the leaves, twigs, and fruit. In color they are usually light lemon-yellow. They have six well-developed legs, also antennæ and eyes, and are highly organized in comparison with the degraded condition soon to be assumed. After finding a suitable situation, often within a few minutes from the time of their emergence, though sometimes not for an hour or two, they settle down, thrust their long slender hair-like beaks into the plant, and immediately begin growth, the first evidence of which is the secretion of waxy filaments from the upper surface of the body, which mat down and form the beginning of the scale covering (fig. 12). This waxy secretion continues during the life of the insect, the covering scale being enlarged as the insect increases in size. The females undergo two molts, and the skins thrown off in these molts form a definite part of the scale, being cemented to it closely with the wax. The female insect, after the second molt, soon reaches full size, and when fertilized by the male begins to develop her numerous progeny.

The preliminary stages of the male scale insect exactly correspond with those of the female. After the first molt, however, the male assumes a slightly different appearance, being more elongate than the female at this stage. With the second molt the male diverges entirely from the female; the old skin is thrust out from beneath the covering scale, and does not become a part of it, as with the female, so that in the case of the male insect the first-shed skin only is associated with the scale, which never becomes more than one-half the size of that of the female. With this second molt the male insect transforms to a preliminary pupal stage, in which the antennæ, legs, and wings are partially developed. A third molt occurs with the male insect, resulting in the final pupal stage, which exhibits more fully formed legs and wings than the preceding stage and also the so-called terminal style. A fourth and last molt of the male produces the perfect insect, which escapes from beneath the covering scale and can fly about (fig. 11, e).

The periods between the moltings vary with different species and with weather conditions. Most of the species, however, reach full growth in from four to six weeks in summer; development is slower in winter.

The female insect, having once thrust her beak into the tissues of the plant as a larva and begun the secretion of a covering scale, never moves from her position; and, in fact, if she be removed by force is never again able to penetrate the bark with her sucking beak, and soon perishes. The opportunity for the local spread of these insects is, therefore, limited absolutely to the larval stage, as in this respect they differ from the Lecaniums and mealy bugs, which have the power to move about until nearly the end of their growing period.

The number of eggs from a single female varies somewhat with the species, but may be from 100 to 500, the number being less in unfavorable seasons. The progeny from a single female in a year, if they should all survive, would represent almost inconceivable numbers, running into the billions. It is not to be wondered at, therefore, that plants become thoroughly infested with these insects in a very short time, especially in climates where the breeding is but little checked by the winter season.

The waxy covering makes it necessary to use rather strong washes to penetrate the scale. The difficulty increases when the old scale protects a mass of eggs, as is usually the case with the species of Mytilaspis, represented by the long and purple scales; and it is not always possible with the best washes to kill all the eggs of these species, hence the necessity of spraying repeatedly to destroy the young as they emerge. Remedial operations should be instituted as far as possible when the greatest percentage of the scales are in a young or partly mature condition.

FIG. 9.—Long scale (*Mytilaspis gloveri*): Group figure, showing cluster of male and female scales on fruit of orange—enlarged 7 diameters (original).

The Long Scale.

The long scale (*Mytilaspis gloveri* Packard—fig. 9) is supposed to have originated in China, but in common with most of the other species discussed has now a world-wide distribution, being represented in practically every important citrus region. It made its appearance in Florida about 1838, and soon became a very serious pest in that State and elsewhere in the Gulf region. At its first appearance it was vastly more destructive than later on, parasitic and natural enemies having in later years kept it decidedly in check. At present it is everywhere distributed throughout Florida and Louisiana in the orange and lemon groves, and also on wild orange. Strangely enough, it was a long while getting into California. About 1889 or 1890, however, in company with the purple scale and rust mite, it was carried into California on a lot of stock from Florida, but it has not developed as a very serious pest in the Pacific coast region.

This insect is characterized by its very elongate form; in other respects it closely resembles *Mytilaspis citricola*, and also the common oyster-shell scale of the apple and other deciduous fruits. In color it is a rather rich reddish, often obscured by extraneous matter taken from the surface of the leaves or bark. It apparently requires a great deal of moisture to thrive well, and hence is apt to be abundant on oranges or other plants grown in conservatories, and this also accounts, doubtless, for its greater multiplication and injury in Florida than on the Pacific coast.

Breeding continues practically throughout the year. According to Hubbard, there are three periods in Florida when the young are especially abundant, marking in a rough way the appearance of the main broods, namely, in March and April, in June and July, and in September and October; the fourth, irregular brood, occurring in January or February.

The treatment for this scale is the use of the oily washes and fumigating with hydrocyanic-acid gas. It is much more easily controlled than the purple scale.

The Purple Scale.

The original home of the purple scale (*Mytilaspis citricola* Packard) (figs. 10 to 12) is unknown, but it now occurs practically wherever

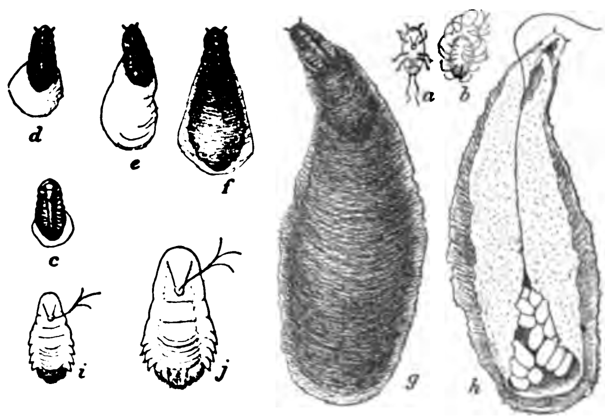


FIG. 10.—Purple scale (*Mytilaspis citricola*), showing different stages of female: *a*, newly hatched larva; *b*, same with first waxy secretion; *c* to *f*, different stages of growth; *g*, mature scale; *h*, same inverted, showing eggs; *i* and *j*, half-grown and full-grown female insects removed from scale—all much enlarged (original).

the orange or lemon is grown. It was probably introduced into this country at an early date. It is frequently associated with the long scale, and is one of the most troublesome scale insects affecting the orange and lemon, because it is very difficult to get an application on the trees strong enough to kill all of its eggs with one treatment. For many years the purple scale was limited in this country to Florida and the Gulf region, but some years since it was carried on Florida stock into southern California, where, fortunately, it has not yet become widely distributed. In general color it is a brownish purple, and in shape duplicates the oyster-shell scale of the apple. The life history and habits are the same as those of the long scale. The purple scale is not limited to citrus fruits, but occurs also on many other plants.

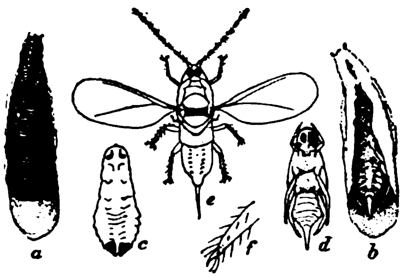


FIG. 11.—Purple scale (*Mytilaspis citricola*), showing different stages of male: *a*, fully developed male scale; *b*, same inverted, showing male pupa within; *c*, propupa; *d*, final pupal stage; *e*, mature winged insect; *f*, foot of same much enlarged—all greatly enlarged (original).

FIG. 12.—Purple scale (*Mytilaspis citricola*), illustrating the formation of the scale covering: *a*, newly hatched young, with enlarged antennæ at left and leg at right; *b*, side view of forming scale; *c*, same from above—all greatly enlarged (original).

Neither the gas treatment nor any of the washes is a certain remedy for this scale, except in the immature stages. Occasionally a very strong treatment will kill the eggs, but it is usually necessary to repeat the application once or twice at intervals of two or three weeks to effect anything like extermination.

The Red Scale of Florida.

This is another scale insect (*Aspidiotus ficus* Ashmead) of world-wide distribution. As an orange scale it is not a very serious pest on trees grown out of doors, but on trees grown in conservatories or under glass it is very apt to thickly infest the leaves and fruit. It has a very wide range of food plants and is one of the commonest of scale insects. This and the following species differ from the Mytilaspis scales in being nearly circular in general outline, with the molted skins in the center of the scale instead of at the small end (fig. 13). The color of this scale is a rich reddish

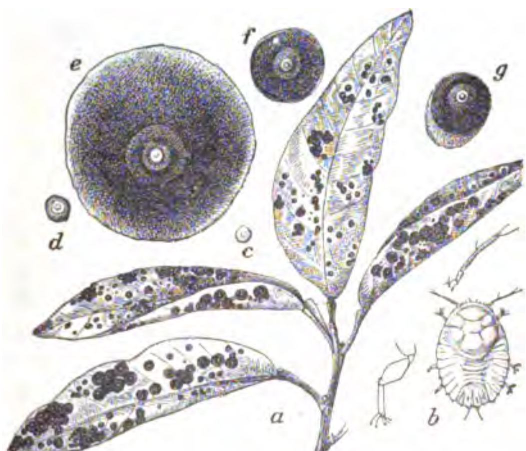


FIG. 13.—Florida red scale (*Aspidiotus ficus*): *a*, leaves covered with the male and female scales—natural size; *b*, newly hatched insect with enlargements of antennæ and leg; *c*, *d*, *e*, *f*, different stages in the development of the female insect, drawn to the same scale; *g*, adult male scale—similarly enlarged (original).

brown, almost black. The central portion, however, is much lighter, giving the appearance of a dark ring with a light center. The number of generations can not be accurately given, breeding going on throughout the year, but undoubtedly in greenhouses and tropical regions six or seven generations are not unusual, and in subtropical regions five generations may be safely counted. It seems never to have attracted any attention as an enemy in the orange and lemon groves of California, the dry climate evidently not suiting it. The moist climate of Florida and the Gulf region seems more favorable to it.

The Red Scale of California.

This species (*Aspidiotus aurantii* Maskell) (fig. 14) is entirely distinct from the red scale of Florida. Its name comes not from the covering scale, as with the Florida species, but from the fact that the body of the mature female turns a reddish brown and shows through the thin transparent waxy scale. This insect, although for years very common and destructive in the groves of southern California, and enjoying also a cosmopolitan distribution, has, curiously enough, never appeared in a destructive way elsewhere in this country. Its origin is a matter of some uncertainty. It is now widely distributed, and has undoubtedly been a scale pest in oriental countries for centuries. It is not limited to citrus plants, but may occur on almost any plant growing in tropical or subtropical regions. It is the most destructive and injurious of all the scale insects affecting the orange in California, being especially troublesome in the districts about Los Angeles. So far no effective parasites or predaceous insects have been found to combat it. It is controlled by the oily washes, and also by the gas treatment. The young are born free, or, in other words, the insect is semi-oviparous, and therefore any wash which will kill the old scale will destroy the young also.

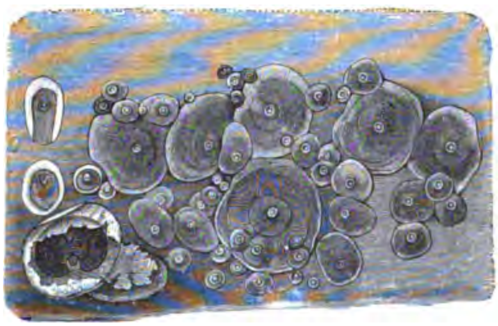


FIG. 14.—California red scale (*Aspidiotus aurantii*), illustrating a group of the female and male scales as they occur on an orange leaf—enlarged about 7 diameters (original).

This insect has, in California, a rather well-marked variety, known as the yellow scale (*Aspidiotus citrinus* Coq.). This variety does not differ in any structural feature from the red scale, but the mature insect remains yellowish in color. This variety is attacked by quite a number of parasitic flies, which keep it more or less in check, so that it is not, as a rule, so abundant as the red variety.

The Oleander Scale.

This species (*Aspidiotus hederæ* Val.) is not distinctively an orange pest. It occurs on a great variety of plants and has a world-wide distribution. It occasionally occurs on the lemon and orange, especially in California, not apparently being so likely to attack this plant in Florida. It is a very delicate scale, with a very thin waxy covering, and yields readily to treatment. It frequently occurs on the oleander, and is commonly known as the oleander scale (fig. 15). The male scales are white and very greatly exceed the females in abundance (much more so than indicated in the accompanying illustration). The female scales are light buff in color with a faint purple tinge, rather than white, are two or three times the size of the male scales, and rather larger also than the scales of the species already described. The fruit of the lemon and orange is often invaded by the females of this species.

FIG. 15.—Oleander scale (*Aspidiotus hederæ*), illustrating a group of the female and male scales as they occur on a leaf—enlarged about 7 diameters (original).

The Chaff Scale.

With this scale insect (*Parlatoria pergandei* Comstock) the molted skins are at one end of the scale, as in the case of Mytilaspis, and the scale is oval or nearly circular, as in the case of Aspidiotus. It is very apt to be clustered thickly, often overlapping on leaves or twigs and fruit, giving the surface a rough appearance, as though covered with loose chaff (fig. 16). In color the female scale is light straw-yellow, the female insect showing through, usually with a greenish tinge. The number of generations and life history correspond very closely with the species already described. As a rule, the chaff scale by preference remains on the trunk and branches, covering these portions of the plant densely before going on the leaves and fruit. This fact renders it somewhat less noticeable than the other species, and its presence may, for a time, be overlooked.

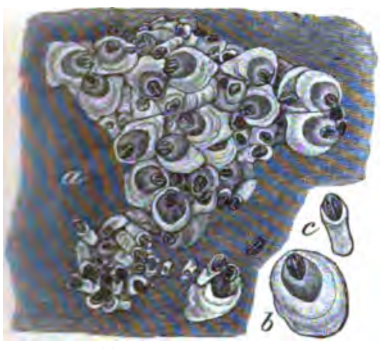


FIG. 16.—Chaff scale (*Parlatoria pergandei*), illustrating a group of the female and male scales as they occur on a leaf—enlarged about 7 diameters (original).

The chaff scale has been destructive, so far, only in Florida and the Gulf region, having apparently been introduced from the Bermuda

Islands or some of the West Indies. It is closely allied to certain scale insects occurring in the Old World, and probably came to this country from Europe or Asia. It yields to the same treatments which are advised for the other armored scales.

The Orange Chionaspis.

This species (*Chionaspis citri* Comstock) occurs in the orange groves of the Eastern United States, and is also especially troublesome in Louisiana. Professor Morgan reports that its presence on the trees causes a bursting of the bark and very ugly wounds, followed in very many cases by the rotting of the trunks of the older trees. The orange Chionaspis (fig. 17) is found also in several of the West Indian islands, Mexico, and in most foreign countries where citrus fruits are grown. The male scales are striking objects on account of their white color, and the females are readily distinguished from the other armored scales of similar general shape by the distinctly ridged appearance of the waxy portion. The orange Chionaspis is readily controlled by the same treatments advised for the other armored scales.

FIG. 17.—Orange Chionaspis (*Chionaspis citri*), illustrating a group of the female and male scales as they occur on a leaf—enlarged about 7 diameters (original).

GROUP 2.—THE UNARMORED SCALES.

The species to be considered in this group include three Lecaniums, the mealy bug, two wax scales, and the fluted scale. Strictly speaking, the Lecaniums are the only ones which secrete no covering. The mealy bug secretes a waxy or mealy powder, which covers its body, and a similar secretion in less amount is made by the fluted scale. Both of the latter species secrete very abundant quantities of wax for the protection of their eggs. The wax scales cover themselves with copious waxy secretion, which, however, attaches firmly to the body, and can not be considered as a separate covering in the sense of the scale of the armored species. The development of the different species in this group is very similar, in that they all retain the power of locomotion until nearly the end of their lives, and do not suffer the loss of limbs and the marked retrograde development already described in the case of the armored scales. They excrete liberally the honeydew, which is followed by the smut fungus. In this group are included some of the worst scale pests of the orange and lemon, notably the black scale, the fluted scale, and the mealy bug. Not being so firmly attached nor protected by a covering shell or scale, they are as a rule more easily stroyed by fumigation or sprays, and they fall a more ready prey to tacks of predaceous and parasitic insects. All of the species are egg-ying. The Lecaniums and wax scales deposit their eggs in cavities nder their bodies, formed by the contraction of the female insects, so ıat ultimately the mothers become mere shells over vast numbers of ggs and hatching young. The mealy bugs and fluted scale excrete a uantity of cottony fibers, which are stocked with eggs. After a cer-ain amount of incubation, the young hatch and escape from beneath he old parent scales or burrow out of their cottony nests. In trans-formations and general life history, except in the points noted, these scale insects closely duplicate the habits of the armored scales.

The Black Scale.

This scale insect (*Lecanium oleæ* Bernard—figs. 18, 19, and 20) is notably an olive pest, but it also attacks citrus fruits, and is quite as destructive to the latter as to the olive. It is an insect of world-wide distribution, having been an important enemy of the olive and citrus fruits in the Old World as far back as we have any records. It also affects a great variety of other fruits and plants. It occurs more or less in greenhouses, and has undoubtedly been transported to various parts of the world upon greenhouse plants as well as upon the various subtropical fruits. In the United States it is especially destructive only on the Pacific coast, and while it occurs generally in Florida it has never there assumed any great importance as an enemy of the orange or lemon. It not only saps the vitality of the plants by the extraction of their juices, but also abundantly secretes honeydew, which results in a badly attacked plant becoming thoroughly coated and blackened with the sooty fungus.

FIG. 18.—Black scale (*Lecanium oleæ*): Group of scales, showing natural position and appearance—enlarged 4 diameters (original).

The adult insect is dark brown, nearly black, in color. Its characteristic features are the one longitudinal and the two transverse ridges. Very often the portion of the longitudinal ridge between the two transverse ridges is more prominent than elsewhere, giving a resemblance in these ridges to a capital letter H. The general surface of the body of this scale insect is shagreened or roughened, which will distinguish it readily, under a hand lens, from the allied species, even before the ridges have become prominent. Very fortunately for the citrus grower, the development of this insect is slow, and it has but one brood annually. The young, however, appear over a very wide interval of time, and this gives the appearance of more than one brood.

On reaching full growth, early in the summer, the female insect deposits her eggs beneath her already much-hardened parchment-like skin, the lower surface of the body gradually contracting until there is nothing left but the shell, covering a mass of hundreds of eggs. The eggs will hatch in a comparatively short time, but, as the females come to maturity at different dates, the young from this species are constantly appearing and spreading over the infested plants between June and the end of October. The growth, however, is very slow, and even those earliest hatched do not reach maturity until late in autumn, the latest maturing in June and July of the following year.

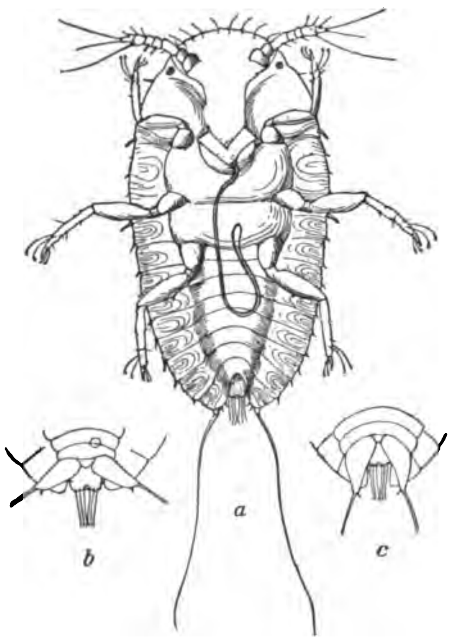


FIG. 19.—Black scale (*Lecanium oleæ*): *a*, greatly enlarged drawing of newly hatched larva, viewed from beneath, with enlargements of anal extremity viewed from above—*b*, showing anal segment extruded, and *c*, same retracted (original).

While retaining the power of movement practically throughout its development, this scale insect is very little apt to change its position after it is once settled, or, at least, after it is half grown. There is a general migration from leaf to twig, but the scale often develops

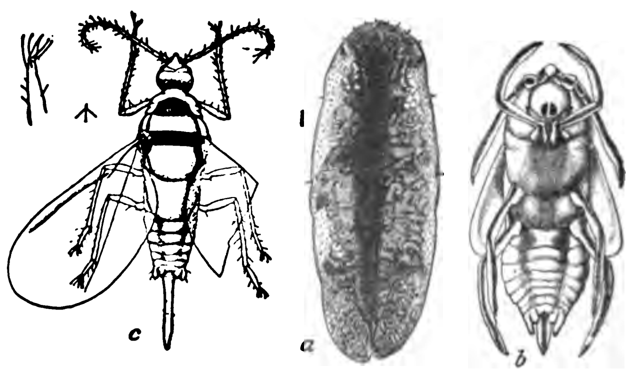


FIG. 20.—Black scale (*Lecanium oleæ*), male series: *a*, fully developed male scale; *b*, pupa; *c*, winged adult—natural size indicated by hair lines (original).

on the leaf if the latter remains vigorous and supplies it sufficient nourishment.

In view of the extraordinary abundance of the black scale it is surprising that until very recently the male insect had not been discovered, in spite of the most careful search for it. What we know of this stage is due to Dr. B. W. Griffith, of Los Angeles, Cal., who has found the male scales on oleander, orange, lemon, pepper, and ivy leaves between the months of November and April, in Los Angeles County. The accompanying illustrations of this sex (fig. 20) are based on material furnished by Dr. Griffith.

The natural enemies of the black scale promise to be very efficient in its general control and warrant special notice. They include both the parasitic flies and various species of ladybirds.

FIG. 21.—Imported ladybird enemy of black scale (*Rhizobius ventralis*): *a*, mature beetle; *b*, larva—both greatly enlarged (author's illustration).

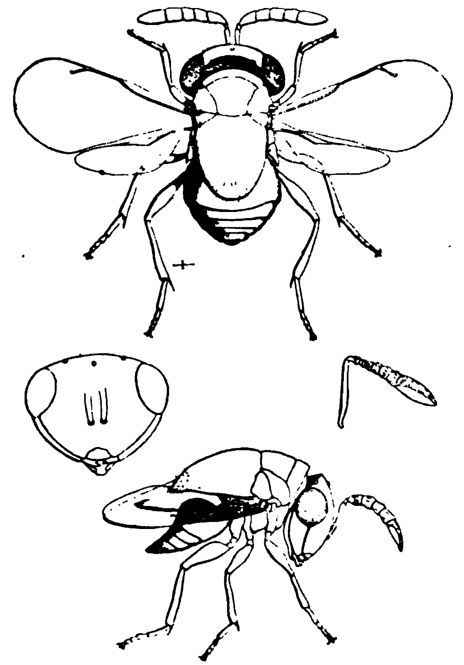


FIG. 22.—Imported chalcidid parasite of black scale (*Scutellista cyanea*), dorsal and lateral views—greatly enlarged (after Howard).

The ladybird enemy of special importance is the *Rhizobius ventralis*, imported by Mr. Koebele. This ladybird (fig. 21) has been colonized in various parts of California, and in districts where the climatic conditions proved favorable its work has been most satisfactory, notably on the ranch of Hon. Ellwood Cooper, at Santa Barbara. Hundreds of thousands of these beetles have been distributed in southern California and have accomplished in some localities a very great deal of good in keeping the black scale in check. Away from the moist coast regions, however, it is less effective, and experience has shown that this ladybird can not be completely relied upon to control the black scale.

A parasite which promises to be most effective in controlling the black scale is the very odd-shaped little chalcidid fly (fig. 22) known as *Scutellista cyanea* Motsch., first found attacking *Lecanium coffeæ* in Ceylon. It was later reported by Dr. Berlese as attacking a wax scale (*Ceroplastes rusci*) in Italy. Subsequent to its discovery in Italy, various efforts were made by Dr. Howard, with the assistance of Dr. Berlese, to introduce it into Florida and the Gulf districts, particularly as a means of controlling the wax scales. In the meanwhile it was found with the black scale in Cape Colony by Mr. Lounsbury, who, at Dr. Howard's suggestion and with his assistance and the cooperation of different persons in California, notably Mr. Craw and Mr. Ehrhorn, succeeded, in 1900, in getting the parasite into California, where it has been installed under conditions which promise a successful introduction of the species. During the last three years it has been constantly distributed in California and reports of its work are most favorable. In South Africa, as reported by Mr. Lounsbury, the black scale very rarely is abundant enough to be considered at all injurious, and this is apparently due to its parasitism by this little insect. If the latter can be induced to play the same rôle in California the saving will be second only to that accomplished by the Vedalia.

FIG. 23.—Soft scale (*Lecanium hesperidum*): Orange twig showing characteristic massing of the scales—natural size (after Comstock).

The remedial measures for the black scale are spraying with the oily emulsions and the gas treatment.

The Soft Scale.

This scale insect (*Lecanium hesperidum* L.—fig. 23), also known as the turtle-back scale or brown scale, is closely related to the black scale, but is a much softer and more delicate insect. It changes in color with age from a transparent yellow in the young to deepening shades of brown in the adult. The adult scale has a length of 3 or 4 millimeters, is turtle-shaped, and very much swollen, the body of the mother in the last stages becoming a mere cap filled with young. In the early stages the insect is thin and flat and semitransparent, so that it is scarcely noticeable on the surface of the leaf or twig. It is very commonly found on various greenhouse plants, and has been carried to all parts of the world on such material. In climates suitable for the growth of the orange and lemon it occasionally gains a foothold on outdoor plants. It has a gregarious habit, and commonly lives in colonies, frequently covering the young limbs and the midribs of the leaves. These colonies are usually not of long duration, being soon attacked and exterminated by parasitic and predaceous enemies, the soft texture of the insect not furnishing much, if any, protection. The transformation and habits are very similar to those of the black scale. It, however, is much more rapid in growth, and, where the climate is favorable, goes through a continuous series of generations, or broods, throughout the season. It readily yields to oily washes or to the gas treatment.

The Hemispherical Scale.

This scale (*Lecanium hemisphæricum* Targ.—fig. 24) is also distinctively a greenhouse pest, and it can hardly be considered as especially injurious to citrus trees in orchards. It occurs all over the world, and occasionally will multiply to a slight extent on orchard trees. The individuals are about the same size as those of the last two species. In color it ranges from light brown in the young to dark brown, changing to reddish in the old scale. The adult scale is hemispherical in shape perfectly smooth and shiny, and this, with its color, readily distinguishes it from the other two species. The remedies are those used against the black scale.

FIG. 24.—Hemispherical scale (*Lecanium hemisphæricum*): *a*, characteristic group of adult scales on olive—natural size; *b*, three female scales—considerably enlarged; *c*, scale lifted from leaf, showing mass of eggs (original).

The Florida Wax Scale.

This very curious and striking scale insect (*Ceroplastes floridensis* Comstock) secretes a white waxy covering, arranged in a very regular geometrical pattern (fig. 25). It was long known from Florida, where it is undoubtedly native, its principal food plant being the gall berry. It has now been carried, however, to other parts of the world, notably some of the adjacent West Indian islands, and also to the Old World. It was imported into California on stock from Florida in 1889, and possibly earlier, but has never gained any foothold on the Pacific coast. This insect often occurs on citrus plants, though rarely in sufficient numbers to be of very great importance. The white color and striking appearance of these scales cause them often to be noted, and very natural fears of damage are excited, but as a rule the natural enemies and other causes result in very few of the young reaching the adult stage. This, as shown by Mr. Hubbard, not only follows the action of parasites, but also is due to the fact that the scale lice as they become old and gravid can not maintain their hold on the smooth surface of the lemon or orange leaf and fall to the ground and perish. The citrus plants, therefore, are not especially adapted to this insect and very rarely suffer long or seriously from it.

FIG. 25.—Florida wax scale (*Ceroplastes floridensis*): Group of scales, illustrating different stages of growth—enlarged about 4 diameters (original).

The Florida wax scale is three-brooded, development not being very rapid and extending over three or four months. The waxy secretions give an appearance to the young insect of an oval stellate object, the waxy prominences coalescing and disappearing with age.

The Barnacle Scale.

This insect (*Ceroplastes cirripediformis* Comstock—fig. 26), which is closely allied to the last, has been found in two or three localities in Florida, notably at Jacksonville and in Volusia County, on orange and quince, and also on a species of Eupatorium. It is frequently associated on citrus plants with the Florida wax scale. It has since been found on the same and other food plants on some of the West Indian islands and in Louisiana and California. The barnacle scale is much larger than the Florida wax scale, having an average length of 5 millimeters and a width of 4 millimeters. The waxy covering is a dirty white, mottled with several shades of grayish or light brown, and the division of the waxy excretion into plates is distinct, even to a late age. The development of the insect and secretion of the waxy scale covering is very similar to that of the last species described. The barnacle scale is of very little economic importance, and is mentioned merely because its presence might arouse suspicions of probable injury.

FIG. 26.—Barnacle scale (*Ceroplastes cirripediformis*): Group of scales on twig, illustrating different stages of growth—enlarged about 2 diameters (original).

The Fluted Scale.

Of all the scale insects attacking citrus plants, this species (*Icerya purchasi* Maskell—figs. 27 and 28) is perhaps the most notable, not so much from the damage now occasioned by it as from the problems of control which it has brought to the front and the international character of the work which it has occasioned.

The facts indicate that Australia is undoubtedly its original home, from whence it was introduced on Australian plants into New Zealand, Cape Town, South Africa, and California at about the same time. The evidence points to its introduction into California about the year 1868 on *Acacia latifolia*. It is a very hardy insect, will live for some time without food, and thrives on a great number of food plants. In California it spread rather rapidly, and by 1886 had become the most destructive of orange scale pests. The damage occasioned by it was of such a serious character as to threaten the entire citrus industry of the Pacific coast. The nature and habits of this insect made it almost impervious to any insecticide washes, and the orange growers of California were rapidly losing heart.

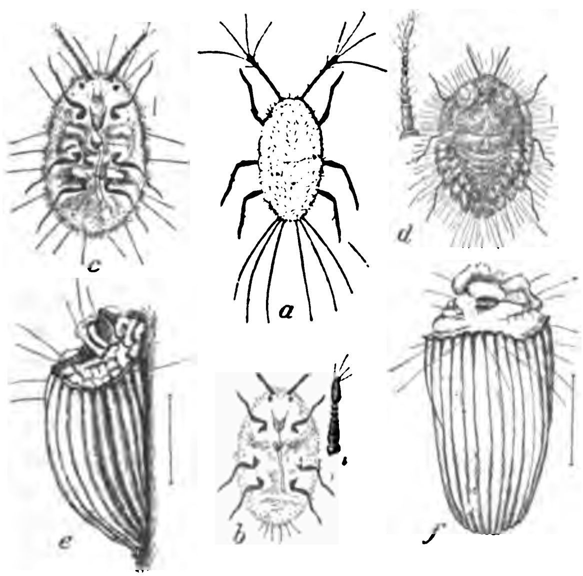


FIG. 27.—Fluted scale (*Icerya purchasi*), female series, illustrating the development of the female insect from young larva to adult gravid stage: *a*, newly hatched larva; *b*, second stage; *c*, third stage; *d*, full-grown female; *e* and *f*, same after secretion of egg sac—(original and after Riley).

In 1889, however, through the agency of Mr. Albert Koebele, an assistant of this office, the natural ladybird enemy of the fluted scale was discovered in Australia and imported into California. This ladybird, *Novius* (*Vedalia*) *cardinalis* (fig. 29), multiplied prodigiously, and in a very short time practically exterminated the fluted scale, saved the State of California annual damage amounting to hundreds of thousands of dollars, and removed this scale insect from the roll of dreaded injurious species.

The beneficial results derived from this ladybird have not been confined to California. Through the agency of this Department and in cooperation with the California State authorities, this ladybird has been sent to South Africa, Egypt, Portugal, and Italy, and in each of these countries its introduction has been followed by similar beneficial results in the control of the fluted scale.

While the fluted scale, at the time or soon after its injurious record in California, gained access to several foreign countries, very fortunately Florida and the Gulf districts remained long free from it.

The first and presumably only introduction of this insect into Florida was an intentional one, though not malicious, and illustrates the risk run in importations of beneficial insects undertaken by persons unfamiliar with the subject. A nurseryman of Hillsboro County, Fla., hoping to duplicate against the common Florida scale insects the wonderful work of the imported Australian ladybird against the fluted scale in California and, ignorant of the fact that the ladybird in question did not feed on any of the armored scales which he especially wished to have controlled by it, got one of the county horticultural commissioners of California to ship him a lot of these ladybirds, together with some of the fluted scale as food. The whole lot was liberated on his premises and resulted, naturally enough, in stocking some of his trees very thoroughly with the fluted scale. The infestation coming to his attention, he sent, in June, 1894, specimens to the Division of Entomology and they were promptly determined as the dreaded California scale pest. Fortunately, the nurseryman in question realized the enormity of his offense and took, at Dr. Howard's earnest suggestion, immediate and active measures to exterminate the fluted scale on his premises, ultimately taking out and burning the trees.

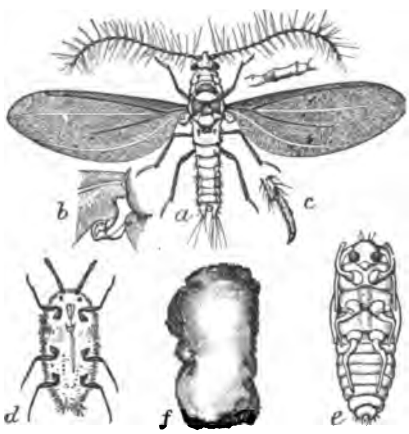


FIG. 28.—Fluted scale (*Icerya purchasi*), male series: *a*, male insect with greater enlargements of base of wing and foot at *b* and *c*; *d*, second stage of larva; *e*, pupa; *f*, cocoon—enlarged about 7 diameters (re-engraved from Riley).

It was hoped that extermination had been effected, but four years later (1898) the fluted scale was again received from the same district. In view of its quite general spread, as reported, in the immediate region, it seemed improbable that it could be easily exterminated, and the introduction of the Australian ladybird was urgently advised. During the spring and summer of 1899 the ladybird in question was successfully colonized in Florida by Mr. Gossard, with the assistance of Mr. Craw.

The fluted scale in Florida evidently does not multiply as rapidly as it does in California. Furthermore, as shown by Mr. Gossard, it is attacked by a fungous disease which appears suddenly in July and results in the death of from 25 to 70 per cent of the partly grown scales. We may hope that with the aid of this disease, and by means of the prompt introduction of its natural enemy, the fluted scale will never play the rôle in Florida which it originally did in California.

The habits and transformations of the fluted scale (figs. 27 and 28) closely parallel those of the species of Lecanium already described ıeral appearance of the insect, however, is strikingly dissimilar, to the waxy excretions from the ventral plate of the adult insect. These are ribbed, or fluted, from whence the insect ts name, and become the receptacle of a vast number of eggs, a female being the possible parent of more than a thousand young. raxy material constituting the egg sac issues from countless pores ıe under side of the body, especially along the posterior and al edges. As this secretion accumulates the body is lifted, so ultimately the insect appears to be standing almost on its head, early at right angles to the bark. The eggs are laid in the waxy etion as it is formed, the waxy fluted mass often becoming from to two and one-half times as long as the insect itself. The young of reddish color, very active, and spread by their own efforts l by the agency of the winds, ds, and other insects. The male insect is, for the most rt, a reddish orange, more less spotted with white or mon.

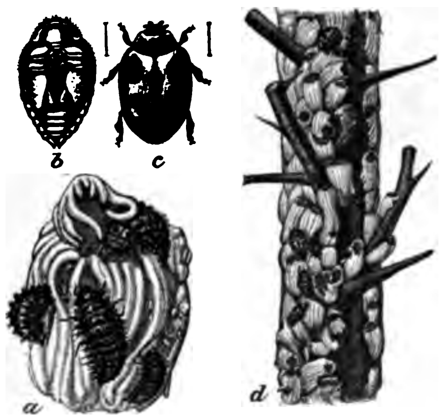


FIG. 29.—*Novius cardinalis*, Australian ladybird enemy of the fluted scale: *a*, ladybird larvæ feeding on adult female and egg sac; *b*, pupa; *c*, adult ladybird; *d*, orange twig, showing scale and ladybirds—natural size (author's illustration).

The early stages of the male e similar to the corresponding stages of the female. Before appearing as an adult, the ale insect secretes itself in me crack in the bark, or in ıe ground, and exudes a waxy vering, which forms a sort of coon, in which the transforations are undergone, first into e pupa and then into the adult sect. The winged male (fig.) is rather large for a coccid, and has a reddish body with smoky ings.

The rate of growth of the fluted scale is comparatively slow, and it es not normally have more than three generations annually. This sect is quite active, the female traveling and moving about very eely nearly up to the time when she finally settles for egg-laying. he male is active up to the time when it settles down to make its coon.

The fluted scale exudes a great quantity of honeydew, and trees dly attacked by it are covered with the sooty fungus, characteristic f the black scale and the white fly.

The remedy for this scale insect is always and emphatically to secure once its natural and efficient enemy, the *Novius cardinalis*. Where is insect can not readily be secured, the scale may be kept in check frequent sprayings with the kerosene or resin washes. Fumigation is comparatively ineffective against it, because the eggs are not destroyed by this treatment. Spraying is, for the same reason, effective only when it is repeated sufficiently often to destroy the young as they hatch.

The Mealy Bug.

The mealy bug (*Dactylopius citri* Risso) (fig. 30) of the orange and other citrus plants is especially destructive in Florida and the West Indies. It is not of much importance in California.

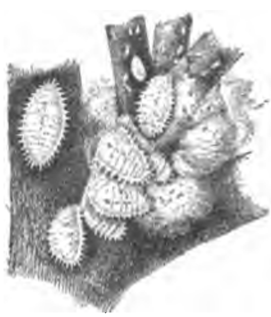


FIG. 30.—Mealy bug (*Dactylopius citri*): Mass of insects at fork of leaf, showing different stages and cottony excretion covering eggs—enlarged 4 diameters (original).

It occurs very commonly in greenhouses, and has been carried to every quarter of the globe. The insect is mealy white in color, the female attaining a length of nearly a quarter of an inch when fully adult. The edge of the body is surrounded by a large number of short waxy filaments. This insect is active in all stages and the eggs are laid in and protected by a cottony or waxy secretion, the female insect as this is developed being gradually forced from the bark, as in the case of the fluted scale. The adult winged male is light olive brown.

This species is somewhat gregarious and occurs in masses in the angles of the branches and leaf petioles and about the stem of the fruit. The remedies are the emulsions and oily washes, repeated as often as necessary to reach the young as they hatch.

IMPORTANT CITRUS PESTS OTHER THAN SCALE INSECTS.

THE WHITE FLY.

The white fly (*Aleyrodes citri* Riley and Howard) of Florida and the Gulf region (figs. 31 and 32) is not a scale insect, but belongs to a closely allied family. In general appearance and habits, however, at least in its economic features, it exactly duplicates the true scale insect. For many years this very interesting insect has been known to infest the orange trees of Florida and Louisiana and also to be a common pest on the orange in greenhouses. It has been found also on a number of plants other than orange, such as viburnum, cape jasmine, and the aquatic oak of the South. These other food plants are of significance only in indicating that it may be harbored in situations near orchards in which efforts have been made to exterminate it. The first careful description of this insect and general account of its habits was given by Riley and Howard in 1893, and from their article the data following are largely derived.

The white fly is limited, economically, to the citrus plantings of Florida and the Gulf region. It is widely distributed in greenhouses, as already noted, and has undoubtedly been carried to California on many occasions, but has never gained a foothold out-of-doors. The dry hot season of southern California probably accounts for this, and may prevent its ever becoming troublesome in that region. Its origin is unknown. It first came into prominence about 1885, but probably had been present in greater or less numbers for a much longer period, and perhaps is native ;o Florida.

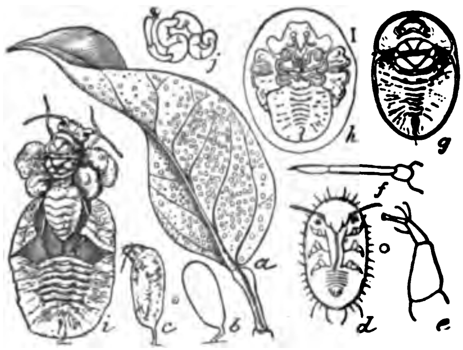
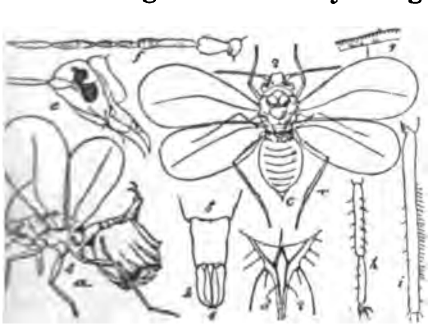


FIG. 31.—White fly (*Aleyrodes citri*): *a*, orange leaf, showing infestation on under surface—natural size; *b*, egg; *c*, same, with young insect emerging; *d*, larval insect; *e*, foot of same; *f*, larval antennæ; *g*, scale-like pupa; *h*, pupa about to disclose adult insect; *i*, insect escaping from pupal shell; *j*, leg of newly emerged insect, not yet straightened and hardened—all figures except *a* greatly enlarged (reengraved from Riley and Howard).

While closely resembling a cale insect in its early stages, he white fly in the adult stage merges, in both sexes, as a ninute white gnat, having four halky wings of a fine glandlar texture, from which fact ; is frequently called the "mealy wing." This active adult condition ives the white fly a distinct advantage over scale insects in means of pread.

The damage occasioned by it is greatly increased by the secretion, in the larval and pupal stages, of a honeydew similar to that secreted by the true scale insects. This is in enormous amount, and the sooty mold which develops in it frequently covers the entire upper surface of the leaves and produces very serious effects on the vitality of the plant; the fruit does not ripen properly, is deficient in quality and size, and keeps poorly, involving in addition the expense of washing before it can be marketed.



. 32.—White fly (*Aleyrodes citri*): *a*, winged male sect, with enlarged view of terminal segments *b*; *c*, dorsal view of winged female, with enlargents of ovipositor, head, antenna, wing margin, id leg at *d*, *e*, *f*, *g*, *h*, *i* (reduced from Riley and oward).

The life round of the insect, briefly, is as follows: The winter is ssed in the mature larval stage as a thin, elliptical, scale-like object the under sides of the leaves. Early in the spring the transformation to the pupal stage occurs, this stage differing but slightly from the larval in appearance. The adults begin to appear by the middle of March and continue to emerge through April. The eggs deposited by this brood require about three weeks for development, hatching into larvæ from the middle of April to the 1st of May. The adults of the second brood begin to emerge by the middle of June and continue to appear until the middle of July. Between the middle of July and the middle of September a third brood is developed, the larvæ of which, hatching about the last of October, carry the insect through the winter. The number of eggs laid by a single female is in the neighborhood of twenty-five, and they are placed, by preference, upon new leaves, but all of the plant is taken when the multiplication of the insect makes it necessary. The young larva is active, resembling closely the larva of a true scale insect. The life of the adult ranges from ten to twenty days.

The most satisfactory remedies for this insect, as demonstrated by Messrs. Swingle and Webber, are the kerosene and resin washes. The treatments may best be made during the winter, between December and March, and again, if necessary, in May, and also in August or early in September. Two or three applications may be made in the winter. The application in August is made if the sooty mold is found to be spreading to the fruit. Since the insect lives on the under sides of the leaves almost exclusively, it is of prime importance that the under surface be thoroughly wetted with the spray, and it is necessary that the tree be opened up by pruning. Fumigation with hydrocyanic acid gas is also a ready means of destroying this insect. It is undoubtedly kept more or less in check by parasitic and predaceous enemies, and is subject to attack by several fungous diseases, which may be of occasional value in preventing its undue multiplication.

THE RUST MITE OF THE ORANGE AND THE SILVER MITE OF THE LEMON.

This mite (*Phytoptus oleivorus* Ashmead—fig. 33) is an enemy of both the orange and lemon, affecting these fruits in a somewhat different way. For many years this mite was known only in Florida, and its injuries were notable only in the case of the orange. It is probably native to the Florida peninsula, possibly having originally some food plant other than the orange.

The lemon and orange groves of California were for a long time entirely free from the attacks of this mite, but about 1889 some carloads of citrus trees were taken into California from Florida and planted, without careful inspection, in the Rivera and San Diego Bay districts. This shipment of trees brought with it, unfortunately, two or three of the Florida scale insects, and also this rust mite, which has gained a foothold in the important lemon districts about San Diego and is now one of the worst pests the lemon grower has to deal with. For a number of years the effect of its attacks in California was ascribed to a fungous disease, and it was not until the writer visited the lemon districts about San Diego Bay in 1896, and identified the injury as due to the Florida rust mite, that its true nature was known. Our knowledge of its life history and habits and the remedies for it are chiefly due to the work of Mr. Hubbard in Florida.

This mite develops on both the leaves and fruit, although its presence on the former is often overlooked. On the foliage the presence of the mite causes the leaves to lose their gloss and become somewhat curled, as though by drought. The leaves are never killed, however, the attack resulting merely in the considerable checking of the vigor of the plant.

The presence of this mite affects the fruit of the lemon slightly differently from that of the orange. The ripening fruit of the orange, after having been attacked by the mite, becomes more or less rusted or brownish, and the rind is hardened and toughened. While the orange loses its brilliant fresh color and gloss, the toughening and hardening of the rind enables the fruit to stand long shipment, and protects it very materially from decay. The quality of the juice is rather improved by the mite than otherwise, the mite-attacked oranges being more juicy and sweeter flavored. As a result of this, a demand grew up in the Northern markets for the rusty fruit, and good prices were obtained for it.

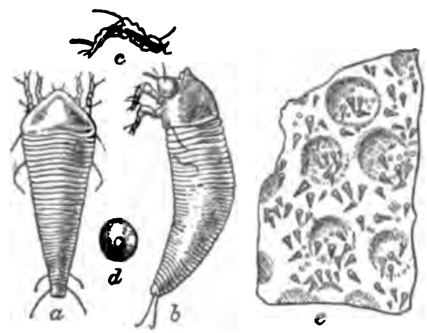


FIG. 33.—The rust or silver mite (*Phytoptus oleivorus* Ashmead). *a* and *b*, dorsal and lateral views of adult mite; *c*, leg of same; *d*, egg; *e*, lemon rind showing pits normal to surface and mites and eggs—all greatly enlarged. (*a* to *d* copied from Hubbard; *e*, original.)

In the case of the lemon, however, an injury to the rind is an important consideration, a perfect rind being a requisite of the fruit, on account of the numerous uses to which the rind is put and the valuable products obtained from it. The effect on the lemon is also somewhat different from that on the orange. The rind of both fruits, when attacked by this mite in the green stage, becomes somewhat pallid or "silvered," due to the extraction of the oils and the drying up and hardening of the outer layer of the skin. This whitening is much more marked with the lemon than with the orange, and, since the lemon is often picked while green, the subsequent rusting is not nearly so notable; hence, in California this mite is known chiefly as the silver mite. If the lemon is allowed to fully ripen on the tree, however, it also becomes bronzed or rusted, but rather lighter in shade than the orange.

As in the case of the orange, the rind of the lemon is hardened and toughened, but the juicy contents are not affected materially; furthermore, a silvered lemon will keep very much longer than a perfect lemon, and will bear long shipment without risk of much loss. Until very recently the rusted lemon in southern California found no market whatever, and was a total loss to the grower. The scantiness of the crop in 1900 resulted, however, in some shipments of rusty fruit being made under the name of "russet lemons," about half the normal price being obtained. Should the manufacture of citric acid assume very much importance in southern California, the mite-injured lemons could be used for this purpose. Nevertheless, considering the ease with which the mite may be controlled, there is no excuse for allowing it to maintain itself in injurious numbers in a lemon grove, since, irrespective of the appearance and value of the fruit, its work on the foliage materially lessens the healthfulness and vigor of the plant.

The rust mite avoids exposure to sunlight, and hence the lower half of the fruit is nearly always first invaded, and only gradually does the mite work its way around to the upper surface, very frequently a small portion exposed to the direct rays of the sun remaining unattacked. This gives the appearance, most prominently shown in the case of the orange, of a discolored band extending about the fruit. The multiplication of this mite goes on at all seasons of the year in the orange and lemon districts, being merely less prolific and active in winter than in summer. It has been supposed in Florida that dry weather is inimical to it, but the fact that it thrives in southern California would seem to throw doubt on this belief.

The rust mite itself is very minute (fig. 33), practically invisible to the naked eye. It is honey-yellow in color, and about three times as long as broad. It is provided with four minute legs at its head extremity, by means of which it drags its wormlike body slowly from one spot to another. The eggs are circular and are deposited singly or in little clusters on the surface of the leaf or fruit. They are about half the diameter of the mother and nearly transparent in color, having, however, a slight yellowish tinge. They hatch in four or five days in hot weather, but in cold weather the egg stage may last for one or two weeks. The newly hatched mite is very similar to the adult. About a week after hatching, it undergoes a transformation, or molt, requiring a period of about forty-eight hours, after which it escapes from the old skin, which remains adhering to the leaf or fruit for some little time. This moult brings the mite to its adult stage, in which it is somewhat darker in color than the young and opaque. No sexual differences have been discovered, and the number of eggs deposited by a single mite is not known. The entire development of the mite is short, probably not much exceeding, in warm weather, two weeks.

The food of the mite seems to be the essential oil which is abundant in all the succulent parts of citrus plants, and which is obtained by the mites by piercing the oil cells with their beaks.

These mites, while excessively minute, are capable of very active ocomotion, moving from one part of the leaf to another, as the conlitions of light and food necessitate.

An estimate, made from actual count, indicates that the mites and ggs on a single leaf in midwinter may reach the enormous number f 75,000. This indicates for trees, in the active breeding season of ummer, billions of mites. The mite is very readily distributed by leans of insects and birds.

The rust mite is readily destroyed by various insecticides. The ggs, however, are much more difficult to kill, and practically no wash an be relied upon to reach and destroy all the eggs of this mite. xperience in California indicates that gassing is also ineffective gainst the eggs. The sovereign remedy for the rust mite is sulphur. may be applied as a powder on trees, and, moistened by rain or ew, will adhere to the leaves for quite a long period, not being adily washed off even by a hard rain. When spraying is done for ale insects, the flowers of sulphur can be mixed and applied with e spray, accomplishing both purposes at once. A better method, rhaps, is to first dissolve the sulphur with lye, as follows:

Mix 20 pounds of flowers of sulphur into a paste with cold water, en add 10 pounds of pulverized caustic soda (98 per cent). The disving lye will boil and liquefy the sulphur. Water must be added om time to time to prevent burning, until a concentrated solution of gallons is obtained. Two gallons of this is sufficient for 50 gallons spray, giving a strength of 2 pounds of sulphur and 1 of lye to 50 lons of water. An even stronger application can be made without nger to the foliage. This mixture can also be used in combination h other insecticides.

There are several species of mites which attack citrus plants, the st troublesome one of which, especially in Florida, is the one named ve. Almost any insecticide will kill the adult mite, such as keroe emulsion, resin wash, or even a simple soap wash, but unless the s are killed the trees will be reinvaded about as thickly as ever in course of a week or ten days. The advantage of the sulphur treatnt arises from the fact that the sulphur adheres to the leaves and young mites are killed as soon as they come in contact with it.

THE SIX-SPOTTED MITE.

his leaf mite or spider (*Tetranychus sexmaculatus* Riley—fig. 34), is ely allied to the common red spider of greenhouses. It first made ppearance as an important orange pest in Florida in 1886. Folng the severe freeze of the winter of 1885–86, the weakened trees seemed to be especially favorable for the multiplication of this mite; it increased suddenly in enormous numbers during the dry weather of the early summer and was responsible for very considerable damage to the foliage of the orange.

The original food plant of this mite is unknown. It was first noted on wild orange, from which it spread to other citrus trees. It is probably a native of Florida.

Like its allies, this insect is greatly influenced by climatic conditions, and needs for its excessive multiplication dry hot weather. Therefore, in rainy seasons it is not especially troublesome, and it usually disappears as soon as rainy weather sets in. In Florida its period of greatest destructiveness falls between February and the middle of May. This mite was carried to California a decade or more ago with Florida stock, doubtless at the same time that several other Florida citrus insects were transported to the Pacific coast. In California, however, the principal mite injury seems to be due to an allied species, also brought from Florida, *T. mytilaspidis*.[a]

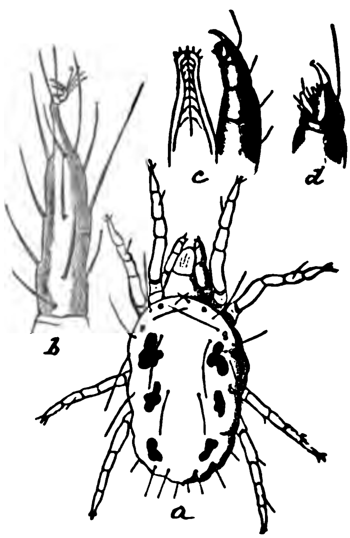


FIG. 34.—Six-spotted mite of the orange (*Tetranychus sexmaculatus*): *a*, dorsal view of adult mite—vastly enlarged; *b*, greater enlargement of foot; *c*, *d*, mouth parts (from "Insect Life").

The attacks of the six-spotted mite are confined largely to the under side of the leaves, which are covered with a fine web, beneath which the mite feeds. The first indication of its presence is usually a yellowing in streaks and spots of the upper surface of the leaves. The under surface becomes soiled by the accumulated excrements in the form of minute black spots and by the web of the mite. On badly attacked trees the foliage curls and shrivels and the trees may lose half or more of their leaves, and similarly also a large percentage of the half-formed fruit. Being an accompaniment of drought in Florida, part of the damage may undoubtedly be ascribed to the effect of the dry weather.

The remedies are the same as for the rust of silver mite. The bisulphide of lime is also an effective wash. It can be made very cheaply by boiling together in a small quantity of water equal parts of lime and sulphur. Five pounds of lime and 5 pounds of sulphur, dissolved by boiling, should be diluted to make 100 gallons of spray. Gassing is ineffective.

[a] See Bul. 145, Cal. Agr. Expt. Sta., for detailed account of this species.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 175.

Home Manufacture and Use of Unfermented Grape Juice.

BY

GEORGE C. HUSMANN,

*Expert in Charge of Viticultural Investigations, Bureau of Plant Industry,
U. S. Department of Agriculture.*

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1903.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
Washington, D. C., May 28, 1903.

SIR: I have the honor to transmit herewith a paper on Home manufacture and use of unfermented grape juice, by Mr. George C. Husmann, expert in charge of viticultural investigations in this Bureau, and to recommend it for publication as a Farmers' Bulletin.

Part of the matter contained in this paper has already been published in Bulletin No. 24 of this Bureau on the Manufacture and Preservation of Unfermented Grape Must, but the widespread interest in the subject and the demand for information regarding appliances and methods of manufacture adapted to the ordinary farm and kitchen makes desirable its wider circulation through the Farmers' Bulletin series.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON, *Secretary.*

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ILLUSTRATIONS.

HOME MANUFACTURE AND USE OF UNFERMENTED GRAPE JUICE.

INTRODUCTION.

Unfermented grape juice has no doubt been used ever since wine has been made from the grape. The following practical suggestions will enable housewives to put up unfermented juice at the time of the fruit harvest, and thus to utilize much fruit that is now annually lost through inability to preserve it in the fresh state. In this form it is a pleasant, wholesome drink and food well adapted to home use. On some farms enough such preventable wastes occur almost every year to largely reduce the possible profits, or even to cause failure to meet the running expenses of the farm. By preventing these wastes an unprofitable farm may often be made profitable.

HISTORICAL NOTES.

Galenius, the Greek physician and writer says (A. D. 131): "A good many Asiatic wines were stored in bottles which were hung in the corner of fireplaces, where, by evaporation, they became dry." This process was called "fumarium."

The Greeks had two kinds of wine, "protoplon," or first juice of the grape before pressing, and "denterion," or pressed juice. The Romans called them "vinum primarium" and "vinum secondarium." Some of them drank the juice before fermentation had started, and called it "mustum." After the must or juice had been through a heating process (called "reduction" nowadays), they called it "frutum," and when, after long heating, it had been reduced to one-half or one-third its original volume, they called it "sapa." This was used by the Romans on their bread and was equivalent to what we now call grape syrup.

In Europe physicians often send their patients to the wine-growing districts during vintage time to take daily rations of the fresh juice as it comes from the crusher. This, however, restricts its use to a brief season of the year and to the immediate vicinity of the vineyards, or to individuals who are yet strong enough to undertake the journey.

Of late years repeated efforts have been made to prevent the juice from fermenting and to preserve it in vessels of such size and shape as can be easily transported, thus rendering its use possible at all times of the year. Until recently its use has been almost exclusively restricted to juice for medicinal or sacramental purposes. Unrestricted and general use has been retarded through lack of knowledge of the principles underlying the process of manufacture. This lack of knowledge and of the necessary skill in applying it has resulted in many failures, thus rendering the production of a good article uncertain and expensive.

COMPOSITION OF THE GRAPE.

The grape contains 12 to 28 per cent of sugar, about 2 to 3 per cent of nitrogenous substances, and some tartaric and malic acids. The skins contain tannin, cream of tartar, and coloring matter. The seeds contain tannin, starchy matters, and fat. The stems contain tannin, diverse acids, and mucilaginous matter. The value of the juice made from any grape is determined by the relative proportion and composition of these various parts.

CAUSES OF FERMENTATION.

It is well known that grapes and other fruits when ripe have the invisible spores of various fungi, yeasts (ferments), and bacteria adhering to their skins and stems. When dry these spores are inert, but after the grapes are crushed and the spores are immersed in the juice they become active and begin to multiply. If the juice is warm, the changes take place rapidly; if, on the other hand, it is cool, the change is slower. But in either case, if left alone, the organisms increase until the juice ferments. The most favorable temperature for fermentation is between 65° F. and 88° F. Cold checks, but does not kill, the ferment. This fermentation, now commonly called the elliptic yeast, changes the sugar in the grape to alcohol and carbonic-acid gas, and is the leading factor in converting must[a] into wine. Hence it will be readily seen that to keep grape juice sweet fermentation must be prevented, and to be salable the product must be clear, bright, and attractive.

METHODS OF PREVENTING FERMENTATION.

Fermentation may be prevented in either of two ways:

(1) By chemical methods, which consist in the addition of germ poisons or antiseptics, which either kill the germs or prevent their growth. Of these the principal ones used are salicylic, sulphurous,

[a] The word "must" as used in wine making invariably refers to the unfermented juice of the grape and is so used in this publication.

boracic, and benzoic acids, formalin, fluorides, and saccharin. As these substances are generally regarded as adulterants and injurious, their use is not recommended.

(2) Mechanical means are sometimes employed. The germs are either removed by some mechanical means, such as filtering or a centrifugal apparatus, or they are destroyed by heat, electricity, etc. Of these, heat has so far been found the most practical.

When a liquid is heated to a sufficiently high temperature all organisms in it are killed. The degree of heat required, however, differs not only with the particular kind of organism, but also with the liquid in which they are held. Time is also a factor. An organism may not be killed if heated to a high temperature and quickly cooled. If, however, the temperature is kept at the same high degree for some time, it will be killed. It must also be borne in mind that fungi, including yeasts, exist in the growing and the resting states, the latter being much more resistant than the former. A characteristic of the fungi and their spores is their great resistance to heat when dry. In this state they can be heated to 212° F. without being killed. The spores of the common mold are even more resistant. This should be well considered in sterilizing bottles and corks, which should be steamed to 240° F. for at least fifteen minutes.

Practical tests so far made indicate that grape juice can be safely sterilized at from 165° F. to 176° F. At this temperature the flavor is hardly changed, while at a temperature much above 200° F. it is. This is an important point, as the flavor and quality of the product depend on it.

This bulletin being intended for the farmer or the housewife only, the writer refers such readers as desire to go into the manufacture of grape juice in a systematic manner for commercial purposes to Bulletin 24, Bureau of Plant Industry, Department of Agriculture, on the same subject, this publication treating only of methods that can be applied in every home.

HOME MANUFACTURE.

Use only clean, sound, well-ripened but not over-ripe grapes. If an ordinary cider mill is at hand, it may be used for crushing and pressing, or the grapes may be crushed and pressed with the hands. If a light-colored juice is desired, put the crushed grapes in a cleanly washed cloth sack and tie up. Then either hang up securely and twist it or let two persons take hold, one on each end of the sack (fig. 1, p. 8), and twist until the greater part of the juice is expressed. Then gradually heat the juice in a double boiler or a large stone jar in a pan of hot water, so that the juice does not come in direct contact with the fire, at a temperature of 180° F. to 200° F.; never above 200° F. It is best to use a thermometer, but if there be none at hand heat the juice until it steams, but do not allow it to boil. Put it in a glass or enameled vessel to settle for twenty-four hours; carefully drain the juice from the sediment, and run it through several thicknesses of clean flannel, or a conic filter made from woolen cloth or felt may be used. This filter is fixed to a hoop of iron, which can be suspended wherever necessary (fig. 2). After this fill into clean bottles. Do not fill entirely, but leave room for the liquid to expand when again heated. Fit a thin board over the bottom of an ordinary wash boiler (fig. 3), set the filled bottles (ordinary glass fruit jars are just as good) in it, fill in with water around the bottles to within about an inch of the tops, and gradually heat until it is about to simmer. Then take the bottles out and cork or seal immediately. It is a good idea to take the further precaution of sealing the corks over with sealing wax or paraffin to prevent mold germs from entering through the corks. Should it be desired to make a red juice, heat the crushed grapes to not above 200° F., strain through a clean cloth or drip bag, as shown in fig. 4 (no pressure should be used), set away to cool and settle, and proceed the same as with light-colored juice. Many people do not even go to the trouble of letting the juice settle after straining it, but reheat and seal it up immediately, simply setting the vessels away in

FIG. 1.—Cloth and press.

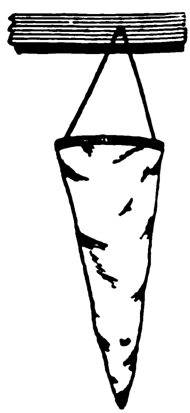

FIG. 2.—Cloth or felt filter.

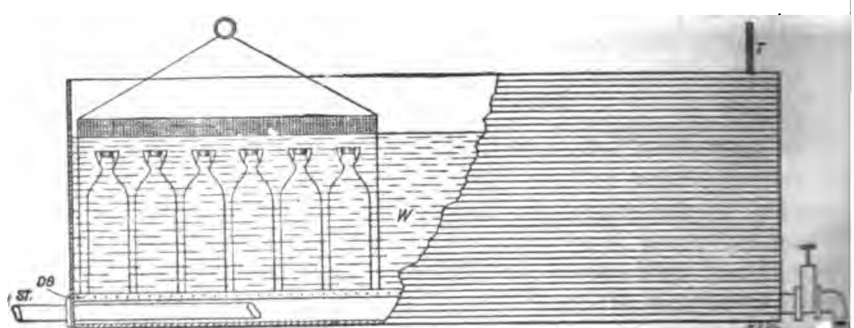

FIG. 3.—Pasteurizer for juice in bottles: *DB*, Double bottom. *ST*, Steam pipe. *W*, Water bath. *T*, Thermometer. (Bottle shows method of adjusting a cork holder of sheet metal.)

a cool place in an upright position where they will be undisturbed. The juice is thus allowed to settle, and when wanted for use the clear simply taken off the sediment. Any person familiar with the ı of canning fruit can also preserve grape juice, for the princi- volved are identical.

of the leading defects so far found in unfermented juice is that of it is not clear, a condition which very much detracts from its wise attractive appearance and due to two causes y alluded to. Either the final sterilization in s has been at a higher temperature than the pre- g one, or the juice has not been properly filtered s not been filtered at all. In other cases the has been sterilized at such a high temperature t has a disagreeable scorched taste. It should membered that attempts to sterilize at a tem- ure above 195° F. are dangerous, so far as the of the finished product is concerned.

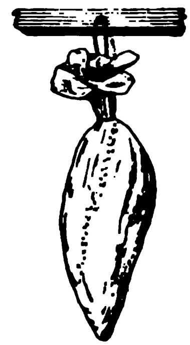

FIG. 4.—Drip bag.

other serious mistake is sometimes made by put- he juice into bottles so large that much of it be- ı spoiled before it is used after the bottles are d. Unfermented grape juice properly made and bottled will keep nitely, if it is not exposed to the atmosphere or mold germs; but a bottle is once opened it should, like canned goods, be used as soon as possible, to keep it from spoiling.

FIG. 5.—Barrel and skid.

MANUFACTURE OF LARGER QUANTITIES.

Another method of making unfermented grape juice, which is often resorted to where a sufficiently large quantity is made at one time, consists in this:

Take a clean keg or barrel (one that has previously been made sweet). Lay this upon a skid consisting of two scantlings or pieces of timber of perhaps 20 feet long, in such a manner as ıke a runway (fig. 5). Then take a sulphur match, made by dip- strips of clean muslin about 1 inch wide and 10 inches long into d brimstone, cool it and attach it to a piece of wire fastened in the end of a bung and bent over at the end, so as to form a hook (fig. Light the match and by means of the wire suspend it in the barrel, the barrel up tight, and allow it to burn as long as it will. Repeat ntil fresh sulphur matches will no longer burn in the

Then take enough fresh grape juice to fill the barrel one-third full, bung up tight, and roll and agitate violently on the skid for a few minutes. Then burn more sulphur matches in it until no more will burn, fill in more juice until the barrel is about two-thirds full; agitate and roll again. Repeat the burning process as before, after which fill the barrel completely with grape juice and roll. The barrel should then be bunged tightly and stored in a cool place with the bung up, and so secured that the package can not be shaken. In the course of a few weeks the juice will have become clear and can then be racked off and filled into bottles or jars direct, sterilized, and corked or sealed up ready for use. By this method, however, unless skillfully handled, the juice is apt to have a slight taste of the sulphur.

Fig. 6.—Sulphur hook.

A FEW USEFUL APPLIANCES.

Fig. 7 shows a very practical and inexpensive corking machine. The illustration shows the cork in place, ready to be driven through the tapering hole in the machine into the neck of the bottle underneath. The corks should be put in hot water and allowed to stand for a few minutes before using in order to soften and make them pliable. This enables one to use a cork large enough to seal securely.

Fig. 7.—Corking machine.

Care should be taken to set the bottles on a flat piece of rubber or on a piece of cloth folded several times, as shown in the figure, so as to take the jar of the blow when the cork is driven. It is even a wise precaution to have a pan underneath, as it frequently occurs that bottles thought to be entirely good have blemishes and break.

An ordinary cider press is not expensive; nevertheless the majority of farms do not have one, and it frequently occurs that a farm is locat so far away from any establishment dealing in such implements that the fruit might spoil or not be sufficiently valuable to justify the purchase price and time lost and expense incurred in getting it. Fig. 8 gives an illustration of a lever press, very efficient for this and similar uses, which any farmer handy with tools can make, the material for which can be found on almost any farm at any time. The press consists of the following parts:

Two upright posts (F) set deep and firmly in the ground side by side and about 12 inches apart. (It is a good idea to attach some deadmen to them in the ground to prevent them pulling out too easily.) Between these posts the lever (E) is hung by means of a bolt (T), or the lever may be hung to the side of a building, or a hole notched into a tree large

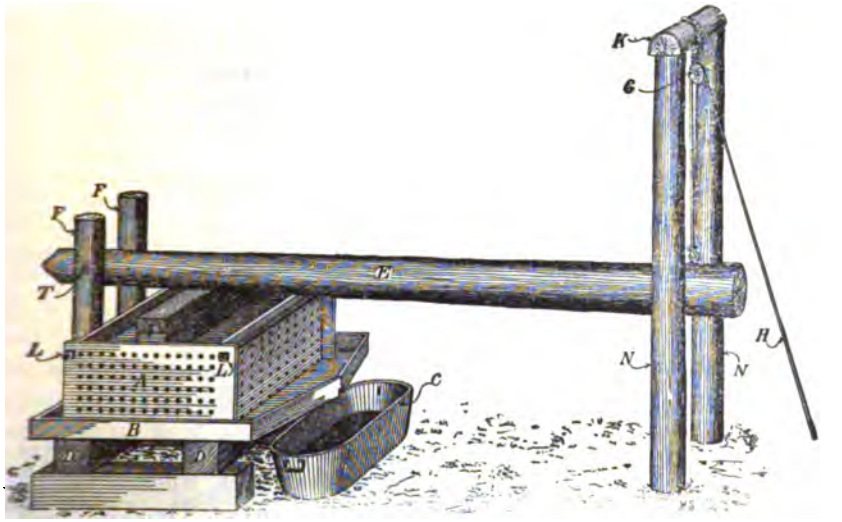

FIG. 8.—Home-made lever press. A, Press basket. B, Press bottom. C, Tub. D, Skids. E, Lever. F, Upright posts. G, Block and tackle. T, Lever bolt. I, Press block.

nough to admit the end of the lever and a bolt run through that. At e other end of the lever are two posts, so set that the lever can be ised up between them by means of block and tackle. The press itself nsists of two timbers (D), on which the press bottom (B) rests, and n this bottom is the press basket, consisting of the two sides and two ds, and so constructed that it can be easily taken apart and set up gain, being held together at the ends by means of rods (L). The sides d ends should be bored full of small holes from three-eighths to one-lf inch in diameter to allow exit for the juice.

After the press is filled, the top (which is made to fit in the inside of e basket) and cross blocks (I) are put on and the lever is then allowed press down on it. A press like this has the advantage that it can be led in the evening and left to press until morning while the farmer sleeps. The precaution, of course, must be taken to set a tub (C) large enough to hold the juice under the press.

It is perhaps well to state that the longer and heavier the lever the greater the pressure it exerts. Where it is not convenient to make the lever very long, weights are placed or hung on the outer extremity of the lever to increase the pressure. It will thus be seen that with a little ingenuity a person can adapt the press to suit his individual requirements.

For ordinary purposes a press basket 3 feet square and 2 feet high will be found a very convenient size. This will accommodate a ton of crushed grapes.

COMPOSITION OF UNFERMENTED GRAPE JUICE.

Herewith are given the component parts of a California and a Concord unfermented grape juice, the former being analyzed by the California Experiment Station, the latter by the Bureau of Chemistry, United States Department of Agriculture:

	Concord.	California.
	Per cent.	*Per cent.*
Solid contents	20.37	[illegible]
Total acids (as tartaric)	.663	[illegible]
Volatile acids	.023	[illegible]
Grape sugar	18.54	18.15
Free tartaric acids	.025	[illegible]
Ash	.255	.19
Phosphoric acids	.027	[illegible]
Cream of tartar	.55	[illegible]

This table is interesting in so far that California unfermented grape juices are made from Viniferas or foreign varieties, whereas the Concord is a Labruska or one of our American sorts. The difference in taste and smell is even more pronounced than the analysis would indicate.

FLAVOR AND QUALITY IN GRAPE JUICE.

In the making of unfermented grape juice a great deal of judgment can be displayed and many variations produced so as to suit almost any taste by the careful selection of the varieties of grapes from which it is made. From the Mission grape, for instance, when fully ripe, a juice would be obtained that would be delicate and simply sweet, without any other taste; from the Muscat we would get that rich musky flavor found in our leading raisins; in the Concord that sprightly foxy taste so well known; in the Catawba or Isabella that fragrance so peculiarly their own, and in the Iona a pleasing, mild, yet just pronounced enough aroma and taste to strike the right spot. Thus we might continue along the list.

Equally as pronounced variations in color can be had, as, for instance, almost colorless, yellow, orange, light red, red, and a deep purple.

The writer has often been asked what kind of grapes should be used in making unfermented grape juice, when, as a matter of fact, it can be made from any grape; not only this, but unfermented juice is made from other fruits as well, for instance, apples, pears, cherries—and berries of different kinds yield excellent juices. It is really good judgment in selecting the right varieties when planting for fruit production. That also determines the quality of our unfermented juice. For instance, the richer, sweeter, and better in quality the fruit we use, the richer, sweeter, and better will be our unfermented juice. If, on the other hand, the fruit is sour, green, and insipid, the juice will be likewise. As stated before, the intention of this bulletion is to show how to avoid some wastes, and to increase income by utilizing those products of which there is a surplus, and instead of, as is usually done, letting them rot, convert them into something that can be kept, used, and disposed of at any time when desired, or when fresh fruit is not available.

USES OF UNFERMENTED GRAPE JUICE.

The uses are indeed many. It is used in sickness, convalescence, and good health; as a preventive, restorative, and cure; by the young, by persons in the prime of life, and by those in old age. It is used in churches for sacramental purposes; at soda fountains as a cool and refreshing drink; in homes, at hotels, and at restaurants as a food, as a beverage, as a dessert, and in many other ways. When people become accustomed to it they rarely give it up. When properly prepared, unfermented grape juice can be made to please the eye by its color and attractive appearance, the sense of smell by its aroma or fragrance, the palate by its pleasant flavor.

It is food and drink, refreshment and nourishment, all in one. Not a by product, but made from fruit going to waste—one of the blessings given us, that some are too careless, others too ignorant, to make use of.

FOOD VALUE OF UNFERMENTED GRAPE JUICE.

The effects of unfermented grape juice on the human system have been studied for a number of years, especially at the so-called grape cures so long in vogue in Europe. A smaller number of investigations have been made in laboratories.

It is quite generally claimed that using a reasonably large amount of unfermented grape juice with an otherwise suitable mixed diet is beneficial and that digestion is improved, intestinal fermentation diminished, and that gains in body weight result. It should not be forgotten that the abundant diet and hygienic methods of living practiced at the

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 182.

POULTRY AS FOOD.

BY

HELEN W. ATWATER.

PREPARED UNDER THE SUPERVISION OF THE OFFICE OF EXPERIMENT STATIONS.

A. C. TRUE, Director.

WASHINGTON:
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1903.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., September 25, 1903.

SIR: I have the honor to transmit herewith an article on poultry as food, by Miss Helen W. Atwater, prepared in accordance with instructions given by the Director of this Office, and under the immediate supervision of Prof. W. O. Atwater, chief of nutrition investigations. From time to time this Department has published popular summaries and discussions of the nutritive value and importance in the diet of different food materials, especially those which are most commonly used. In the present bulletin, which is of the same general character, it has been the purpose to include data which have accumulated in connection with the nutrition investigations carried on by this Department and material reported by the experiment stations, supplementing this by such information gathered from general sources as needed for an adequate discussion of the subject. The poultry industry represents a large investment of capital and is of importance in all regions of the country. The present article, it is believed, is a useful summary of available information regarding the place of poultry in the diet, and its publication as a Farmers' Bulletin is therefore recommended.

Respectfully,

A. C. TRUE,
Director.

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

POULTRY AS FOOD.

INTRODUCTION.

Poultry has for many centuries supplied a large proportion of the food of civilized man, and in almost every country of the world the poultry industry is an important branch of agriculture. According to the returns of the census for 1900, the total number of chickens, including guinea fowls, on farms in the United States was 233,598,085; the total number of turkeys, 6,599,367; geese, 5,676,863, and ducks, 4,807,358. From the statistics gathered it appeared that poultry was kept on 88.8 per cent of the farms in this country, and that the total value of the poultry raised on farms in 1899 was $136,891,877. Although many chickens are kept for eggs rather than for their flesh, a good proportion of them finally appear in the meat market, and almost all of the other varieties of poultry are bred primarily for the table. It is safe to say that 250,000,000 chickens and other kinds of poultry are consumed in this country each year.

DEFINITION OF POULTRY.

In its strictly technical sense the word "poultry" is used to describe birds domesticated for their eggs or flesh. Game birds are often used on the table, and, as in the case of some wild ducks, may be closely related to domestic varieties; but as long as they are in their wild state they can not be classed with poultry. Nor are all domesticated birds necessarily poultry. Pigeons bred for ornament or as carriers would not come under that head, though they do belong there when bred for their flesh. Peafowls were formerly often bred for the table and were an important variety of poultry; but now they are bred mainly for ornament and form an almost negligible part of the poultry industry.

From this it will easily be seen that the kinds of birds included under the term poultry may differ in different places and at different times. Here and in Europe, however, it now commonly includes chickens, turkeys, geese, ducks, guinea fowls, pigeons, and occasionally peafowls, pheasants, quail, and swans.

Chickens, turkeys, guinea fowls, pheasants, and quail belong to the same scientific order of birds—the Gallinaceæ, or comb bearers—and resemble each other more or less closely in structure and habits. They are distinguished from other birds in that the flesh on the breast and wings is lighter in color than on the rest of the body. This difference in the flesh in different parts of the birds is not fully understood; it is generally supposed that the light flesh has less muscular power. At any rate, these birds, whose chief means of locomotion is walking and who consequently do not need as strong wings and breasts as flying or swimming birds, have paler breast and wing flesh. The difference in color is apparently due to variation in the amount of hemoglobin (the principal red substance of blood) present in the flesh. Investigations carried on in France a number of years ago showed that the red color was a product of muscular activity. In other words, when muscles work as actively as those of the breast of flying birds this red coloring matter is produced.

Pigeons belong to the order of Columbidæ, or doves, and are its only representatives in the poultry world. They, in a way, stand between the comb bearers and swimmers, as there is a slight difference between the color of the flesh on the breast and on other parts of the body, but not so great a difference as in the comb bearers. They are, however, sometimes classed with the white-fleshed birds.

Ducks, geese, and swans belong to the order Natatores, or swimmers, characterized by their web feet and long, thick bills.

VARIETIES OF POULTRY.

CHICKENS.

In all probability chickens were at a very early period domesticated from the jungle fowl native in southwestern Asia and Oceania. By mating individual birds which are bred under peculiar conditions or which showed especially desirable traits, many breeds have been developed, each of which has certain distinct qualities fixed in it. American poultry experts designate as "meat or table breeds" the Asiatic class, which includes Light and Dark Brahmas; Buff, Partridge, White and Black Cochins, and Black and White Langshans.

A good table bird should have a large proportion of flesh to the size of its bones, and a large, full breast, on which is found the delicate white meat. Long, thin legs and wings are undesirable, as they contain much bone and little meat. In England dark-legged birds are considered better than those which have legs and body of the same color, but in this country the preference is for the latter, though the reason for either choice is not clear. Light-colored birds perhaps pluck cleaner than dark ones, and are easier to make attractive for the market, which demands a skin free from visible pinfeathers. It is safe to say that almost any of the standard breeds, except some of the fancy varieties, can be made into good table birds. However, some of the fancy varieties, notably Games, are thought to be especially desirable for the table, and the Pit Game, it is said, has always been considered satisfactory for this purpose, the flesh being fine grained, tender, and sweet.

Ordinarily the breeder depends on eggs as well as table birds for his profit, and selects free-laying, well-shaped, hardy varieties, relying on care and feeding to develop the quality and flavor of the flesh. Plymouth Rocks and Wyandottes are probably the most satisfactory of the common breeds used in this country for "general purpose" birds.

Next in importance to the qualities of the breeds are proper care and feeding. Cleanliness is especially important when the birds are destined for the table, for dirt or taint of any kind injures their appearance or affects the flavor of the flesh and makes it very unattractive and often actually harmful.

Hens under usual conditions, at least in temperate regions, lay most abundantly in the early spring and summer, and hence the best season for "spring" chickens and broilers—i. e., chickens from two to four months old—is from May to September or October. Older chickens are of course to be had at all times of the year, but they are most frequently sent to market in the winter months, when the hens are laying poorly.

The flesh of a mature cock is usually thought to be too tough and highly flavored to be very palatable; accordingly, if a poultryman has more cockerels than he can dispose of advantageously as chickens he often resorts to caponizing. If successfully performed the bird will bring a fine price whenever marketed, for capons are considered the choicest of table fowl. Their flesh has the tenderness of a pullet, with a much better flavor; moreover, the tender parts of the body develop more than in ordinary chickens, giving a larger proportion of white meat. Poulards, as the spayed females are called, are fattened to some extent, notably in France, though it is doubtful if their flesh is much better than that of the ordinary pullet.

TURKEYS.

These birds were imported into Europe from North America, where very similar varieties are still found wild. Their English name is probably due to a misapprehension with regard to the country from which they came. At present they are much more common here than in Europe. Many breeders find that the birds improve in hardiness and their flesh in flavor by an occasional introduction of wild blood, and a wild "gobbler" is often kept for mating. Birds with three-eighths or one-quarter wild blood are considered the most satisfactory table birds.

There is little demand for young turkey chicks, which are very scrawny and do not bear shipping well. However, in July and August growers near fashionable summer resorts can sometimes sell "broilers," weighing from 1½ to 4 pounds each, for $3.50 or $4.50 a pair. The general market rarely sees fresh turkeys before September, and the season can hardly be said to begin before the last of October. Many of the birds are fattened to very large size (25 to 30 pounds) for the Thanksgiving and Christmas trade, but from January until the season for fresh turkeys ends in late February or March medium-sized birds are most abundant. New England turkeys are to be had in eastern markets up to Christmas time, but later in the winter the birds are supplied mainly from the West, whence come also the "cold-storage" turkeys of the summer months.

GUINEA FOWLS.

As the name implies, these birds are natives of Africa. They have been carried to many parts of the world, but do not yield to domestication as easily as some other kinds of poultry. They are quite commonly bred, especially in the southern United States, as egg producers and for the table. With proper treatment they can be made very profitable, as both flesh and eggs are highly prized delicacies. Young birds are ready for market in the early autumn, and older birds may be bought all through the winter. The young chicks and caponized birds have tender flesh, with a flavor like that of partridge, while older birds are thought to resemble pheasants in taste. Coming as they do when game is scarce, they are much esteemed as a substitute for it. To get the best flavor many believe the bird should not be cooked until it has been killed for some days, or just before it begins to "turn."

PEAFOWLS.

These birds, as we have seen, are not always to be regarded as poultry, but they are bred for the table frequently enough to warrant mention here. In classic days they were considered very delicate eating, especially the hen, and during the middle ages the peacock, served whole and garnished with his own gorgeous plumage, made the principal dish at many feasts. Like many other kinds of poultry, they were introduced into Europe from Asia.

The hens lay during the summer months, which brings the market season for young birds into the winter. They have a large amount of flesh in proportion to the weight of bone. Some persons consider the flesh of peahens as delicate as that of pheasants; others call it dry and tasteless; but nowadays all agree that a mature peacock is not worth the eating, and peafowl of all ages are rare in our markets.

PHEASANTS.

These birds originated in Asia. Strictly speaking they have even less place in the poultry world than peafowl, for they are bred almost exclusively for sport or ornament; but they are coming to be used so much on our tables that it will not be out of place to speak of them here.

Pheasants have always been considered a delicacy, and now are especially valued for the variety they give to the bill of fare. Their flesh is tender, but has little taste until it has been kept for some time. The hens are preferred to cocks for table purposes. The birds are usually shot in their first year and weigh from 3 to 4 pounds on the average. Most of those seen in our markets have been sent from England or from Russia in cold storage, although the number reared in this country is constantly increasing.

QUAILS.

These delicious little birds have long furnished some of the choicest titbits of the hunting season, but it is only quite recently that they have been domesticated to any appreciable extent. The industry of taming and raising quails for aviaries and for the table is still very small, but if reports can be relied upon it is perhaps well enough established in the United States to suggest classifying the birds with poultry. The European quail is not found in America, but the name is loosely applied to various similar birds in the United States, most commonly perhaps to the species known as Bob White, or in some regions as partridge. It is this bird which is ordinarily tamed. As yet quail, like pheasants, are too expensive for common use, but they give a most delicate variety to the epicure's bill of fare.

PIGEONS AND SQUABS.

The varieties of pigeons used for food have been developed from the wild blue rock dove, but are considerably larger than their wild ancestors. They have always been used as food in Europe, but in this country they have only recently become generally common. The flesh of birds which have been allowed to fly becomes so tough that it requires very long and careful cooking to make it palatable. Consequently the young birds, called squabs, are most usually eaten and are in great demand for restaurants, hotels, etc. The young birds are generally at their best for the table when about four weeks old, that is, after they have begun to grow plump, and before they leave the nest to fly. Squabs are most plentiful in midsummer, but when artificial mating and breeding is practiced the young birds can be obtained the year round, the best often appearing in midwinter. Adult pigeons, which are rarely seen in any but the largest markets, are much cheaper than squabs. A recent publication of this Department[a] treats of squab raising for market and the various topics which would naturally be included under this subject.

DUCKS.

Most of the domesticated breeds of ducks have been derived from the wild Mallard. Duck breeding has long been practiced in the Old World, where the birds are extensively used for the table, but until recently they have been raised in this country only incidentally by farmers who happened to have access to pond or stream. Of late years, however, the duck-raising industry has been greatly developed, with the result that the birds are much improved in size and quality, and are more commonly eaten than formerly. The young of certain early maturing breeds are known to poultry dealers as "spring ducks," and begin to reach the market in May and may be had until January. Old ducks can be obtained at any season, but are best during the winter months.

GEESE.

Geese have been used as table birds at least ever since the days of ancient Egypt. They are now common all over the world, but perhaps most abundant in Germany, where their flesh is relished in every imaginable form, from the smoked Pomeranian goose breast to the popular "Pökelgans," pickled, stewed, and preserved in fat. Goose fat is also preserved in Germany, and is often eaten on bread in place of butter, and is considered unexcelled in the preparation of many dishes. Among orthodox Jews everywhere it is frequently used as a culinary fat. Pâté de foie gras, made from the livers of specially fattened geese, will be described in a later section (p. 16).

Geese live to a great age, but for table purposes they should be killed when 3 years old at the latest, and most persons would probably consider even that much too old. Their flesh becomes very tough as the birds grow older, and loses its agreeable flavor.

Green geese (half-grown birds) can be had from May until early winter; older birds can ordinarily be procured at any season.

SWANS.

These birds are usually bred for ornament rather than for the table, but occasionally a few are kept among a flock of geese, and the young, called "cygnets," are killed for eating, perhaps most commonly in England. Some persons consider them delicious, but most regard their flesh as too highly flavored to make them popular table birds. In earlier times they were more commonly eaten than at present.

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[a] U. S. Dept. Agr., Farmers' Bulletin 177.

POULTRY FEEDING IN ITS RELATION TO FOOD VALUE.

There are many conditions which influence the flavor and quality of poultry flesh. Doubtless one important factor is breed, but our information on this point is as yet so scanty, and is so little considered by marketmen—size being more often the prime requisite—that not much can be said of it. Another factor is age. Everyone knows that a young bird has tender, delicately flavored flesh and that an old one is tough and stronger in taste, the changes being doubtless due to the toughening of the muscle fibers and an increase in nitrogenous substances called extractives, which give the flavor to all kinds of meat. Sex causes similar differences, the female birds as a rule being more tender and less highly flavored than males. Flavor and especially toughness are also increased by too much exercise.

The effect of food on the quality and flavor of the flesh is even more important and more easily controlled. It has been observed, for example, that if geese and ducks are allowed to eat too many of the fish and water bugs of which they are so fond, their flesh develops an undesirable "fishy" flavor; and if poultry eat onions or wild garlic habitually the effect on their flesh is also marked. On the other hand, the peculiar and delicious flavor of the Chesapeake canvas-back ducks is said to be due to the wild celery on which the birds feed along the shores of the bay.

All these facts and many others must be taken into consideration by the man who is raising poultry for the table, as they will help him to get the best returns in flesh for the least expense for food and care. But the subject of poultry feeding and management with reference to the profitable production of eggs and birds for market is too large for discussion in this place, even if it were desirable.

The essential points for raising table birds are, briefly, sufficient variety in the feed and proper proportions of protein, fats, and carbohydrates, with grit (and lime), pure drinking water, and sanitary surroundings. In most of the feeding experiments with poultry which have been reported the question generally studied has been the profitable production of eggs or of marketable birds; that is, the comparative merits of different feeds and rations for increase in egg production or inducing gains in weight quickly and economically. In a few cases the effect of the feed on the appearance, flavor, or quality of the flesh has also been considered, and some reference should be made to such studies.

Many breeders believe that soft food, that is, crushed grains or paste, is more easily and completely digested by the birds, and that it produces more tender flesh. In experiments made at the New York State station, chickens, laying hens, and capons all produced better results with ground than with unground grain. According to a test at the Canada Experimental Farms, chickens fed a ground-grain ration were when dressed 5 per cent heavier, were plumper, slightly yellower, and of better appearance than chickens fed a similar ration of unground grains. When cooked the flesh of the birds fed the ground grain was regarded as juicier, "owing evidently to a marked (though not excessive) deposition of fat in the tissues."

Some have advanced the theory that warm food was preferable to cold, but experiments made along this line at the Ontario Agricultural College and Experimental Farms indicate that mixing feed with hot water has little effect on the quality of the flesh.

In regard to the influence of food on the color of the flesh, it is said that animal feed, as meat meal, scraps, etc., tend to make it darker, and it seems fair to say that this may be true of any food rich in nitrogen. At the Cornell station two similar lots of chickens were fed, one a nitrogenous ration of wheat and skim milk, the other a carbonaceous ration of Indian corn. When they were killed the flesh of the first lot appeared darker, more tender and juicy than the second, which, however, contained larger masses of fat. On the other hand, a ration of yellow corn used at the Ontario Agricultural College and Experimental Farms produced "dark yellow" flesh, while oats, buckwheat, and milk gave a "creamy white" color. In later experiments the presence of a considerable amount of corn meal in the ration with ground buckwheat and pearl oat dust produced a rather cream-colored flesh. From these somewhat conflicting statements it will be seen that although the food eaten apparently has an effect on the color of the flesh, our actual knowledge of the subject is as yet very uncertain. It is commonly believed in the United States that the fat fowls with yellow skin which are wanted can be secured most cheaply by feeding a grain ration composed largely of Indian corn for two or three weeks before the fowls are slaughtered.

FATTENING POULTRY AND ITS EFFECT ON FOOD VALUE.

GENERAL METHODS OF FATTENING.

Wherever the poultry industry has been highly developed, fattening has formed an important and often a separate branch. In France, especially about Houdan and in Normandy, the art of fattening has long been extensively and very skillfully practiced. Very often the rearing and fattening are done in separate establishments. The largest poultry market in the world is held in Houdan. Here live birds are brought in by breeders by the thousands, and bought by fatteners who, a few weeks later, bring them into another section of the market plump and fattened for the table. In Great Britain, also, fattening forms a separate branch of the poultry industry. Thousands of Russian chickens are annually sent into Germany to be fattened for German markets. Belgian poultrymen are said to make a regular practice of importing fine laying Leghorn pullets from Italy, keeping them one season for their eggs, and then fattening them for the market. In the United States the fattening of poultry is less commonly practiced in separate establishments, nor is it anything like as general in Europe, although probably most poultrymen keep their birds on a special ration for awhile before marketing them. Within a few years experiment stations and private breeders have been making very interesting investigations of the subject.

One of the points most discussed is whether birds fatten better when confined in small pens than when remaining at large. The advocates of liberty maintain that the abnormal quiet of the penned birds prevents their getting the full value of the large rations, or induces the formation of fat rather than flesh, while those who prefer the use of pens hold that the flesh of the resting birds becomes equally abundant and much more tender. To help settle the question, experiments were made in Canada in which turkeys and chickens were fattened, part at large, part in small pens. The results were that "the penned fowl, both turkeys and chickens, were plumper and in every way more inviting than those which had been running at large; but that close confinement appeared to injure the chickens otherwise." In other tests the conclusion was reached that the practice of fattening chickens in crates is to be commended and that by using a cramming machine to feed them chickens can be given a finer appearance when dressed than those fed in the ordinary way. In a subsequent experiment, however, it is said the pen-fed birds presented a finer appearance as to color and size when dressed than similar birds fed in a crate. Other experiments have been made at the Maine Station, in which chickens were fattened, some in small pens, and some having the run of a small yard. The penned chickens made gains as great or greater than those obtained by similar methods in Europe, while those with a little liberty made still greater gains and appeared in every way as inviting. If these two sets of experiments may be relied on, the verdict seems to be that a little exercise is better for fattening than either close confinement or full liberty.

SPECIAL FATTENING OF GEESE—FOIE GRAS.

The most extreme method of artificial fattening is employed with geese whose livers are to be used for the delicacy known as "foie gras" (fat liver). This art of fattening geese until fatty infiltration of the liver has set in and that organ weighs from 2½ to 3 pounds is practiced on a large scale about Strasburg, and to a less extent about Toulouse and elsewhere. The birds are usually confined in small, dark cages, where they can move only a few inches, and are fed two or three times a day, commonly with all the ground maize or wheat-flour paste they can be made to eat. When they have become very fat, usually at the end of about three weeks, they are killed and the livers removed.

The livers, which are perhaps no more abnormal than the flesh of an over-fat hog, commonly appear in our markets in jars or tins in three distinct forms: *Foie gras au naturel*, *pâté de foie gras* (by far the most popular), and *purée de foie gras*. The *foie gras au naturel* is simply the liver preserved without any dressing. The *pâtés* are made of large pieces of the liver, cooked and dressed with truffles and other condiments. These pieces are fitted into cans by trimming off the edges, and are covered with melted goose fat or suet. Many persons find the flavor of the goose fat too strong and prefer the suet. The trimmings of the liver in the *pâtés* are preserved with truffles, etc., and sold as *purée de foie gras.*

DRESSING AND MARKETING POULTRY.

CLEANLINESS.

Poultry of different kinds and in different places is prepared and marketed in a variety of ways, but, however it is done, the dealer and the purchaser should insist on cleanliness everywhere—in killing, plucking, and packing, as well as in storing and displaying. Not only is any suggestion of dirt very disagreeable in connection with our food, but dirt, especially about flesh foods, is an open door to decay and disease.

LIVE POULTRY.

In the United States poultry is usually killed before it is sent to market, though in country districts and often in southern cities it is sold alive. Of course this insures freshness, but it entails on the purchaser the bother of killing and plucking, which most persons gladly avoid. Birds sent to market alive should be humanely treated. Too close confinement, lack of water, etc., are needless cruelties and, besides, injure the appearance or quality of the birds for the table.

KILLING AND PLUCKING.

It is well to make the bird fast for twelve hours or more before it is killed, in order that its crop may be quite empty and the other organs as free as possible from excrementitious substances. It is generally conceded that the best way to kill a bird is to sever the main artery in the roof of the mouth. When this is done the bird quickly bleeds to death. As soon as cut it should be hung head down, to allow the blood to run out of the body. Immediately after the bird is dead, and before the animal heat has left the body, the feathers should be plucked out.

pains being taken to remove all the pinfeathers and not to tear the skin. The feathers come out more easily if the carcass is put in boiling water for a few minutes; but this method, although very common, injures the wholesome look of the skin and, it is believed, makes the flesh decompose more quickly. Dry picking is therefore far preferable and should be insisted on.

COOLING AND "PLUMPING."

If a bird is to be kept before using, it should be put in a cool place to drive out the animal heat, which if left in might hasten decomposition. Some poultry men put the plucked birds into cold water, which serves the double purpose of cooling them and of making them look plumper. There may be no objection to it if the water is clear and they are left in only a few minutes, but if they are allowed to soak until they swell beyond their natural size it is certainly fraudulent and probably injurious. A still more objectionable way of plumping birds is by blowing them out. This is bad enough when a bellows is used, but when, as is often the case, the dresser blows directly from his mouth it is disgusting and dangerous.

CHANGES IN DRESSED POULTRY FLESH.

In the Southern States and other warm regions chicken is often prepared for the table just after it is killed, a practice almost unknown in the North. In that case the bird is cooked before the animal heat has left the body, and the flavor of the meat differs somewhat from that of a bird which has been kept. If the bird is not to be cooked immediately after it is killed, it should be kept twelve hours or more before it is used. After the animal heat leaves the body a change known as "rigor mortis" sets in, which stiffens the flesh and tendons until they become quite hard. After some hours, however, this stiffness gradually passes off, probably as the result of the growth of micro-organisms or the action of natural ferments in the flesh. The first noticeable effect is the softening of the flesh and tendons, which increases for some days. Other changes also take place, which after a time, when they become more apparent, we call decomposition or putrefaction. These in their later stages are accompanied by a characteristic odor and a disagreeable, acid taste. The younger the animal the more rapidly does this decomposition set in. Pheasants, wild duck, and some other wild birds are by many considered best for the table just as this taint begins to appear and give the meat a so-called "gamey" quality; but no animal flesh should be eaten after the taint becomes strong, for it is often the herald of ptomaines, very poisonous substances sometimes developed by micro-organisms.

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DRAWN AS COMPARED WITH UNDRAWN POULTRY.

One of the much-debated questions among poultry dealers and consumers is whether or not birds keep better when marketed drawn (i. e., with the internal organs removed) or undrawn. Practice varies in different localities. Opening the body and removing the viscera undoubtedly exposes the internal surface to the air, which always contains micro-organisms, and thus invites decomposition; but, on the other hand, it must be remembered that the viscera decompose more rapidly than other parts of the body, and if left in are likely to infect the rest of the bird. Of course in removing them great care and cleanliness should be observed. Washing the inside of a badly drawn bird with salt and water is said to hinder infection. In experiments reported a few years ago properly drawn birds kept sweet two or three days longer than undrawn ones. In the case of undrawn birds the digestive organs contain more or less moist, partly digested material. The liquid in such matter can pass through the walls of the intestines, etc., and it is thus possible that dissolved bodies of unpleasant flavor can find their way into the adjacent flesh and that the flavor of undrawn poultry which is kept for any considerable time may be injured.

COLD STORAGE.

The micro-organisms which produce the undesirable chemical changes in flesh grow more quickly at a moderately high temperature than at a low one, and in a damp place than a dry one. Ordinarily poultry will remain sweet for a week or more in a temperature of 50° F., but if it is to be kept longer it must be stored in a dry place at a temperature no higher than 34° F. In such "cold storage" it will keep almost indefinitely. Many dealers buy large quantities of poultry when it is most plentiful and keep it over until few fresh birds are available. The ordinary cold-storage season for poultry lasts, roughly speaking, from October until May, though our midsummer turkeys are proof of its occasional extension. Very young birds and some of the delicate game birds do not stand cold storage well, but others keep in excellent condition. Once taken from the storehouse, however, they decompose much more quickly than fresh birds and in the off season buyers should be on their guard against birds which have been unpacked too long.

Sometimes, especially in hot weather, birds are frozen before storing. For this they should be subjected for a time to a temperature of from 5° to 10° F., and then stored in a temperature of about 30° F. Frozen meat of any kind decomposes very quickly when exposed to warmth, and many persons consider that freezing injures the flavor of poultry. For both these reasons ordinary cold storage is preferable to freezing.

MARKS OF GOOD POULTRY.

Nothing is more important to the average buyer of poultry than to know how to distinguish between good and bad, young and old birds. A good, fresh bird shows a well-rounded form, with neat, compact legs and no sharp, bony angles on the breast, indicating a lack of tender white meat. The skin should be a clear color (yellow being preferred in the American market) and free from blotches and pin-feathers; if it looks tight and drawn, the bird has probably been scalded before plucking. The flesh should be neither flabby nor stiff, but should give evenly and gently when pressed by the finger.

FRESHNESS.

In a fresh bird the feet feel moist, soft, and limber, and if dressed with the head on the eyes look bright and full. As it becomes stale the eyes shrink and the feet dry and harden; when too stale, i. e., when decomposition is well under way, the body turns dark and greenish. Cold-storage birds are commonly packed so closely that the wings and legs remain pressed against the body even after the birds have been unpacked some time. They can usually be distinguished by this squeezed look from fresh birds, which should lie or hang in a natural position.

AGE.

One of the commonest ways of testing the age of dressed poultry is to take the end of the breastbone farthest from the head between thumb and finger and attempt to bend it to one side. In a very young bird, say a "broiler" chicken or a green goose, it will be easily bent, like the cartilage in the human ear; in a bird a year or so old it will be brittle, and in an old bird tough and hard to bend or break. Unfortunately tricky dealers sometimes break the end of the breastbone before exhibiting the bird, and thus render the test worthless. If the feet are left on the carcass they furnish a test of the age. In a young bird they are soft and smooth, becoming hard and rough as the bird grows older. The claws are short and sharp in a young bird, becoming longer and blunter with age and use. The spur above the foot is also to be observed; when the bird is very young like a "broiler" chicken, it is hardly apparent; a few months later it is long, but straight; in a mature bird it is larger still and crooked at the end. It is more developed in males than in females and capons.

Turkeys up to a year old are said to have black feet, which grow pink up to 3 years old and then turn gradually gray and dull.

The age of pigeons can sometimes be told by the color of the breast. In squabs the flesh looks whitish as seen through the skin, but becomes more and more purplish as the bird grows older. Red feet are also said to be a sign of age in a pigeon.

In ducks and geese the flexibility of the windpipe is a mark of youth. When the bird is young it can be easily squeezed and moved; later it grows rigid and fixed.

Some of the dealers in fancy and out-of-season goods handle more or less poultry which is only partly plucked, the neck, tail, and wing feathers being left, probably to give the bird a better appearance. However, an unplucked chicken so seldom reaches the average American market that feather and comb tests are of little value here. More commonly the wings of turkeys, ducks, and geese are left unplucked and furnish a clew to the age. If the tips of the quills at the end of the wing are sharply pointed, the bird is probably young; the blunter they are the older the bird.

SEX.

Commonly it takes a trained eye to distinguish sex in dressed birds, but fortunately this is not important save in the case of capons. When caponizing has been properly done the head is small for the size of the body, the comb is pale and withered, the body plumper, rounder, and larger than in an ordinary fowl, and the spur abortive. If the operation was incomplete, the head will be like that of an ordinary bird and the body less rounded. Such birds, known technically as "slip capons," are much inferior to true capons.

COOKING POULTRY.

The heat of cooking develops pleasant flavors, but this is only one of several uses which cooking serves. If carried far enough, the heat kills dangerous parasites or micro-organisms, if such be present, and produces certain chemical and physical changes which probably make the meat somewhat more digestible.

CHANGES PRODUCED BY COOKING.

The muscular tissues which form the greater part of poultry flesh are composed of fibers and connective tissue of varying toughness. Long, slow cooking, as in stewing, gradually softens these fibers and connective tissues, and thus gives the digestive juices a better chance to act upon them. On the other hand, the protein (nitrogenous substance found in the lean of meat) is hardened by the strong heat, much as white of egg, which it resembles in chemical composition, hardens in boiling. Protein thus hardened or coagulated is probably less easily digested than slightly cooked or raw protein, but this disadvantage in the cooked meat is more than compensated by its more attractive taste and appearance. The heat of cooking also develops acids in the lean of the meat, which soften the fiber much as the digestive juices themselves do, and thus aid digestion. The fats *too*, are affected by the heat, being separated from the flesh to some extent and in part changed in flavor by browning more or less. Of course in cooking some fat tries out from the meat, and water is driven off as steam or vapor by the heat. Hence a fowl or any piece of meat when cooked will weigh perceptibly less than before it went into the pot or oven. Such loss is less noticeable in poultry than in cuts from larger animals, in which a greater surface of the flesh is directly exposed to the action of the heat.

METHODS OF COOKING.

Boiling, stewing, roasting, broiling, and frying are the methods of cooking ordinarily used with poultry, as with other meats.

In boiling and stewing the heat reaches the flesh through water in which it is placed, and the chief difference between the two lies in the amount of heat applied at one time. The choice to be made between them should depend on whether the flesh only is to be used, or the poultry and also the water in which it is cooked. If the flesh only, he bird should be boiled; that is, plunged into water which is already it or near the boiling point and allowed to stay at that temperature for 'rom ten to twenty minutes. This exposure to the greater heat will ause the protein near the surfaces to harden and form a sort of oating through which the juices of the interior can not so readily ass. Later the pot should be set in a cooler place and the meat be eft in water below the boiling point until the desired changes have aken place in its inner parts. When, on the other hand, the water lso is to be used, the bird should be stewed; that is, put into water hile it is still below the boiling point and kept there until thoroughly ooked through, since at a moderate temperature no impervious coat- g of coagulated protein will form, and part of the juices, etc., will scape from the meat into the water. If a bird is cut up before it stewed, greater surface will be exposed to the action of the hot ater and more material will pass into the water. Part of the nutri- ous material in the bones, which would otherwise be wasted, can be oked out in this way, adding to the nutritive value of the broth. the stewing is kept up long enough considerable material, espe- ally the bodies which give flavor, will pass into the broth, leaving e rather tasteless muscle fibers. But it must be remembered that ese fibers are the most nutritious parts of the flesh. Well-made oth is fairly rich in nutritive ingredients and is thought to be more sily digested than the original meat, and for this reason chicken oth is often given to sick persons who need their nourishment in turn for a small amount of work of digestion. Furthermore, the oth often enables the invalid to take with it the more nutritious ead, rice, or other food which would not be relished otherwise.

An old fowl can sometimes be made tender without having all its flavor stewed away by cooking, as in a French bain-marie, where the pot is kept in warm water for a long time, or in a special oven with walls which do not conduct away the heat readily, where it is set for hours in a warm air chamber.

In roasting and broiling poultry the heat reaches the meat through the air instead of through water. As in boiling, the flesh is put at once into a high temperature which causes the protein near the surface to harden, thus partially preventing the escape of the juices. If recourse is had to basting, or pouring the escaped juices over the hot meat, a coating is formed over the surface which aids in keeping in the remainder of the juices. The larger the fowl the longer the time required for the interior to become hot. With a large fowl there is not much danger of drying up. On the other hand, if the bird is small there is more danger of this, and it should be cooked as quickly as possible. Hence the rule that the smaller the bird the hotter the oven and the shorter the period of cooking should be.

When the layer of meat over the bones is very thin, as in young chicks or squabs, broiling is preferable to roasting. Here very intense heat is applied to one side of the meat until the surface is coated over with coagulated protein, then to the other side, the interior being cooked at the same time. In this way almost all the juices are retained and the bird is cooked through without drying up.

In frying the meat is surrounded by fat instead of water or air and, like broiling, this process seems appropriate only for thin pieces of meat. The hot fat coagulates the protein on the surface, forming a coating which keeps the juices in. It should be very hot when the meat is put in, else it will soak into the flesh and spoil the flavor. Fat, if overcooked, is commonly believed to be quite indigestible, and chicken or other meat not properly fried is probably less easily digestible than that cooked in other ways.

The amount of heat needed to soften the fibers and develop the flavor of a bird, of course, depends largely on its age and toughness. Long, slow cooking, as in stewing or boiling, softens the fibers more thoroughly than a shorter exposure to intense heat, as in roasting. These methods are therefore preferable for an old, tough bird. An old rule given in many cookbooks is to boil or stew a fowl "an hour for each year of its age and one for the pot." A large bird, of course, needs a longer exposure to the heat than a small one, and a general rule for roasting chickens and turkeys is twenty minutes to the pound. Ducks and geese, having tougher fibers, require a longer time for thorough cooking. Some persons, however, prefer ducks, especially wild ducks, rare.

STUFFING AND SAUCES.

In roasting birds stuffing or dressing—a mixture of crumbs, egg, seasoning, etc.—is very often put inside the carcass. Stuffing serves the double purpose of seasoning the bird and holding it out in shape. Onions are supposed to be indispensable in a good roast duck. Italian chestnuts or pecans are considerd especially fine in roast turkey, and so on through the list. These stuffings do not greatly change the food value of the birds, save as they add their own material to its total composition, or indirectly as they stimulate appetite and through that the flow of the digestive juices. The various sauces and gravies serve much the same purpose; if they are made with the gizzard and other organs which would otherwise be unused, they have the added advantage of saving these from waste.

FANCY DISHES MADE WITH POULTRY.

Cookbooks and bills of fare suggest almost endless ways of cooking poultry, but the differences between them usually lie in the way in which the dishes are flavored by dressing or sauce or in the way they are treated after their first cooking. Chicken pie is nothing but stewed or boiled chicken plus the crust and a little sauce, and chicken croquettes are rather finely divided boiled or roasted chicken plus the seasoning, etc., with which the meat is mixed and the crumbs in which it is rolled before frying. The nutritive value of these dishes depends, of course, on all the materials which go into them.

POTTED AND CANNED POULTRY.

The meat for these goods is prepared in essentially the same way as if it were to be used immediately, and then is treated much as any other canned meat product, the object being to sterilize the can contents and exclude the air with the micro-organisms always present in it. If sterilization is not complete there is, of course, danger of decomposition and its attendant evils. Another possible but slight danger is that of poisoning from improper tin and solder, but this is not so great with meats as with fruits and vegetables in which the acids aid in the formation of dangerous substances. There is no reason why canned poultry, properly put up, should not be just as healthful as fresh, for which it is often a most convenient substitute.

COMPOSITION OF POULTRY AND POULTRY PRODUCTS.

The value of poultry or any substance as food, of course, depends upon the amount and kind of material contained in it which the body can actually use. Not all parts of food materials are suitable for nourishment. The bones of poultry, shells of eggs, and the entrails of poultry, meat, and fish, etc., are almost or entirely useless as food.

At different times and in different countries opinions have varied as to the parts which should be eaten. Chicken feet, skinned and properly dressed, are used for making broth or other purposes in Europe, though they are usually thrown away in this country. Few American cooks would use cocks' combs, yet the French cook prizes them. As regards the skin, which is seldom removed from poultry in the ordinary household methods of preparation, some consider it very palatable, especially if cooked until rather crisp, while others will not eat it under any circumstances. The liver and less commonly the heart are liked by many and are often sold separately in large markets as delicacies, though in many small towns and country regions they would not be so considered. In large markets the demand for the liver is so great that it is often necessary to insist that it be left in the dressed fowl, otherwise it will be removed by the dealer, as he can readily sell chicken livers for a fancy price. The head of a bird is not commonly eaten in the United States, yet European cooks frequently leave it on the cooked fowl, since the brain is considered a delicacy. These usages recall traditions of Roman or mediæval feasts with dishes of larks' tongues and peacocks' brains, and they, perhaps, do not seem unreasonable even to one not familiar with them. The same can hardly be said of the custom observed in some regions of Germany, and possibly elsewhere, of eating the partially digested green feed removed from some game birds. This is especially cooked and is said to be palatable. Apparently this custom is limited to birds which have fed, as they do at certain seasons of the year, almost exclusively on a plant like cress or peppergrass.

The waste parts are usually grouped together as refuse, and in considering the nutritive value of any kind of food, especially in relation to its cost, the proportion which they bear to the really valuable parts must be taken into account. In experiments on the fattening of chickens at the Canadian experimental farms the proportions of different materials removed in dressing and drawing the birds were ascertained, the average results for 72 chickens of different breeds, as calculated on the basis of the weights of the chickens as killed, being as follows: Dressed and drawn carcass, not including the giblets, 66.4 per cent; giblets, 5.5; head and feet, 11.2; feathers, 8.3; and entrails 8.5 per cent.

In discussions of food the term edible portion is applied to all the parts of any article which are not included under the term refuse. In case of poultry and other meats the edible portion includes the muscular tissue, fat, etc. All food materials are made up of a comparatively small number of chemical compounds; namely, water, protein, fat, carbohydrates, and mineral matters or ash. Water is essential to the human body, but it is to be had from so many other sources that the amount found in solid foods is not ordinarily thought of as adding to their nutritive value. That poultry flesh contains water is evident from the fact that it is moist and has more or less visible juice.

The functions of the different nutrients have been discussed at length in other publications of this series.[a] Suffice it to say that protein or other nitrogenous material (especially the true proteid or albumin) is essential for building and repairing body tissue, while this and the fats and carbohydrates together supply the needed energy. The value of nutrients as sources of energy is commonly expressed in terms of heat, the calorie being selected as a unit. The mineral matters or ash present in food supply material needed for building bone and other parts of the body and have various physiological uses besides. Poultry, like other flesh foods, contains protein as a characteristic constituent; fat will also be found, some of it collected together in larger or smaller masses, which may be readily removed by mechanical means, and some so intimately associated with the muscle fibers that it can not readily be separated thus. Carbohydrates, chiefly in the form of a sugar-like body called glycogen, are present in very small amounts in poultry and other flesh, but, excepting in the liver and some other internal organs, the quantity is so small that it is not ordinarily estimated in laboratory analyses. Poultry flesh also contains mineral matter in small amount, though there is no common household process which shows its presence. Should anyone care to make the test it will be found that a bit of poultry flesh will not burn up completely, but will leave behind a little incombustible mineral matter.

A large number of analyses of poultry and poultry products have been reported recently by the Connecticut (Storrs) Experiment Station. Others have been published in connection with the results of feeding experiments and other investigations with poultry carried on at a number of the experiment stations, while a considerable amount of such analytical data has accumulated from other American sources. Table 1, here given, summarizes the results of such analyses of raw, cooked, and canned poultry and poultry products, similar values for a few other foods being included for purposes of comparison.

[a] U. S. Dept. Agr., Farmers' Bulletin 142.

TABLE 1.—*Average composition of poultry, poultry products, and some other foods.*

Kind of food.	Refuse.	Water.	Protein.	Fat.	Carbohydrates.	Ash.	Heat of combustion per pound.
CHICKENS.							
Young:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Calories.*
As purchased	18.8	55.5	17.8	7.2		0.9	765
Edible portion		68.4	21.9	8.9		1.1	945
Meat, not including giblets		66.9	22.6	10.1		1.1	1,000
Dark meat		70.1	20.8	8.2		1.2	850
Light meat		70.8	21.9	7.4		1.1	855
Giblets		71.0	19.8	6.4		1.8	830
Visible fat removed		74.5	21.8	2.5		1.1	665
Liver		69.3	22.4	4.2	2.4	1.7	800
Heart		72.0	20.7	5.5		1.4	770
Gizzard		72.5	24.7	1.4		1.4	[illegible]
Broiler:							
As purchased	29.1	51.2	15.5	3.3		.8	540
Edible portion		69.7	20.7	8.3		1.1	[illegible]
Meat, not including giblets		69.2	21.1	8.8		1.1	[illegible]
Giblets		72.8	18.7	6.1		1.3	730
Capon:							
As purchased	17.5	46.8	17.7	17.5		1.0	1,205
Edible portion		56.7	21.5	21.2		1.2	1,455
Meat, not including giblets		55.8	21.6	22.1		1.2	1,460
Giblets		63.3	20.5	14.6		1.3	1,155
Other:							
As purchased	25.2	47.3	14.4	12.6		.7	910
Edible portion		59.5	20.4	19.2		1.1	1,330
Meat, not including giblets		63.4	19.4	16.6		1.0	1,225
Giblets		64.7	18.7	18.7		1.3	1,090
OTHER FOWL.							
Turkey:							
As purchased	14.3	49.2	19.0	16.2		1.0	1,155
Edible portion		57.4	22.2	18.9		1.2	[illegible]
Dark meat		57.0	21.4	20.6		1.1	[illegible]
Light meat		63.9	25.7	9.4		1.3	1,055
Giblets		56.7	17.7	23.5		1.2	[illegible]
Dark meat, cooked		53.7	39.2	4.3		2.2	[illegible]
Light meat, cooked		58.5	34.6	4.9		1.3	[illegible]
Young, as purchased	32.4	44.7	16.8	5.9		.9	[illegible]
Young, edible portion		66.1	24.9	8.7		1.3	[illegible]
Cooked		52.0	27.8	18.4		1.2	[illegible]
Heart		68.6	16.8	13.2		1.0	[illegible]
Liver		69.6	22.9	5.2	.6	1.7	[illegible]
Gizzard		62.7	20.5	14.5	1.2	1.1	[illegible]
Duck:							
As purchased	15.9	51.4	15.4	16.0		1.1	[illegible]
Edible portion		61.1	18.3	19.0		1.3	[illegible]
Meat, not including breast or giblets		55.5	17.4	26.1		1.0	[illegible]
Breast		73.9	22.3	2.8		1.3	[illegible]
Giblets		73.2	17.9	5.0		1.8	[illegible]
Duckling:							
As purchased	16.2	43.3	12.0	28.0		.7	[illegible]
Edible portion		51.7	14.3	33.4		.9	[illegible]
Meat, not including giblets		48.3	13.5	37.9		.7	[illegible]
Giblets		70.2	18.9	8.1		1.6	[illegible]
Green goose:							
As purchased	12.2	41.9	13.6	31.6		.8	[illegible]
Edible portion		48.2	15.1	36.0		.9	[illegible]
Meat, not including giblets		46.0	15.0	38.3		.8	[illegible]
Giblets		68.7	22.3	7.3		1.4	[illegible]
Goose:							
As purchased	11.1	48.0	14.8	25.5		1.0	[illegible]
Edible portion		54.0	16.6	28.7		1.1	[illegible]
Meat, not including giblets		51.8	16.2	31.5		1.0	[illegible]
Giblets		70.0	20.1	8.2		1.7	[illegible]
Gizzard		73.8	19.6	5.8		1.0	[illegible]
Liver		62.6	16.6	15.9	3.7	1.2	[illegible]
Pigeon:							
As purchased	13.6	55.2	19.7	9.5		1.3	[illegible]
Edible portion		64.0	22.8	11.0		1.5	[illegible]
Meat, not including giblets		63.2	22.9	12.1		1.4	[illegible]
Giblets		68.1	22.2	5.2		2.3	[illegible]
Squabs:							
As purchased	15.6	49.0	15.7	18.6		1.3	[illegible]
Edible portion		58.0	18.6	22.1		1.5	[illegible]
Meat, not including giblets		56.6	18.5	23.8		1.4	[illegible]
Giblets		69.8	19.8	7.2		2.0	[illegible]

TABLE 1.—*Average composition of poultry, poultry products, etc.*—Continued.

Kind of food.	Refuse.	Water.	Protein.	Fat.	Carbohydrates.	Ash.	Heat of combustion per pound.
OTHER FOWL—continued.							
Guinea hen:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Calories.*
As purchased	16.4	57.7	19.4	5.4	....	1.1	730
Edible portion	....	69.1	23.1	6.5	....	1.3	870
Meat, not including giblets	....	68.9	23.4	6.5	....	1.3	865
Giblets	....	69.9	20.8	7.1	....	1.3	855
Pheasant:							
As purchased	12.0	61.5	21.5	4.2	....	1.0	730
Edible portion	....	69.9	24.4	4.8	....	1.1	830
Meat, not including giblets	....	70.0	24.7	4.6	....	1.1	815
Giblets	....	68.9	20.1	7.2	....	1.6	880
Russian pheasant:							
As purchased	14.1	61.1	21.5	1.9	....	1.2	685
Edible portion	....	71.1	25.0	2.3	....	1.4	740
Meat, not including giblets	....	70.6	25.7	2.3	....	1.4	730
Giblets	....	74.4	21.2	2.2	....	1.3	665
Quail:							
As purchased	10.5	59.0	22.3	6.1	....	1.4	835
Edible portion	....	65.9	25.0	6.8	....	1.6	935
Meat, not including giblets	....	66.3	25.4	7.0	....	1.4	945
Giblets	....	68.0	21.8	6.2	....	2.3	970
PRESERVED POULTRY MEAT.							
Smoked goose breast (including skin and fat)	....	35.7	20.1	38.7	....	5.5	2,210
Smoked goose breast (skin and outer fat removed)	....	61.3	26.1	4.4	....	8.0	845
Potted turkey	....	58.0	17.2	22.0	....	3.0	1,390
Potted chicken	....	56.1	19.4	20.3	....	2.5	1,390
Canned chicken soup	....	87.1	2.9	3.3	5.1	1.6	300
Canned chicken gumbo soup	....	91.0	2.4	.2	4.8	1.6	160
Canned boned chicken	....	57.6	27.7	12.8	....	2.2	1,245
Canned sandwich chicken	....	46.9	20.8	30.0	....	2.6	1,825
Canned sandwich turkey	....	47.4	20.7	29.2	....	2.7	1,790
Canned quail	....	66.9	21.8	8.0	1.7	1.6	985
Terrine de foie gras	....	41.3	13.6	38.2	4.3	2.6	2,075
OTHER KINDS OF FOOD.							
Beef, sirloin steak, as purchased	12.8	54.0	16.5	16.1	....	.9	....
Beef, brisket, as purchased	23.3	41.6	12.0	22.8	....	.6	....
Lamb chops, as purchased	14.8	45.3	16.0	24.1	....	.8	....
Mutton, leg, as purchased	18.4	51.2	15.1	14.7	....	.8	....
Pork, chops, as purchased	19.7	41.8	13.4	24.2	....	.8	....
Pork, salt fat, as purchased	11.2	17.6	7.4	59.6	....	5.1	....
Halibut, fresh, steaks, as purchased	17.7	61.9	15.3	4.4	....	.9	....
Mackerel, salt, as purchased	19.7	34.8	13.9	21.2	....	10.4	....
Oysters, solids	....	88.3	6.0	1.3	3.3	1.1	....
Eggs, as purchased	11.2	65.5	11.9	9.3	....	.9	....
Milk	....	87.0	3.3	4.0	5.0	.7	....
Butter	....	11.0	1.0	85.0	....	3.0	....
Cheese, as purchased	....	34.2	25.9	33.7	2.4	3.8	....
Wheat flour	....	12.0	11.4	1.0	75.1	.5	....
Wheat bread, white	....	35.6	9.3	1.2	52.7	1.2	....
Beans, dried	....	12.6	22.5	1.8	59.6	3.5	....
Potatoes as purchased	20.0	62.6	1.8	.1	14.7	.8	....
Apples, as purchased	25.0	63.3	.3	.3	10.8	.3	....

The proportions of the different nutrients in poultry and poultry roducts are shown in Table 1, but before considering this phase of e subject in detail it is desirable to speak of another important matr, namely, the digestibility of poultry; since statistics of this nature e needed in connection with any adequate discussion of nutritive lue.

DIGESTIBILITY OF POULTRY.

It is not alone the amount of nutritive ingredients in a given food which determines its real nutritive value, but the amount of these which the digestive organs can set free for the use of the body. From many digestion experiments it has been learned that not all kinds of foods are digested with equal completeness. The thoroughness of digestion is learned by experiments with man and other animals, or by artificial digestion experiments in which specially prepared ferments are used and body conditions are approximated more or less closely. Few experiments have been made with the special object of learning how thoroughly poultry and poultry products are digested, but some of the investigations conducted by this Department and by others furnish information on the subject, although designed primarily for other purposes. For instance, in several of the digestion experiments carried on at the Maine Experiment Station, chicken formed a part of the diet, and an idea of its digestibility may be learned by comparing the results of these experiments with others in which chicken was replaced by beef. From all the available evidence it seems fair to assume that poultry flesh is as thoroughly digested as that of other domestic animals commonly used for food. As a result of a large number of experiments it is believed that on an average 97 per cent of the protein, 95 per cent of the fat, and 98 per cent of the carbohydrates present in fish and meat of all kinds is digested. These values may be assumed therefore to represent the digestibility of poultry until more evidence is at hand. In calculating the amounts of nutrients furnished by different foods it is a common practice with many American investigators to use the factors just quoted for all animal foods. They are somewhat larger than the corresponding factors for vegetable foods, namely, protein 84 per cent, fats 90 per cent, and carbohydrates 97 per cent. In other words, animal foods, including meats, poultry, fish, and other animal products, are, generally speaking, considered somewhat more digestible than vegetable foods.

By the use of these percentages it is easy to estimate the digestible nutrients of any kind of food whose chemical composition is known, and they have been employed in calculating the value for digestible nutrients in some of the kinds of poultry flesh included. The results of the calculations are included in Table 2, accompanying, which also includes similar values for some of the more common cuts of beef, veal, and lamb for purposes of comparison. Such values can be readily calculated if desired for the other kinds of poultry and poultry products.

TABLE 2.—*Refuse, indigestible nutrients, digestible nutrients, and available energy in poultry and some other foods.*

Kind of food.	Refuse.	Indigestible nutrients.	Water.	Protein.	Fat.	Carbohydrates.	Ash.	Fuel value per pound.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Chicken:								
As purchased	18.8	0.9	55.5	17.3	6.8	....	0.7	685
Edible portion	....	1.2	68.4	21.2	8.4	....	.8	780
Fowl:								
As purchased	25.2	1.0	47.3	14.0	12.0	....	.5	790
Edible portion	....	1.7	59.5	19.8	18.2	....	.8	1,170
Turkey:								
As purchased	14.8	1.9	49.2	18.4	15.4	....	.8	1,025
Edible portion	....	2.2	57.4	21.5	18.0	....	.9	1,195
Duck:								
As purchased	15.9	1.8	51.4	14.9	15.2	....	.8	945
Edible portion	....	2.0	61.1	17.8	18.1	....	1.0	1,125
Goose:								
As purchased	11.1	1.5	48.0	14.4	24.2	....	.8	1,320
Edible portion	....	1.8	54.0	16.1	27.8	....	.8	1,485
Beef, sirloin steak, as purchased	12.8	1.2	54.0	16.0	15.3	....	.7	970
Halibut, fresh, steaks, as purchased	17.7	.7	61.9	14.8	4.2	....	.7	475
Eggs, as purchased	11.2	2.8	65.5	11.5	8.8	....	.7	605
Milk	....	.6	87.0	3.2	3.8	4.9	.5	225
Butter	....	4.9	11.0	1.0	80.8	....	2.3	3,460
Wheat bread, white	....	3.4	35.6	7.9	1.1	51.1	.9	1,165
Potatoes, as purchased	20.0	.9	62.6	1.5	.1	14.3	.6	305

Judged by these figures, it will be seen that poultry compares very favorably with the other flesh foods. Of course, such average values as are given in Table 2 do not represent the exact amount of nourishment each individual would get from the food materials quoted; for the power of digestion varies with individuals. Nor do they refer to the ease and quickness of digestion; such conditions also differ with different persons, and doubtless depend somewhat upon the way in which he food is cooked and upon the toughness or tenderness of the paricular sample. Such variations, however, so far as we know, are omparatively slight among normal persons, and the figures in the table nay be taken, until more definite information is available, to indicate he amount digested by the average healthy person.

NUTRITIVE VALUE OF POULTRY.

In trying to learn the nutritive values of different kinds of food as own in Table 1, it should be remembered that the greater the proporon of refuse and water the smaller will be the proportion of nutritive aterial, and that the presence of fat raises the fuel value, while fuse, water, and ash lower it. It is evident that many of the stateents in the following pages apply to such values as are included in able 2 as well as to those in Table 1, since the former were computed om the latter by uniform factors.

It may be interesting in discussing the value of poultry as food to tice how the different kinds of meats, taken as a class, compare in tritive value with the other classes of foods, such as milk, eggs, getables, fruits, cereals, bread, etc. As might be expected, poultry flesh is very similar in composition to other sorts of meat, and in general meat contains less water than milk but more than eggs or cheese, the common animal foods with which it would be ordinarily compared. As regards its fat content, the proportion of this nutrient is on an average greater than the amount in milk or eggs, but, of course, except in such cuts as fat pork, much less than in butter, lard, or other similar materials which are mostly pure fat. Nearly all vegetable foods contain larger proportions of carbohydrates than do animal foods. Protein and fat are the characteristic nutrients in meats of all kinds, the proportions varying within rather wide limits in different kinds and cuts and within less wide limits in different specimens of the same kind and cut, the figures in Table 1 being simply the best average values which are at present available. Meats supply a considerable amount of fat, but not in such large proportions that the body could get readily all the fuel it needed from them without getting a superfluous amount of protein. Hence the ordinary custom of living on a mixed diet of meats—i. e., nitrogenous foods and vegetables or carbonaceous foods—is very sensible, because it readily furnishes a sufficiency of both building material and fuel without loading the digestive organs with a great excess of either.

COMPARISON OF POULTRY AND OTHER MEATS AND OF DIFFERENT KINDS OF POULTRY.

When we compare the meat of poultry with that of beef, veal, lamb, and pork, we find that on the average the refuse in poultry is slightly less. On an average the various kinds of poultry furnish not far from 5 per cent more protein than the other kinds of meat included in the table and a very little more ash. On the other hand, most of them contain considerably less fat and have a relatively smaller fuel value. As far as the nutritive value alone is concerned, the general advantage of poultry over the other meats thus appears to be that, pound for pound, it contains very slightly more of the building materials needed by the body; its disadvantage is that it furnishes less of the energy-giving material than the fatter meats.

As regards poultry of different sorts, in general the light-fleshed birds are richer in protein and poorer in fat than the others. Probably in all the light-fleshed varieties, at any rate in chickens, the young birds yield a larger proportion of protein and a smaller proportion of fat than the older ones of the same kind; while in the dark-fleshed varieties the young are richer in fat and poorer in protein. As a general thing the young birds contain less refuse, which means that the proportion of bone to total weight is smaller. Their flesh also contains more water, which may indicate that it is not so solid and compact as in the old birds.

Some of these differences in nutritive value in the various kinds of poultry are perhaps large enough to be carefully considered in planning dietaries. If chicken with its 8 per cent of fat were substituted in a menu for green goose with its 33 per cent, or turkey with 20 per cent protein, for duckling with 13 per cent, the proportion of building material and fuel furnished to the body might be noticeably changed. But too much importance should not be put on the differences between closely related birds, such as chicken and turkey, hen and capon; such differences are too small to seriously affect the nutritive value of the diet under ordinary circumstances. Moreover, as was noticed in the comparison of poultry with other kinds of meat, these differences vary with individual specimens, or the greater nutritive value which one kind seems from the table of composition to possess may be counterbalanced by greater losses in cooking, toughness of the particular bird, or by higher price. The consideration of price is so important that it will be discussed at length in a later section.

Various beliefs are current regarding the comparative value of poultry and other meats, and of different parts of the same bird. There is a theory that poultry, along with veal and lamb, is more healthful than red meats (beef), because it contains less of certain undesirable nitrogenous extractives, and some physicians have forbidden the use of red meats to patients, especially those troubled with gout and kidney diseases. Recent German experiments indicate that the differences in this regard between the two classes of meat are inconsiderable, and that they are quite as much in favor of the red as of the so-called "white" meats.

Many people maintain that while duck breast is very nutritious and quite easily digested the rest of the bird is hardly fit to eat. From the figures in Table 1 it will be seen that the breast contains 5 per cent more protein and 24 per cent less fat than the other edible portions. It is a matter of common belief that a large amount of cooked fat of meat or poultry is not easily digestible for many persons. If this be the case, it would naturally follow that the breast would give the digestive system less work to do than other parts, besides furnishing more protein from the same weight of meat, and would really be a more satisfactory food, especially for invalids.

There is also a theory that the light meat of chicken, turkey, etc., is more easily digested, because more tender, than the dark. A glance at the figures for chicken and turkey in Table 1 will show that the light meat of these birds, and especially of turkey, contains more protein and less fat than the dark, and may therefore yield more nourishment for the same amount of digestive effort. But this difference in nutritive value, as far as can be definitely stated, depends on the chemical composition rather than on the texture of the fibers. Artificial digestion experiments have shown that light and dark meat of poultry do not differ materially as regards the amounts digested in a given time under uniform conditions. In some recent experiments with man it was found that boiled chicken left the stomach more quickly than roasted.

It seems fair to say that little is definitely known, save that the differences in the nutritive value of light and dark meat are certainly too small to affect any save possibly the very weakest digestions. It seems probable that as regards ease of digestion the mode of cooking, as well as differences in composition or texture, has an effect on both light and dark meat.

COST OF POULTRY.

The price of poultry varies largely with the season, region, and market. Table 3 shows the average wholesale price per pound of the more common kinds of poultry at various seasons. Its figures, like those in Table 4, were calculated from the market reports from Boston, Chicago, Denver, New Orleans, New York, and St. Louis, obtained through the Division of Statistics of this Department.

TABLE 3.—*Average wholesale price per pound of poultry at different seasons.*

Kind of poultry.	June.	July.	August.	December.	January.	February.	Average of seasons.
	Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
Chickens	11	12	11	11	11	12	11
Turkeys	12	13	15	14	15	15	14
Ducks	10	11½	14	13½	14	14	[illegible]
Geese	8	10	9½	12	11	11	[illegible]

One of the most interesting things shown by Table 3 is the comparatively slight variation between winter and summer prices. Chickens on an average appear to vary only 1 cent per pound, turkeys 3 cents, and ducks and geese 2 cents. Cold-storage poultry probably helps in keeping prices steady, as the storage men can put their birds on the market whenever the price tends to rise in off seasons and can put the new birds into storage when there is danger of a glut in the market. Retail prices vary very much with the season, especially in smaller towns, where part of the supply comes direct from the farms.

In the following table is shown the average wholesale price per pound of the several kinds of poultry in the markets of a number of American cities:

TABLE 4.—*Average wholesale price per pound of poultry in a number of American ci*[illegible]

Kind of poultry.	Boston.	Chicago.	Denver.	New Orleans.	New York.	St. Louis.
	Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
Chickens	14.0	12.5	9.5	[a] 12.5	[b] 11.0	[illegible]
Turkeys	18.5	14.5	11.0	12.0	14.0	[illegible]
Ducks	18.5	18.0	11.5	[c] 11.0	15.0	[illegible]
Geese	[c] 13.0	10.0	12.0	....	12.5	[illegible]

[a] Rates for June, December, January, and February only.
[b] Broilers not included.
[c] Rates for December, January, and February only included.

lifference in the prices of poultry in different parts of the at the same time is also very interesting. Table 4 indicates th of what is commonly believed, that in the South and West is less expensive than in the North and East. This difference ably much more noticeable in retail prices in the country markan in the wholesale prices in the large centers. The birds are er in the South and West, probably because they require less n warmer, steadier climates, and because feed and, in some cases, are cheaper there.

e retail prices of birds are very variable, even at the same place time. The prices for birds of the same [illegible] may differ in two iboring stores, and very justly. If a dealer keeps an attractiveing shop, well supplied with perishable, fancy, and out-of-season ls, and is ready to deliver them anywhere at a moment's notice, he t, other things being equal, charge more than the dealer who s a less expensive stock and sends his delivery wagon on its ids once or twice a day. Each purchaser must decide for himself ther or not he can afford to pay for the extra conveniences and ge of choice of the more expensive market. He will, however, ays find it good economy to trade only in markets which have ple facilities for caring for their stock and which are kept scrupusly clean.

It is almost impossible to estimate what relation retail prices bear the current wholesale prices. It may perhaps be interesting to te that a reliable New York dealer, who keeps an excellent shop and obably charges prices slightly above the average retailer, gave estiites of what he considered the average retail price for poultry in w York City, which were about twice the wholesale prices as given Table 4. Similar estimates obtained in Middletown, Conn., gave ices a little higher in winter and lower in summer than those of the ew York dealer. Of course, in the country, especially from farms here poultry raising is a secondary affair, good birds can sometimes e bought for little more than the wholesale prices.

The less common kinds of poultry, such as squab and pheasant, being luxuries and rather scarce, are naturally expensive beyond all comparison with the standard kinds.

Although the market price is a most important factor in determining whether poultry is a cheap or a dear kind of food, it is not the only one. Just as the true nutritive value of any kind of meat does not depend entirely on its composition, but on the amount of digestible nutrients which it contains, its wholesomeness, etc., so the real cost of poultry as food depends not on its price per pound, but on the price paid for its actual nutrients. Two kinds of poultry, say chickens and geese, may cost the same per pound, but if the chicken contains le[illegible] refuse and water and a smaller proportion of indigesti[illegible] the same amount of money spent for it will provide more actual nour ishment, and it will be a truly cheaper food than the goose. Again if turkeys cost slightly more per pound than chickens, but contain a larger proportion of available nutrients, they may really be the more economical.

Table 5 shows the average cost per pound of digestible protein and fat and the average cost per 1,000 calories of available energy furnished by different kinds of poultry at certain prices per pound, which are believed to represent actual conditions. It shows further the amount of total digestible nutrients and available energy which can be pur chased for 10 cents in the different kinds of poultry at the assumed values per pound.

TABLE 5.—*Cost of digestible nutrients per pound and of available energy per 1,000 calories and amounts of digestible nutrients and available energy furnished for 10 cents by poultry and some other foods at certain prices per pound.*

Kind of food.	Price per pound.	Cost per pound.		Cost per 1,000 calories of energy.	Amount for 10 cents.			
		Protein.	Fat.		Total weight.	Protein.	Fat.	Energ[illegible]
	Cents.	*Dollars.*	*Dollars.*	*Dollars.*	*Pounds.*	*Pound.*	*Pound.*	*Calor[illegible]*
Chicken	15	0.90	0.97	0.15	0.67	0.11	0.10	[illegible]
Do	18	1.08	1.17	.18	.56	.09	.09	[illegible]
Do	20	1.20	1.30	.20	.50	.08	.08	[illegible]
Roasting chicken	20	1.16	2.94	.31	.50	.09	.03	[illegible]
Do	25	1.45	3.68	.39	.40	.07	.03	[illegible]
Do	38	2.20	5.59	.60	.26	.05	.02	[illegible]
Capon	28	1.63	1.69	.26	.36	.06	.06	[illegible]
Turkey	23	1.25	1.49	.22	.43	.08	.07	[illegible]
Do	28	1.52	1.82	.27	.36	.07	.05	[illegible]
Duck	25	1.68	1.64	.26	.40	.06	.06	[illegible]
Duckling	30	2.59	1.13	.22	.33	.04	.09	[illegible]
Goose	20	1.39	.83	.15	.50	.07	.12	[illegible]
Do	28	1.94	1.16	.21	.36	.05	.09	[illegible]
Green goose	29	2.18	.94	.18	.34	.05	.11	[illegible]
Guinea hen	19	1.01	3.73	.32	.53	.10	.03	[illegible]
Pheasant	100	4.78	25.00	1.70	.10	.02	....	[illegible]
Quail	40	1.85	6.90	.59	.25	.05	.01	[illegible]
Pigeon	18	.94	2.00	.23	.56	.11	.05	[illegible]
Squab	58	3.82	3.28	.54	.17	.03	.03	[illegible]
Beef, sirloin	25	1.60	....	.25	.40	.06	.06	[illegible]
Beef, shoulder clod	12	.75	....	.17	.83	.13	.08	[illegible]
Mutton, leg	20	1.37	....	.22	.50	.07	.07	[illegible]
Pork, loin	12	.92	....	.10	.83	.11	.19	[illegible]
Pork, salt fat	12	6.67	....	.03	.83	.02	.66	[illegible]
Cod, fresh, dressed	10	.93	....	.46	1.00	.11	....	[illegible]
Cod, salt	7	.45	....	.22	1.43	.22	.01	[illegible]
Eggs, 24 cents per dozen	16	1.39	....	.26	.63	.07	.06	[illegible]
Milk, 6 cents per quart	3	.94	....	.10	3.33	....	.32	[illegible]
Butter	25	25.00	....	.07	.40	.11	.13	[illegible]
Wheat flour	3	.31	....	.02	3.33	.32	.03	[illegible]
Wheat bread	6	.77	....	.05	1.67	.13	.02	[illegible]
Beans, white, dried	5	.29	....	.03	2.00	.35	.03	[illegible]
Potatoes, 60 cents per bushel	1	.67	....	.03	10.00	.15	.01	[illegible]
Apples	1.5	5.00	....	.03	6.67	.02	.02	[illegible]

The table will be found especially interesting in comparing the economy of different kinds of food. Of course, when the price va the actual cost of the nutrients supplied for a given sum will with it. The prices quoted, which are based on all the data w could be collected, are intended to represent as nearly as possible average retail prices for all reported markets for different seas They are very probably not absolutely correct, but more satisfact ata were not available, and it is believed they are sufficiently accurate o show how the different kinds of poultry compare with each other nd with other foods as to the cost of the nutrients which they furish. Table 5 shows the relative cost of digestible protein and available energy when supplied by poultry and some other foods and also hat amounts of digestible protein, fat, and available energy 10 cents ent for various foods at the prices given in the first column will ipply. If in chicken at 18 cents per pound, a pound of digestible rotein costs $1.08 and 1,000 calories of available energy 18 cents, it evident that 10 cents spent for the same fowl would furnish a little ore than one-half a pound of material, with 0.09 of a pound of gestible protein and 556 calories of available energy.

From the figures given in the table it may be seen that chickens, ung and old, up to 25 or 30 cents per pound, turkey, low-priced ose, guinea hen, and pigeon are as cheap sources of protein as the re expensive cuts of beef and mutton, but that none of these, less it be the low-priced chickens, is as cheap in this respect as the re inexpensive cuts of beef and pork. When we consider the cost the energy supplied by the various kinds of meat we find that r-priced chicken and goose compare in economy with the lowced cuts of beef and pork, and chicken, turkey, duckling, goose, l pigeon with the more expensive cuts of beef and mutton. Both protein and the energy of capon, duck, green goose, and especially pheasant, quail, and squab, are much more expensive than those m the ordinary meats. Chicken at low prices, turkey, goose, pigeon, , where available, guinea hen, seem, then, to be the kinds of poultry ch are really as economical as ordinary beef, mutton, and pork. cken and turkey at out-of-season prices, capon, duck, duckling, and en goose are more expensive as sources of protein and energy, le pheasant, quail, and squab are among the most expensive of all ts.

PLACE OF POULTRY IN THE DIET.

f course, the first essential in any diet is a supply of the different ls of nutrients large enough to meet the needs of the body, and in onable proportions. Another important point is the attractiveof the food, and to attain this good cooking and variety of matecome into consideration. It is obvious that the more money one spend on food the easier it is to obtain the variety which helps rd attractiveness. The question before us now is, How much try should be used by people of different circumstances in order tain this variety. Most persons agree that poultry of different makes delicious eating, and the question of its use is mainly one onomy.

a

If every penny must be made to count for actual nourishment, poultry should ordinarily play a small part in the meals of people who buy in city markets. Low-priced chicken is practically the only kind which compares in real economy of nutrients furnished for a given sum with the cheaper kinds of beef and pork, and then only because by using the broth, parts otherwise wasted can be utilized. If the income is large enough to warrant paying a little extra for the sake of variety, chicken, turkey, and goose in their season will make very nutritious and pleasant changes in the bill of fare and will not be any more extravagant than sirloin of beef or leg of lamb. Families that can afford porterhouse steaks and rib chops of lamb would do well to introduce duck and goose as well as chicken and turkey into their bills of fare, for in this way they can get a much greater variety of meat without any added expense. Pheasant and squab are delicacies and have their place in costly menus, but they are too expensive to be ordinarily used by people who have to consider the amount of their butchers' bills.

Whether or not a given amount of poultry will "go farther" than a like quantity of beef or other meat is a point which should be taken into account in discussing the relative economy of its use. Unfortunately this is a question on which it is not easy to obtain accurate information. It is a common belief that certain dishes, such as fricasseed chicken, will serve a rather larger number of persons in proportion to the amount of chicken used, and are more economical in this respect than roast or fried chicken. Of course, all such statements as the above should not be taken as hard-and-fast rules.

Whether or not it is actually more easily digested, the meat of poultry, especially of the white-fleshed kinds, is so delicate and appetizing that it often has for convalescents and invalids, whose appetites are capricious, a value far beyond its cost. If a person can relish squab when the sight of roast beef sickens him, he would probably get more good from squab than beef, though its nutrients cost just about twice as much.

In many parts of the country, especially on farms, chicken is probably much cheaper than beef, as only the cost of production needs to be considered. When chickens, and, for that matter, any poultry, can be raised with little labor and can find most of their food or use of otherwise useless table refuse, skim milk, etc., they ought to be a very economical and agreeable substitute for pork and beef, and to be used liberally.

Judged by the results of a large number of investigations carried on in different regions of the country, most of them under the auspices of this Department, poultry of all kinds furnishes 1.1 per cent of the total food, 2.6 per cent of the total protein, and 1.2 per cent of the total fat in the diet of the average American family. The amounts are small as compared with beef and veal, which together furnish 10.3 per cent of the total food, 24.6 per cent of the total protein, and 19.5 per cent of the total fat, but compare very favorably with the values obtained for mutton and lamb together, which are 1.4 per cent of the total food, 3.3 per cent of the total protein, and 3.8 per cent of the total fat.

It is undoubtedly true that much larger amounts of poultry are eaten in some regions than in others. In the Southern States chicken has always been a favorite food both in country and town, perhaps in part because it can be easily raised, and in part because it can be kept alive until needed, and hence does not present the same difficulties of storage as fresh beef, mutton, or pork.

In connection with the nutrition investigations of this Department, an investigation was undertaken a few years ago at the University of Tennessee to secure data regarding the relative worth of chicken and beef as economical foods for that region. The average weight of a large number of dressed chickens, such as were commonly sold in local markets, was found to be 2.25 pounds (without heart, liver, and gizzard), and their average cost 25 cents each, or 11 cents per pound. At this price they were a little more expensive than beef, but were regarded as more economical, since they involved less waste in preparing and serving. From a consideration of the data secured, the conclusion was drawn that "too much prominence can not be given to chicken as an article of food in the South."

As stated above, the share of food contributed by poultry to the average table is at present relatively small, and it is also surprising to realize how few kinds of poultry are in general use in this country. Most American families of moderate means eat chicken and turkey more or less frequently, and goose and duck much less often. If duck and goose were used more commonly, and a taste for capon and guinea fowl cultivated, there could be more variety in the diet with practically no increase in cost, judging by present prices, and the housekeepers would not have to ring such frequent changes on the beef, mutton, and pork.

SUMMARY.

Although not as many varieties of poultry are in common use in the United States as in Europe, and although eggs form perhaps the most important part of the total poultry industry with us, enough birds are raised and sold for their flesh to make poultry an important item in our list of foods. Chickens are, of course, far the most common of the kinds of poultry. Next come turkeys; then ducks and geese, followed by capons and squabs, the other varieties, such as guinea fowl, pheasants, and quail being least common of all.

[illegible]

milarly, white-fleshed birds may be more easily digested than dark-
shed, because the fibers of their flesh are less closely set; but this
not fully proved. Indeed, very little is positively known on this
'bject, and that little seems to indicate that the differences in thor-
ghness of digestion are very slight, and that cooking has much more
do with the digestibility of the birds than these slight differences
composition and texture.

The price of poultry varies largely with the region and the season,
l, as regards retail price, with the particular market. Although
proportion of refuse, water, and indigestible nutrients which each
ticular sort contains makes some difference in its real economy as
ource of nourishment, the price is, after all, the most important
sideration. Reckoning the cost of the actual nutrients, we find
t chicken is on the whole the cheapest kind, and compares favor-
y in economy with cheap cuts of beef and pork. Chicken, at low
average prices, then turkey and goose, follow in order of real
omy, and furnish about as much protein and energy for a given
unt of money as sirloin of beef or leg of mutton. Out-of-season
ken and turkey, capon, duck, and green goose are slightly more
ensive, while squab, pheasant, and quail are so dear as to be lux-
. Save chickens, then, poultry can hardly be used economically
he very poor, but the cheaper kinds may be economically used by
moderately well-to-do, while all kinds except the very costly might
be more frequently used by those who can afford to pay for a
ant variety in their diet. In sickness delicate poultry is often
ble far beyond its cost, because it is so appetizing and is at the
time fairly easily digested. The rapid increase in the amount of
ry raised for the table in this country is strong proof that it is
ning more and more popular, and although it may not deserve
pularity on the grounds of strict economy, it certainly does earn
its attractive flavor, easy digestibility, and the pleasant variety
es to our meat list.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 185.

BEAUTIFYING THE HOME GROUNDS.

BY

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1904.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., November 16, 1903.

SIR: I have the honor to transmit herewith a paper on Beautifying the Home Grounds, prepared by Prof. L. C. Corbett, Horticulturist of this Bureau, the same being a revision of a paper published in the Yearbook of the Department of Agriculture for 1902. As the ideas embodied should be of interest to farmers and suburban residents, I recommend that it be issued as a Farmers' Bulletin.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

ILLUSTRATIONS.

BEAUTIFYING THE HOME GROUNDS.

INTRODUCTION.

The appropriate use of trees, shrubs, vines, and herbaceous plants in the adornment of city, village, suburban, or country home grounds gives a charm and beauty which are interesting and pleasing to the passer-by as well as to the occupant of the home. Plants are a means of expressing restfulness and beauty. Their gradually changing aspect with the succession of the seasons heightens their pleasing effect and relieves monotony. The changes which occur in the life of vegetation during the year have caused man to speak of the stages of human existence as the "spring," "summer," and "autumn" of life. The leaf, the branch, and the flower, as well as the general form of the plant, manifest a grace and beauty which art endeavors to copy. While art can not take the place of nature, it nevertheless plays an important part in teaching us to see and appreciate the beauties of nature. After the eye has been trained to see and the mind to interpret the beauties which the eye beholds, then association with nature produces its greatest effect.

In the artificial adornment of grounds by means of plants, Nature is our best instructor. From her we learn the uses of grass, flowers, vines, shrubs, and trees, and how to combine them to the best advantage. By growing together for ages, the various classes and species of plants have developed forms, habits, and requirements which enable them not only to live and thrive in harmony, but actually to assist one another.

Man should first provide for his necessities, then for comforts, and finally for pleasures. In a new country such as ours, the expenditure of time and means for the adornment of grounds has naturally received so little attention. The people have been necessarily concerned with acquiring lands and buildings. But a stage of development has now been reached when Americans should give more attention to the embellishment of their home grounds.

THE PLANTING PLAN.

The first essential in the adornment of a home area is the formation of a suitable plan. In making this plan the principal things to be considered are the size of the area, the amount which the owner feels able to expend for the purpose, the climatic conditions, the soil, the exposure, the peculiarities of the site, and the style of treatment, whether formal or natural.

Small places, consisting of an acre or less, situated among others of like dimensions, can only be appropriately improved in a formal style.

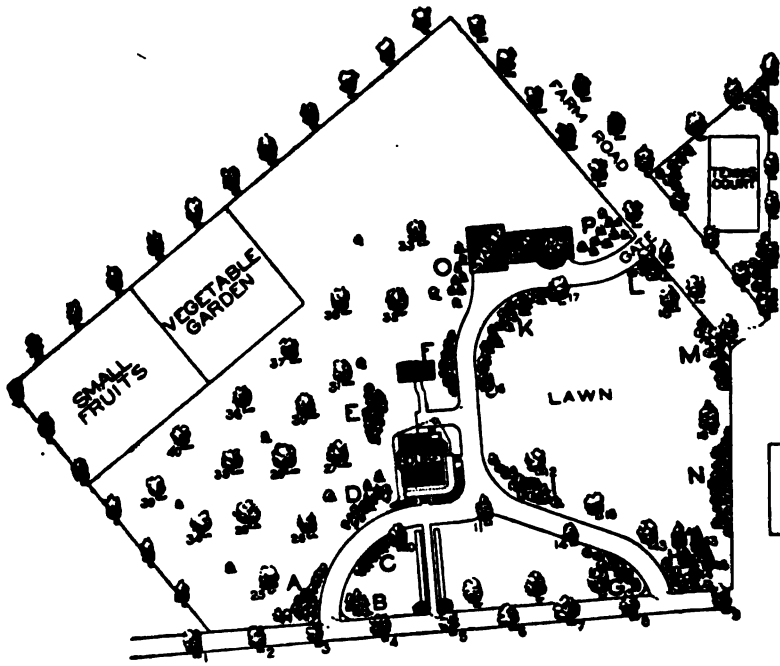

Fig. 1.—Planting plans for a house lot for farm or suburban home: 1 to 9, Pin oaks; 10 to 12, Ginkgo biloba; 13, Willow oak; 14 to 16, Norway maples; 17 and 19, Red oaks; 18, Elm; 25 and 27, Norway maples; 26 and 30, Tulip trees; 28 and 31, Red oaks; 29 and 32, Pin oaks; 33 and 34, Elms; 35 and 37, Green ash; 36 and 38, Black walnuts; 39, Red oak; 40, Elm; 41 to 45, Picea alba or Picea pungens.

On the other hand, large suburban places or country seats should, in order to maintain unity and harmony with their surroundings, be treated in the natural style. It is impossible to develop a forest, park, or even a grove on an area less than an acre in extent; and it is equally impossible to maintain fountains, terraces, sheared trees, hedges, and carpet bedding over an area of several acres. Hence the two general styles of landscape gardening have been developed. One of these may be adopted, or both may be combined to suit the circumstances.

Before a tree or shrub is placed in its permanent location an outline map of the area to be treated should be made. This map should locate ıll existing structures, indicate the direction in which most pleasing ›utlooks are to be had, and also the contour of the ground to be beautified. The aim should be to hide by means of trees and shrubbery all objectionable buildings or portions of the place, and also to ihut from view all unsightly objects maintained by neighbors; to locate he trees and shrubs so as to allow an uninterrupted line of vision where he outlook is pleasing, and to so locate the plantings on large estates s to afford the greatest protection from winds and undesirable suroundings consistent with good landscape effect.

Figure 1 serves to illustrate what is meant by the use of shrubs and rees for protective as well as for screening or cover purposes. The roups marked M and N have for their object the hiding of buildings rhich, while not seriously bad in themselves, contribute nothing to he general effect of the grounds under treatment. Group K serves ıe double purpose of a bay plantation for the curved drive and a :reen for the stable and workshop, while groups E and F are designed s covers or screens for the woodshed at the rear of the residence.

A variety of trees and shrubs should be used. The selections made ır this illustration (fig. 1) are intended merely to indicate some good ırieties, and to illustrate methods of arrangement and grouping. The lan to be adopted and the selection of varieties must always depend ore or less on local conditions.

Where trees and shrubs are needed neither as screens nor windeaks, their disposition should be such as will afford a pleasing effect ıd at the same time preserve as large an area of unbroken greenrard as practicable. At the right in figure 1 the area bounded by the ırved drive is an unbroken lawn, with trees and shrubs disposed ›ng the margins. On the left, however, the plantation has assumed e character of a grove in order to hide undesirable features in that ıarter and for the purpose of serving as a wind-break.

WALKS AND DRIVES.

All walks and drives on small lots should be direct, as shown in ure 2. The planting of trees and shrubs or the placing of fountains d flag poles in the course of a walk which will cause the traveler to viate unduly from his natural course is a common but objectionable angement. On small areas walks and drives should be straight less there be good reason, because of the contour of the surface, for making them curved. In more extensive areas, where the grouping of shrubs becomes an important factor in the construction of the place, curved walks and drives are most pleasing and effective.

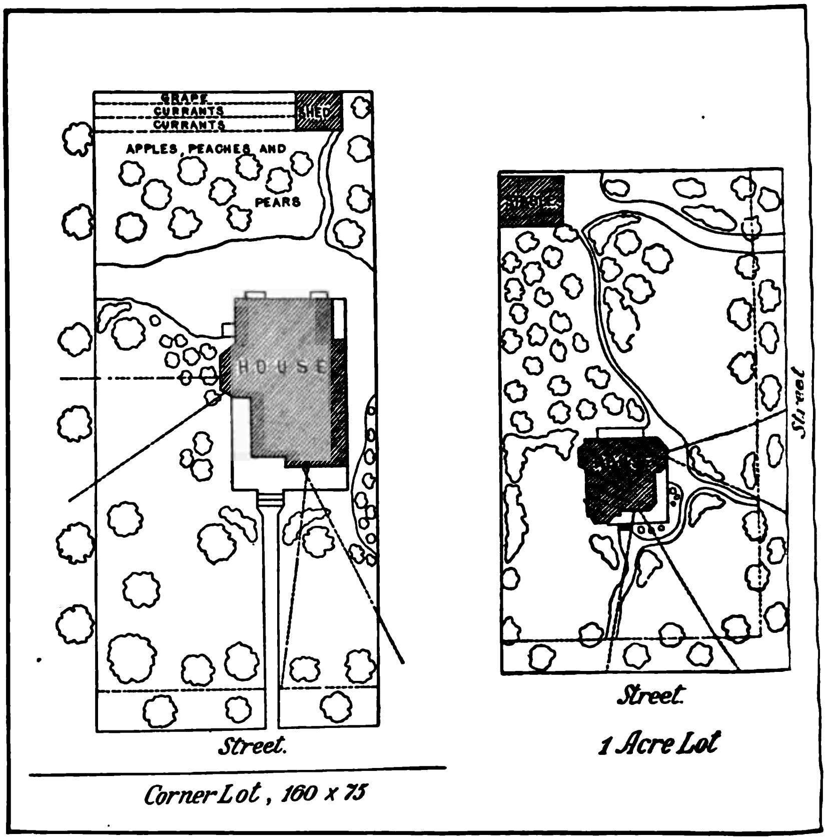

FIG. 2.—Planting plans for town lots: Irregular outlines and smaller circular figures represent groups of shrubbery; large circular forms show position of ornamental shade trees. In the plan of the acre-lot the plantation between the house and stable provides for a home fruit garden.

THE GREENSWARD.

With trees, shrubs, vines, and herbaceous bedding plants, pleasing contrasts can be produced. Each plant or group of plants has an expression peculiarly its own, and when used with suitable surroundings the effect is pleasing. While each of these plants possesses an intrinsic decorative value, this value is enhanced in proportion to the perfection of the greensward in which it is set. Green grass is not only useful as a covering for the earth, but it is of itself beautiful. A perfect lawn is one of the rarest possessions of either public or private establishments. A good lawn demands great skill and judg ment in its making as well as in its maintenance. The difficulties of lawn making become more accentuated as the heavy clays and clay loams of the North and West are replaced by the light, sandy soils of the South. The superb Kentucky bluegrass, which produces such perfect lawns in regions with heavy soils and abundant rainfall, must be supplemented by white clover as the soils become light and sandy, and finally, as southern latitudes are reached, both these must be replaced by Bermuda grass (*Capriola dactylon*) or by St. Augustine grass (*Stenotaphrum dimidiatum*).

The chief charm of a lawn consists in an even stand of grass of uniform color kept closely mown. In order to secure this a pure grass, such as Kentucky bluegrass, must be used, or the mixture must be so perfectly made from grasses of like habit of growth and coloring that a mottled effect will be avoided. For permanence, a greensward consisting of a blend of grasses is superior to one made from a single sort. For this reason, therefore, lawn mixtures usually consist of a number of different species. The great difficulty, however, lies in securing good germination from such mixtures, with uniform lawns as a result. The fescues all grow in stools or bunches; the rye grasses are lighter n color, coarser in leaf, and of more rapid growth than the Poas or bluegrasses. Most satisfactory combinations, both as regards beauty nd permanence, come from mixing redtop and bluegrass (*Poa pratensis*). For poor soils containing much sand, the white Dutch clover s most satisfactorily used in combination with bluegrass and redtop.

In the South, however, lawns can only be successfully made from urf or from rootstocks. The grasses which succeed in the North and re there comparatively easily grown from seed are not successful in he South. Grasses which develop underground stems are most successful under southern conditions.

SELECTION AND USES OF SHRUBS.

General Arrangement of Trees and Shrubs.—In general, trees should and either as single specimens in isolated positions or in irregular oups rather than in long rows. Under certain conditions long avees of trees regularly disposed on either side of a prominent drive or sta may contribute a very pleasing and imposing effect to a large ue. The general rule for trees also applies to shrubs, except that ir use should be chiefly in groups or belts rather than as specimen nts, although specimen plants are of value in formal plantations. w shrubs possess a sufficiently graceful and characteristic habit of wth to make them pleasing objects when grown singly upon the n, but where a number of specimens of varying habit are brought ether in a single group, the differences are emphasized by contrast the variety produces a pleasing effect, particularly if the rate and habit of growth as well as the color and character of the foliage be somewhat different. Pleasing results in groups of shrubs do not come from large numbers of the same variety in mass, but from a harmonious arrangement of different genera, species, and varieties. In order to secure the greatest pleasure from shrubs in groups, each group should represent some idea either of spirit or of rest, and always of beauty. These effects come from the habit of growth of the plants used. Tall-growing, graceful, reed-like plants produce an effect of grace and beauty, while plants of a more sturdy habit may indicate strength and resistance. The latter are well suited for wind-breaks or

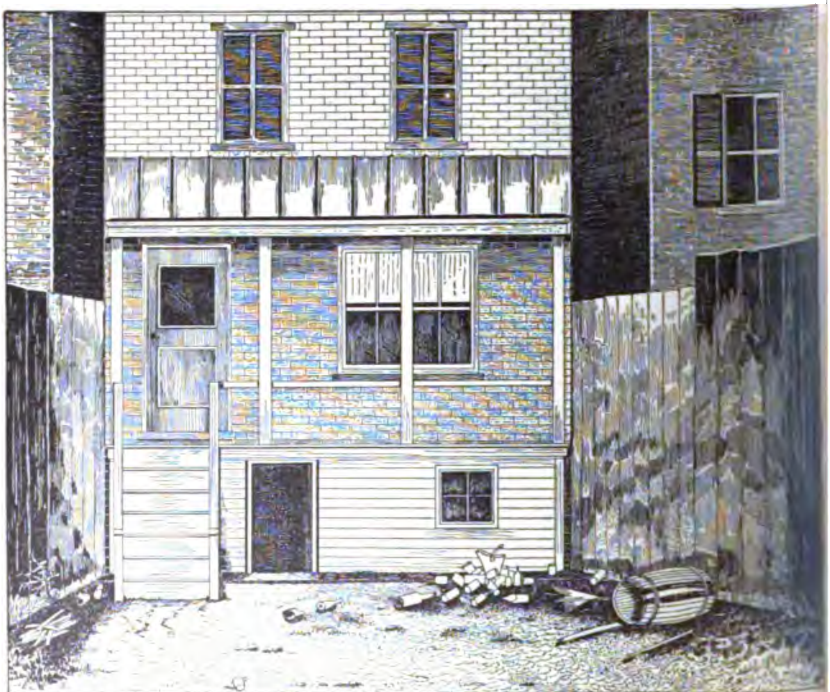

FIG. 3.—The back yard of a residence, showing a condition which too often exists.

shelter belts, while the former lend themselves to the formation of screens or masks, either for walks or drives or for fences or unsightly buildings. Each group or plantation made upon the grounds should have an excuse for its existence and a reason for occupying the particular spot it does.

If there are unsightly rear views, plantations in groups or belts should be provided, in order to hide such objects. If a portion of the grounds is to be used for a garden or a stable, then the planting should be so made as to effectively shut these areas from view.

Figure 3 shows the back yard of a city house which is a dumping ground for rubbish. Figure 4 shows a rear view of the same premises after a gardener had given the place his attention.

Producing Color Effects.—Pleasing effects in shrubbery plantations come also from massing sorts so as to produce a floral display each month of the year. A group which blooms in May or June, and which presents no additional feature other than a mass of foliage from June until autumn, has little merit from a decorative point of view. Variety is the secret of pleasing effects in shrubbery groups. Glaring contrasts in habit of growth or in color of flowers or foliage are as objectionable in planted groups as in tapestries, but reasonable and

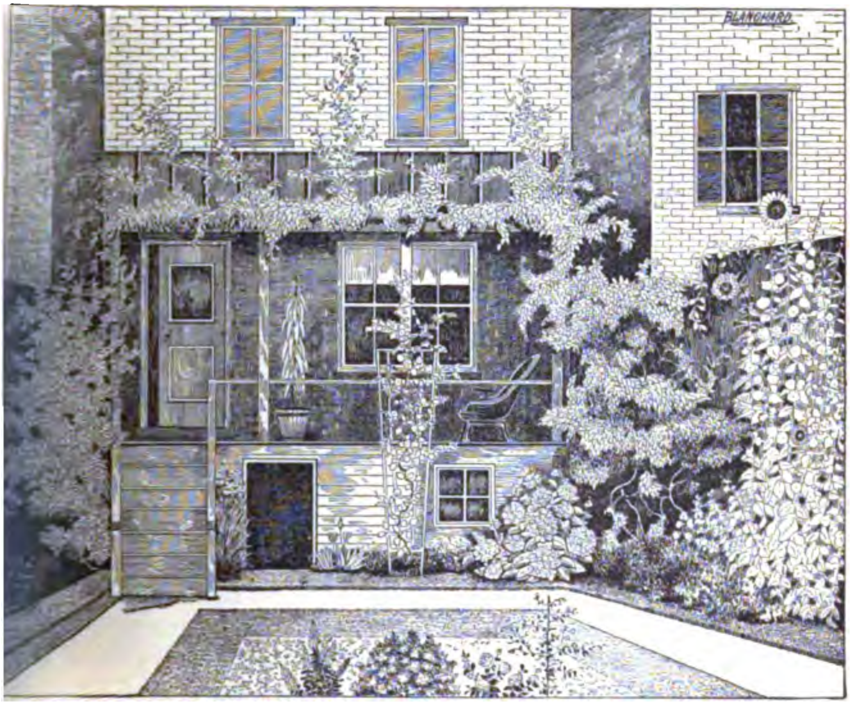

FIG. 4.—The same yard shown in figure 3, with a suggestion of the changes possible.

armonious contrasts only add beauty and variety to the landscape. ot only do the flowers and foliage of spring and summer contribute these results, but autumn colors add a most desirable and valuable ntribution to the seasons' panorama.

Shrubs should be studied not alone from the standpoint of the size, lor, and profusion of their bloom, but the time of leafing should be ted. The color of the leaf during summer as well as in autumn is so important. But most important of all is the time the leaves fall, hether early or late, or whether they remain on all winter. Some rubs retain their foliage well on into winter, while others, such as the California privet and many of the barberries, retain it all winter. Some of the magnolias retain their large glossy leaves until the

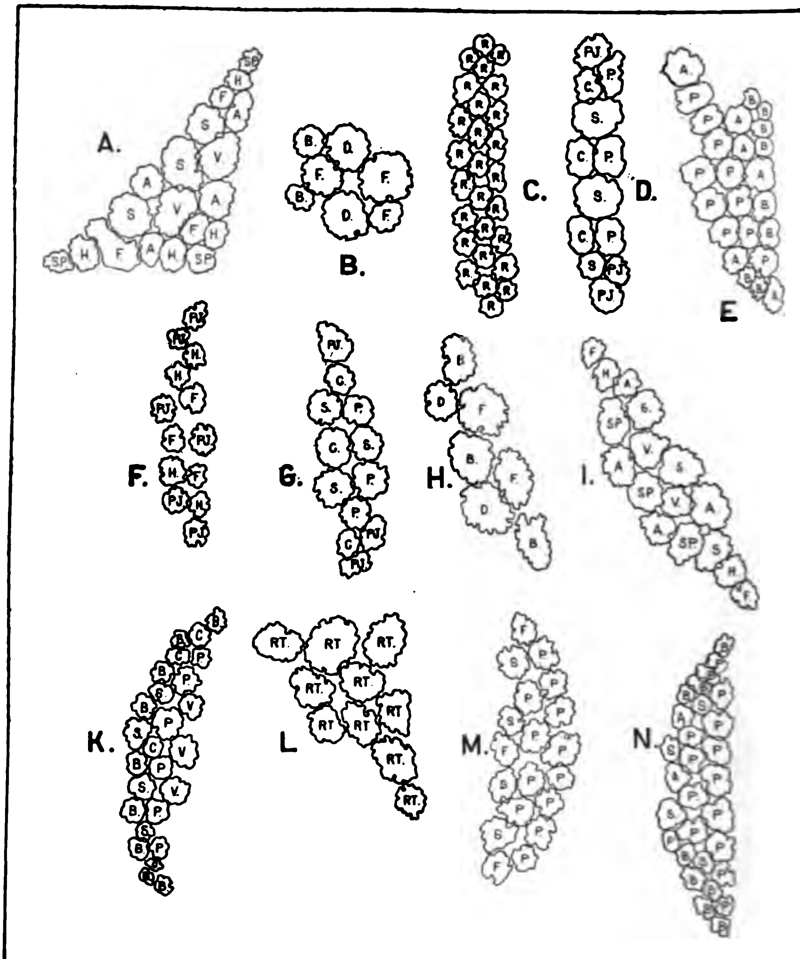

FIG. 5.—Detail of shrubbery groups shown in figure 1. GROUP A.—F, 3 Forsythia (May); S, 3 Syringa (May); V, 2 Viburnum (June); SP, 3 Spiræa (July); A, 4 Althea (August and September); H, Hydrangea (August and September). GROUP B.—D, 2 Deutzia crenata (June); F, 3 Forsythia; 2 Berberis. GROUP C.—R, 27 Roses in variety. GROUP D.—C, 3 Calycanthus; P, 3 Philadelphus; 3 Syringa (white); PJ, 3 Pyrus japonica. GROUP E.—A, 6 Althea; B, 8 Berberis; P, 10 Pr... GROUP F.—F, 3 Forsythia; H, 4 Hydrangea; PJ, 6 Pyrus japonica. GROUP G.—C, 3 Calycanthus; 3 Philadelphus; S, 3 Syringa (white); PJ, 3 Pyrus japonica. GROUP H.—D, 2 Deutzia crenata (Ju...; F, 2 Forsythia; B, 3 Berberis. GROUP I.—F, 2 Forsythia (May); S, 3 Syringa (May); V, 2 Viburnum (June); SP, 3 Spiræa (July); A, 4 Althea (August and September); H, 2 Hydrangea (August and September). GROUP K.—V, 3 Viburnum plicatum; S, 4 Syringa (white and purple); C, 4 Calycanthus; B, 9 Berberis; P, 6 Privet. GROUP L.—RT, 10 Rhus typhina (sumac). GROUP M.—P, 12 Pr...; S. 4 Syringa; F, 3 Forsythia. GROUP N.—P, 14 Privet; S, 4 Syringa; A, 2 Althea; B, 9 Berberis.

approach of spring, when they turn brown and fall, to be replaced a few weeks later by a new set equally as large and glossy.

In this connection it is interesting to note a feature in our oaks and beeches which has some value from a decorative standpoint. Several of the oaks, notably the white oak (*Quercus alba*), hold their leaves after they have become brown and lifeless. This habit, while of some merit from an artistic point of view, is a very great annoyance to the lover of clean lawns and to the leaf gatherers, for the leaves of these trees fall continually from autumn until spring. The same objection also applies to some of the beeches, notably the American beech.

Arrangement According to Form and Size.—In grouping shrubs, those with an upright habit and robust growth should occupy either a rear or a central location in order that they may form the general barriers against which all lower-growing sorts may be arranged in regular gradation to the border line, which latter should be given up to the decumbent and effeminate sorts, in order that the eye may be carried from the greensward to the top of the group without receiving offense from bare stalks between the turf and the foliage of the group itself. Avoid bare trunks in evergreens and bare stalks in the group.

Low-growing, dense-foliaged plants are as essential to a successful group or border as are the tall-growing sorts. Nature herself is one of the safest guides. Her groups are always made up of a variety of light-loving and shade-enduring plants growing together, each one assisting the other to secure the environment best suited to its highest development. For instance, the ailanthus, sumac, and ampelopsis all grow and develop beautifully in full sunshine, but are, at the same time, among the most common undergrowth of the forest. Various species of Cornus, Viburnum, and Rubus adapt themselves well to underplanting. It is because of these adaptations of plants to natural environments so markedly unlike that nature always presents a pleasing and restful picture.

Modern landscape horticulture is at best only a poor reproduction of the model set by Nature herself, but in making the counterfeit every possible advantage should be taken of the natural adaptations of plants in order to secure the most pleasing effects from the material at command. In all planting it should be the aim to conceal the hand of the gardener to the utmost possible extent. In small formal places with straight walks and hedges, the gardener's shears must be used frequently, but the aim should always be to produce harmony and symmetry without materially altering the natural habit of the plants. Formal hedges are an exception, but specimen trees and shrubs need not be.

The Masking of Walks and Drives.—The bays of curved walks and drives should be filled with groups of shrubs, so that if there be no natural object for the road to make a curve around, the plantation will serve as a substitute for one, and in so doing produce one of the highest effects which can be secured in landscape gardening. By a judicious use of plants in the bays of walks and drives new and unexpected features in the form of vistas, lawn pieces, or specimen plants can be brought before the observer, thus producing pleasant surprises and holding his interest. This is suggested in figure 6. The plantations show variety as well as serve the purpose of marking the walk.

The planting of bays or the masking of walks and drives is one of the fine arts in landscape decoration. If care and skill are exercised, the interest of the visitor will not be allowed to flag, for at each turn in the road some new beauty will appear. The sense of discovery is an important one to be gratified. The skillful planter realizes this and takes advantage of the curves in the road to shut out for the time

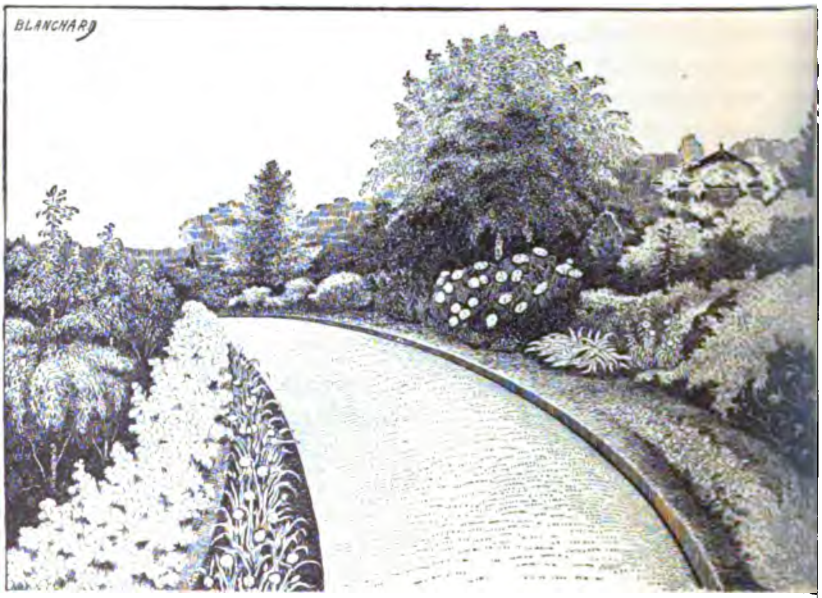

FIG. 6.—A pleasing effect produced by successful bay and border planting.

being those objects of interest and beauty which lie beyond. From the nature of the result desired, tall-growing deciduous trees are not suited to this character of planting. Masking groups must be dense enough and tall enough to shut out the view. They must not be formal, but should lose their outlines gradually and grade harmoniously off into the greensward or grosser planting, according to the general character of that part of the grounds. The same rules in regard to harmony and variety hold for masking groups as for those designed as shelter belts or as screens.

Arrangement of Shrubs in Groups.—Returning to the groups of shrubbery provided for in figure 1, it is desirable to combine in each group as much of interest as possible without making the group heavy and unattractive. In Group A it is proposed to plant the following-named shrubs in the numbers indicated: Forsythia, 3; syringa, 3; viburnum, 2; spiræa, 3; althea, 4; hydrangea, 4. The next point to settle is the relation of these plants to one another in the group. Because of the different habit and rate of growth of the several sorts mentioned their location will have an important bearing upon the ultimate character of the plantation. It is evident that the tall-growing viburnums must have a central location along with the syringas; these to be flanked by the altheas; outside of these the forsythias and spiræas, with the hydrangeas near the corners, the plantation being completed by a spiræa at each point. (See Group A, fig. 5.) In this group there are 19 individual plants, representing six different types and genera of plants. The blooming season provided for in the group is, forsythia and syringa, May; viburnum, June; hydrangea and spiræa, July; althea, August and September, with the althea frequently blooming well on into October. Here, then, we have not only a variety of foliage and a different rate and habit of growth, but a blooming period beginning in May and extending well into October, when the viburnums will begin to take on autumn coloring. In such a group each month brings a new glory in addition to the variety produced by the diversity in the shrubs themselves. Variety, harmony, and beauty are the ends sought in this plantation.

DECIDUOUS TREES.

Trees which shed their foliage at the approach of cold weather must necessarily form a large portion of the grosser decorative material for plantations in the North Temperate Zone. Not only do such trees make up a great portion of the indigenous growth of the region, but the deciduous trees present a great range of size and form, as well as great variety of colors and leaf forms, features of the utmost importance in producing variety in landscape effects. The colors which add so much beauty to the landscape during the autumn months appear only in deciduous trees and shrubs.

The Oaks.—During youth the oaks present a symmetrical form, together with a variety of leaf forms, which renders them especially attractive objects. The broad, spreading, rugged habit characteristic of the white, red, rock, and willow oaks produces a striking contrast with the numerous small-sized drooping branches and pyramidal form of the pin oak. The leaves of the oak range in size from the massive broad leaves of the mossycup oak (*Quercus macrocarpa*), often 10 or 12 inches in length and 4 or 5 inches in width, to the short, narrow leaves of the willow oak (*Q. phellos*). This group, which is interesting and valuable from an economic as well as an æsthetic standpoint, contains not only a variety of deciduous forms, but at the South offers in the live oak (*Q. virginiana*) an evergreen form which is among the most valuable of the shade trees for the section to which it is adapted.

The Maples.—Next to the oaks as regards variety in form and beauty of autumn coloring stand the maples. This group, like the oaks, presents dwarf, shrubby forms as well as gigantic timber trees. From the standpoint of the landscape gardener, the maples are less desirable than the oaks and many other deciduous trees, because of their liability to injury by heavy winds. The wood of this group is brittle, and the branches have an unfortunate habit of forking in such a fashion that a weak union results which, when subjected to heavy pressure from wind or ice, gives way, causing wounds which produce conditions leading to early destruction of the trees. To offset these unfortunate features, the maples as a class are of rapid growth and symmetrical form, adapting themselves to a great variety of conditions. The red maple (*Acer rubrum*) is a water-loving plant, but can be quite successfully grown on the upland. The silver maple (*A. saccharinum*) endures under the rigorous conditions of the Northwest, and is at the same time extensively planted with success throughout the Middle Atlantic States for ornamental purposes. In autumn the most brilliant reds and yellows of our forests are produced by the maples.

The American Elm.—Among the more valuable deciduous trees, both for street and ornamental planting, may be mentioned the American elm (*Ulmus americana*), which is hardy over a wide range, grows rapidly, and forms one of the most graceful and beautiful trees native to our forests.

The Ashes.—The ashes are of rapid growth and have clean foliage which gives them an attractive appearance. The one drawback to the ash as a park tree is its habit of producing great quantities of seeds, which in turn produce a crop of weedy seedlings upon the lawn.

The Lindens.—The American as well as the European lindens are useful lawn and park trees, but do not long endure the privations of street life in cities. In the open, their broad leaves, clean branches and fragrant blossoms render them of value for lawn purposes. The extreme hardiness of the linden extends its use to the Northwest. In its native habitat it is much prized as a honey plant, and also for its timber, which is extensively used in the manufacture of light boxes and other receptacles.

The Poplars.—The poplars present another group of widely varying plants, which on account of their rapid growth and extreme hardiness are extensively planted in the treeless sections of the Northwest, as well as about residences in more equable climates, where quick shade and protection are desired. When used for immediate effect they are usually accompanied by slower-growing trees, which, when sufficiently grown, will altogether replace the poplars.

The Willows.—Willows are seldom used either as street or park trees, but upon extensive grounds, where moist places occur which do not offer a congenial habitat for other desirable deciduous trees, the willows, because of their adaptation to such spots, are very useful.

The Tulip Tree.—The tulip tree, which is also known as the yellow poplar (*Liriodendron tulipifera*), is a rapid-growing tree, attaining immense size and showing most attractive, glossy, fiddle-shaped leaves. In spring, trees growing in the open show a profusion of yellow, tulip-shaped flowers, which are later followed by the characteristic fleshy fruit of the magnolia, of which it is a representative. While seldom used for street purposes in cities, it is of value for driveways and parks where trees of great size and beauty are admissible.

The Sycamore.—The sycamore, or plane tree, both native and oriental, is a most useful street tree and as well a striking lawn or park tree. In age it presents a most picturesque appearance as a result of its sturdy, irregularly branching limbs and its peculiar greenish-white bark. The leaves of the native species suffer severely in some localities from a parasitic fungus, which detracts greatly from the value of this tree for ornamental purposes.

The Hardy Catalpa (*Catalpa speciosa*).—Because of its rapid growth and symmetrical form when grown in the open, taken in connection with its broad leaves and showy racemes of flowers, this has become a favorite tree for planting in the prairie regions, where comparatively few broad-leaved trees endure. Besides its ornamental value, the catalpa produces very durable timber, highly prized as post material.

The Horse Chestnut (Æsculus).—This group of trees is of especial merit because they combine with attractive form and foliage a beautiful floral display during the months of May and June. The drawbacks to the horse chestnut are the objectionable litter made by the ripening fruits in the autumn and the fact that in some localities at least the European species (*A. hippocastanum*) is subject to a disease of the foliage. The hardiness of the horse chestnut and the beauty of its flowers and foliage are sufficient to warrant its use as a specimen tree, despite its objectionable fall litter.

The Kentucky Coffee Tree (*Gymnocladus canadensis*).—This is a deciduous tree of an ornamental nature, with very long bipinnate leaves. It is adapted to the Middle and Western States, and produces best results in rich, moist soils. Seeds are produced in long, broad pods, the shells of which are hard and resistant when mature, as are also the seeds themselves. The growth is upright and rapid. The bark is rough, but ornamental, while the shoots themselves are stiff and blunt, the compound leaves giving the whole plant a light, airy appearance, which is augmented by their bluish-green color.

The Yellow Wood (*Cladrastis tinctoria*).—This free-growing, ornamental deciduous tree is native to the region of Kentucky and Tennessee. It is desirable because of its rounded form and its compound leaves of a bright light green, which in autumn turn to a warm yellow. Its flowers, which are generally borne in great profusion, are irregular (pea-shaped), white, sweet scented, and appear in long, drooping racemes, which frequently make the tree a veritable bouquet. It is free from disease, makes a moderate growth, has smooth bark, makes no objectionable litter in the autumn, and is therefore very desirable for lawn and city purposes.

EVERGREEN TREES AND SHRUBS.

The general effect of an evergreen or coniferous forest is that of somberness. Life is apt to have enough of the somber element forced into it by circumstances outside of one's control, and for that reason, if for no other, plantings which develop this effect in the surroundings of the home should be avoided. The use of the narrow-leaved evergreens is therefore restricted from an æsthetic standpoint. They are also generally restricted by climatic conditions to high altitudes and latitudes. A limited use of conifers at the North adds a very desirable variety to the character of a place during summer as well as during winter. In summer the effect is one of contrast in growing plants, while in winter it is, as it were, a contrast of the living with the dead. During winter the conifers by retaining their leaves carry with them an expression of life and warmth, and when draped in snow and ice the long, graceful branches of the pines and spruces present most interesting and beautiful objects. The gaunt, bare branches of the leafless oaks and maples produce a marked contrast with the compact form of well-grown conifers.

Because of the undesirable effect resulting from the close planting of evergreens, their use is restricted. As a means of emphasizing slight elevations they are exceedingly useful. Screens which can not be made sufficiently dense or lasting with deciduous trees can well be formed with conifers. A limited use of conifers at the North is in conformity with the general character of the forest growth of the region. True, some sections show only deciduous, while others possess only coniferous, forests. In landscape gardening neither of these extremes can be followed with profit. An intermingling of evergreens with the deciduous plants produces a pleasing effect which relieves the faults of a too general use of either.

At the South the character of decorative plantations is of necessity very different from that at the North. Here evergreen forests abound; the marked contrast of the seasons is not emphasized in nature. Even during winter, conditions comparable with those of the spring months the North obtain; growth is only temporarily interrupted, and ere is therefore no natural reason why plants should shut themlves up in frost-proof boxes, as do the broad-leaved species of the orth. At the South evergreens are the rule and not the exception. ı habit of growth and character of foliage, the evergreen plants of ıe South, aside from the conifers, of which there are many, are quite tempt from the objection urged against the profuse use of conifers ; the North. The beautiful rounded form of the live oak which, om Richmond, Va., southward along the coast, forms such an impor.nt feature in street and park adornment, is entirely exempt from the uality of somberness. Other broad-leaved evergreens are the magolias, the palmettoes, the camellia (*Camellia japonica*), and farther outh the cocoanut palm, the mango, the sapodilla, the camphor, and ıe citrous trees. In regions with a sufficiently mild climate, the Ausralian pine (*Casuarina equisetifolia*) makes a most graceful avenue ree.

TALL-GROWING PERENNIAL GRASSES.

In the hardy tall-growing grasses there are valuable objects for use ıpon the lawn and in groups of shrubs for the purpose of adding a ouch of color and variety. The coloring of such grasses as *Eulalia 'aponica*, varieties *zebrina*, *gracillima*, and *variegata*, is so markedly lifferent from that of the common lawn carpet and from the shrubs used in masses and shelter belts that a pleasing contrast is afforded by nterspersing them here and there. Then, too, these hardy grasses, because of their rapid growth, add a touch of variety and carry a suggestion of the tropical. Such tall-growing plants as the "tall reed" (*Arundo donax*) serve the purpose well if used in conjunction with ailanthus or sumac, which if cut back to the ground each season will produce a marked and pleasing tropical effect. If sumac is used as the shrubbery member of the group, a most delightful touch of autumn coloring will be afforded by the rich red of its foliage during October. The best of the sumacs for this purpose is *Rhus glabra*, although the hairy sumac (*Rhus typhina*) is very good, and for tropical effect the ailanthus is best of all, but it lacks the autumn charm of the other two. Besides their use as features in groups of shrubs, the grasses lend themselves well to formal plantations. When placed regularly in rows or in formal beds, they become useful as well as attractive features in the planting plan.

One of the chief advantages which these plants offer is the ease and facility with which they can be increased by division, thus affording a quick and inexpensive method of securing a very satisfactory immediate effect. The hardy grasses can also be used to good purpose as the central features of herbaceous borders or beds. The tall reed (*Arundo donax*) as a central mass bordered by tall-growing, darkleaved cannas, which in turn are bounded by a robust coleus, such as "Golden Bedder," can be used to good advantage in a large place to produce an effect of richness and luxuriance at a minimum of cost. While such expedients can not be classed as a high or desirable type of decoration, they often serve a very useful purpose where funds are limited.

PERMANENT VINES.

Climbing plants meet a demand in the adornment of a place which can be filled neither by trees nor shrubs. Trees and shrubs can be used to hide unsightly objects from a distance, but vines serve the same purpose as the draperies of a garment; they mask by covering unsightly objects, as shown in figure 7.

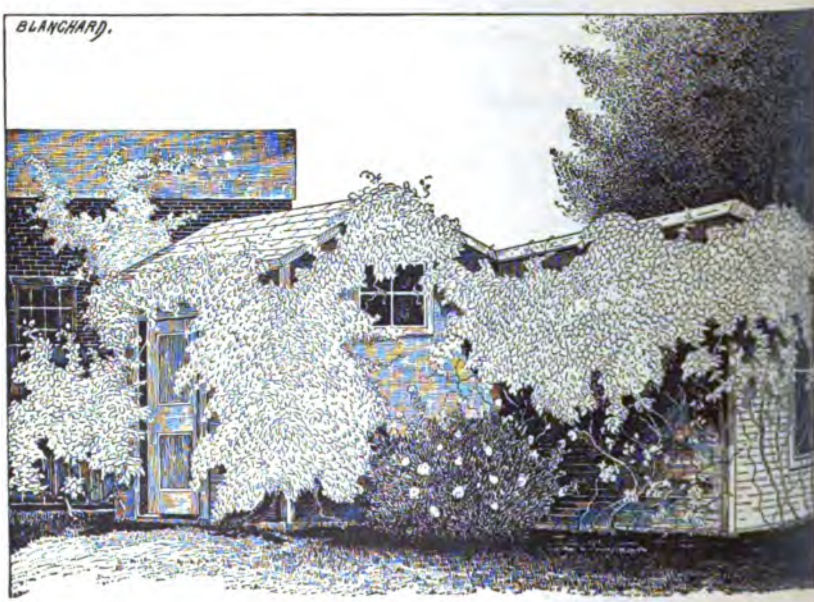

FIG. 7.—Effective masking of outbuildings by shrubs and permanent vines.

Vines have a peculiar value in decorative planting in that as a class they are shade enduring; yet many of the best decorative plants of this group thrive to perfection in full sunlight. Since many vines will thrive in partial shade as well as in full sunlight, they lend themselves well to porch and arbor decoration. A few have the power to attach themselves to bare walls, thus making them extremely useful in covering rough brick, stone, or wooden walls, giving them an effect of age, beauty, and appropriateness which can not be produced by artists and architectural materials. Two of the best vines for covering walls are the Boston ivy (*Ampelopsis tricuspidata*) and the English ivy (*Hedera helix*).

Vines which attach themselves to wire or wood supports and are chiefly valuable because of their covering and shading effects are the clematis, with all its varied forms, the wistaria, the trumpet flower, and the Actinidia and Akebia, both valuable cover plants. For sandy regions either as a soii binder or as an arbor or trellis cover none of the vines is more useful than the Japanese honeysuckle (*Lonicera japonica*). There are many other good honeysuckles (Loniceræ) grown for decorative purposes, but none is more rapid-growing or freer from insect pests and fungous diseases than the Japanese honeysuckle. In this catalogue of valuable vines two more of our native vines justly merit high places—the five-fingered ivy (*Ampelopsis quinquefolia*) and the bittersweet (*Celastrus scandens*).

ANNUAL VINES.

Annual vines may also serve a useful purpose about a new place. The perennial woody vines are slow growing, and usually make but little shade or protection during the first two or three years after planting. With annual plants, however, the case is quite different. Many annual climbing vines have a profusion of leaves, grow rapidly and luxuriantly, and afford a simple, inexpensive, yet satisfactory means of securing an immediate screen. For best results with these plants special attention to early planting, often indoors, is essential. When planting-out time arrives, place them in a rich, well-drained soil, and at all times maintain an abundant supply of moisture. Under such conditions use the moonflower (*Ipomœa grandiflora*), the *Cobœa scandens*, the morning-glory, the cypress vine (*Ipomœa quamoclit*), the hyacinth bean (*Dolichos lablab*), nasturtiums for low screens and lattices, and the wild cucumber (*Echinocystis lobata*) for taller structures. Rustic summer houses and arbors may be very beautifully and satisfactorily adorned with cobœa, or with wild cucumber, during the time which must elapse before the permanent vines can be grown sufficiently to cover the structure.

EMERGENCY PLANTING.

The comparative value of shrubs and perennial grasses and herbaceous annual bedding plants is at once apparent. Residents of the country or of suburban places have difficulty in securing suitable herbaceous plants in sufficient quantities to produce rich effects, and even if such plants can be obtained in profusion they can not take the place of shrubs and grasses either as cover plants or as screens or wind-breaks. A complete arrangement requires a harmonious use of both shrubs and annual herbaceous plants.

For quick results, however, where shrubs of large size can not be secured or are too expensive, a temporary effect can be produced by the use of tall-growing, broad-leaved plants, such as the castor bean (Ricinus), the canna, and the caladium, as shown in figure 8. The castor bean grows rapidly, is easily propagated from seed, and comes true to variety, affording in one plant a wide range in color of foliage and in stature. This plant frequently grows 6 to 8 feet in height from seed, even as far north as New York, in a single season. Its broad-spreading habit, together with its attractive foliage, which in well-nourished plants is retained well down to the ground, renders the castor bean a very satisfactory makeshift or substitute for shrubbery where screens and masking masses are needed. The trouble with all such makeshifts is that they produce an effect which lasts for a few months only, while with

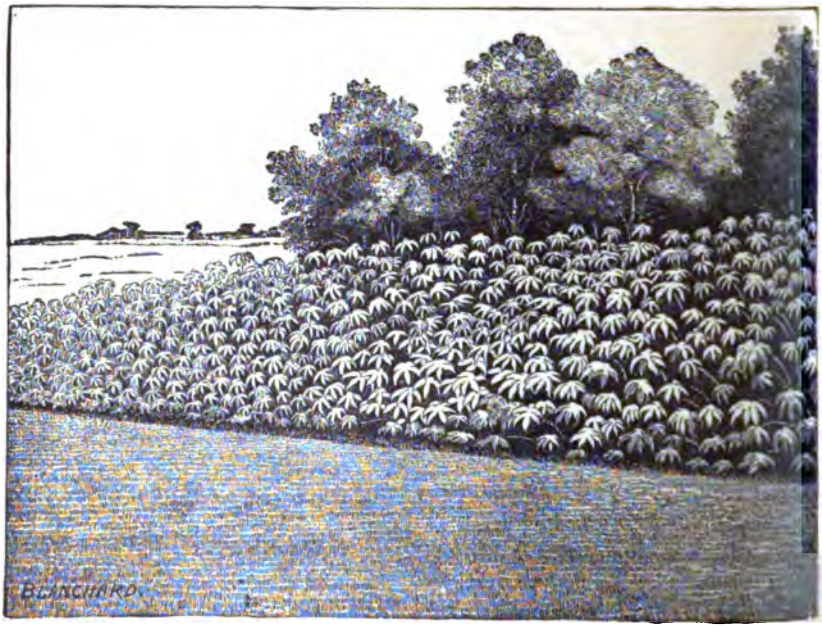

FIG. 8.—Castor beans used as a screen for the bare trunks of trees.

shrubs the benefit is lasting and they serve quite as useful a purpose in the way of shelter belts and screens in winter as during the summer. For the sake of variety, the caladium and canna can be used to good advantage in connection with the castor bean. The tall habit of the canna and the broad leaves of the caladium render them well fitted for massing. Such plants as the castor bean, the canna, and the caladium can be used to good purpose in shrub borders and masking groups before the shrubs are sufficiently grown to produce the effect desired. Even after the shrubs have grown sufficiently to accomplish the end sought an occasional mass of castor beans, asters, eulalias, or arundo interspersed at intervals will lend variety and life to the groups.

CULTURAL SUGGESTIONS.

In addition to a well-executed general planting plan the successful development of a place depends on the preparation and fertilization of the soil, the pruning and planting of trees and shrubs, and the making and maintenance of a greensward.

Preparation and Fertilization of the Soil.—The nature of the plantations upon a city lot or suburban place is such that the main part of the cultivation must necessarily be done before the plantations are made. The soil should be thoroughly pulverized, brought to a general grade, and the surface smoothed and raked with a steel-tooth rake. If a lawn is to be made, the grass seed should be sown immediately after the raking, and then the surface thoroughly compacted by the use of a heavy lawn roller. Fertilizers for the lawn should be free from weed seed and be of a lasting nature. If the soil is heavy it can be improved by plowing in a crop of cowpeas or Canada field peas. If this can not be done, the next best plan is to use thoroughly composted or sterilized stable manure. If the soil is naturally light its store of plant food can be augmented with bone meal. This should not be plowed under, but harrowed in at the time of preparing the soil.

Pruning and Planting.—The critical period in the life of a plant is when it is transplanted from the nursery to its permanent location. In moving trees from the nursery a portion of the root area is lost, and the top should be reduced in proportion to the loss of root area, in order that the newly transplanted and unestablished plant may be able to secure sufficient moisture and food to supply the demands of the top. The roots should also be pruned, so as to protect them against decay, by cutting away all broken and mutilated parts, leaving the cut surfaces smooth and in such position that they will come in contact with the fresh earth. After the plant becomes established certain branches will grow more rapidly than others and the appearance of the plant will be spoiled by this unequal growth. Pruning should, therefore, be resorted to in order to preserve a symmetrical development of the plant without rendering it artificial or formal in appearance. Care should also be exercised during the early development of a plant to maintain a uniform distribution of branches around the central axis, if it be a tree, so as to insure a symmetrical and pleasing form at maturity.

At planting time the excavation prepared for the reception of the tree should be of sufficient depth to allow it to be set as deep as it stood in the nursery and large enough to accommodate the roots without bending them, while the earth in the bottom of the hole should be loosened at least one spade length below the general floor of the hole. In replacing the soil over the roots of the plant, a thin layer of earth should be placed immediately in contact with the roots and thoroughly pressed down by trampling in order to bring the particles of soil in close contact with the feeding roots of the plant. The hole should then be filled and the surface left slightly above the general surface of the surrounding ground.

Maintenance of a Greensward.—Newly established lawns should never be allowed to mature seed. Frequent clipping with the lawn mower, if not made too close, tends to stimulate the stooling of the plants rather than to interfere with their growth. If the lawn is located in a dry section or one subject to long periods of drought, it will be necessary to irrigate or sprinkle. A little water is an injury rather than a benefit. If watering is begun it should be done at night rather than during the day, and sufficient water given to thoroughly wet the soil. During the winter the new lawn should have a dressing of coarse litter or, if the soil is poor, of thoroughly composted stable manure. If neither of these is available or desirable, a fall dressing of bone meal will be found very useful. In the spring, as growth begins, the lawn should be raked with a steel-tooth rake, all breaks carefully filled in with turf or seeded, and the whole area rolled with a heavy roller. Subsequent treatment will consist in maintaining the moisture by proper use of water and frequent clipping with the lawn mower.

CONCLUSION.

To harmoniously arrange trees, shrubs, and herbaceous plants and at the same time adjust them to the contour of the place, to the architecture of the buildings, and to the convenience of the walks and drives, is the aim of the landscape gardener. As his guide and model he takes Nature, and in so far as she is followed his work is pleasing. Every successful attempt to adorn a city lot, a suburban place, or a park has a valuable influence upon the community in which it is situated. It furnishes an object lesson which others will attempt to follow, and in this way it serves the useful purpose of stimulating in others a love for the beautiful in nature. Fortunately, the beauty which is produced by ornamental plantings can not be selfishly kept for the exclusive use of its owner; every passer-by can take the full measure of his capacity without in the least detracting from the value of the plantation to its owner. Every person who plants a tree is a public benefactor.

O

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 188.

WEEDS USED IN MEDICINE.

BY

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ssistant in Drug and Medicinal Plant Investigations, Botanical Investigations and Experiments, Bureau of Plant Industry.

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1904.

LETTER OF TRANSMITTAL

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., December 10, 1903.

SIR: I have the honor to transmit herewith a paper on Weeds Used i Medicine, and recommend that it be published as a Farmers' Bullen. This paper was prepared by Miss Alice Henkel, Assistant in 'rug and Medicinal Plant Investigations, and was submitted by the otanist with a view to publication.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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ILLUSTRATIONS.

WEEDS USED IN MEDICINE.

INTRODUCTION.

It is a matter of interest, primarily to the farmer, that certain of the well-known weeds now either generally or locally infesting the country are the sources of crude drugs at the present time obtained wholly or in part by importation from abroad. Roots, leaves, and flowers of several of the species most detrimental in the United States are gathered, prepared, and cured in Europe, and not only form useful commodities there but supply to a considerable extent the demands of foreign lands. Hence it appears probable that while weeds can hardly be made desirable, still in his fight to exterminate them the farmer may be able to turn some of them to account. Some of the plants coming within this class are in many States at present subject to antiweed laws and farmers are required to take measures toward their extermination. It seems, therefore, desirable to make these pests sources of profit where possible. In many cases, when weeds have been dug, the work of handling and curing them is not excessive and can readily be done by women and children.

The prices paid for crude drugs from these sources are not great and would rarely tempt anyone to pursue this line of work as a business. Yet, if in ridding the farm of weeds and thus raising the value of the land the farmer can at the same time make these pests the source of a small income instead of a dead loss, something is gained.

In order to help the farmer to obtain the best possible prices for such products, instructions for collecting and preparing crude drugs derived from weeds are here briefly given. The collector should observe them carefully.

COLLECTION AND CURING OF DRUGS.

Too much emphasis can not be placed upon the importance of carefully and thoroughly drying all crude drugs, whether roots, herbs, leaves, barks, flowers, or seeds. If insufficiently dried, they will heat and become moldy in shipping, and the collector will find his goods rejected by the drug dealer and have all his trouble for nothing.

Another important matter to be considered in collecting drugs for market is freedom from foreign substances. All drugs should be clean and wholesome looking and contain no admixture of fragments of other plants, stones, dirt, or other impurities. A bright natural color is extremely desirable in leaves, herbs, and flowers, and adds much to the salability of the product. This can be readily brought about by giving careful attention to proper drying in the shade (not in direct sunlight), and by protection from dew or rain by placing the drugs under cover at nightfall or whenever necessary. Roots may be cleaned by washing, but leaves, herbs, and flowers should never be washed.

It is important also to collect drugs in proper season only. Neglect in this respect will bring nothing but disappointment to the gatherer, as drugs collected out of season not only are not acceptable to the dealer on account of inferior medicinal qualities, but there will also be, in the case of roots, a greater amount of shrinkage in a root dug during the growing season than will take place when it is collected after growth has ceased.

The collector should be sure that the plant he is collecting is the right one. There are many plants that closely resemble one another, yet one may possess medicinal properties and the other be absolutely useless. Again, a plant may contain very poisonous principles, and if represented to be something else, it might of course do untold injury. It would therefore be best, where any doubt exists, to send a specimen of the entire plant, including leaves, flowers, and fruits, to a drug dealer or to the nearest State experiment station for identification.

ROOTS.

Roots should never be collected during the growing season, as at that time they are deficient in medicinal properties, and they also shrink more in drying and weigh less than when gathered at full maturity.

The roots of annual plants should be dug just before the flowering period, and those of biennial or perennial plants after the tops have dried, the former in the autumn of the first year and the latter in the fall of the second or third year.

After the roots have been dug the adherent soil should be well shaken from them, and all foreign particles, such as stones, dirt, roots and parts of other plants, should be removed. If the roots can not be sufficiently cleared of soil by shaking, they should be thoroughly washed in clean water. It does not pay to be careless in this matter. The presence of soil increases the weight of the roots, but the intending purchaser is not willing to pay for the weight of the dirt, and grades the uncleaned drug accordingly. It is the clean, bright-looking root that will bring a good price.

After washing, the roots should be carefully dried. This can best be accomplished by exposing them to light and air (not direct sunlight) on racks or shelves, or on clean, well-ventilated barn floors or lofts. They should be spread out thinly and turned occasionally from day to day until completely cured. When this point is reached, in perhaps three to six weeks, the roots will snap readily when bent. During the curing process the roots, if dried out of doors, should be placed under shelter at night and upon the approach of rainy weather.

With some roots additional preparation is required, such as slicing and the removal of fibrous rootlets. Wherever this is necessary mention will be made of it under the descriptions of the different plants. In general, it may be said that large roots should always be split or sliced when green in order to facilitate drying.

BARKS.

The plants considered in this bulletin do not furnish medicinal barks, but inasmuch as there are certain sections of the country where trees furnishing such barks are rather abundant, directions for their collection may not be out of place here.

Barks of trees should be gathered in spring, when the sap begins to flow, but may also be peeled in winter. In the case of the coarser barks (as elm, hemlock, poplar, oak, pine, and wild cherry) the outer layer is shaved off before the bark is removed from the tree, which process is known as "rossing." Only the inner bark of these trees is used medicinally. Barks may also be cured by exposure to sunlight. Moisture must be avoided.

LEAVES AND HERBS.

Leaves and herbs should be collected when the plants are in full flower. It is very desirable that they retain their bright green color after curing, and this can be done by careful drying in the shade. In the collection of leaves the whole plant may be cut and the leaves may be stripped from it, rejecting the stems as much as possible. In the case of herbs the coarse and large stems should be rejected and only the flowering tops and more tender stems and leaves included. All grasses, bits of other plants, and other foreign substances should be carefully removed, as well as dead, shriveled, diseased, and discolored specimens.

Both leaves and herbs should be spread out in thin layers on clean floors, racks or shelves, in the shade but where there is free circulation of air, and turned frequently until thoroughly dry. Moisture will darken them. The same precautions that are necessary in curing roots apply here also, so far as placing them under cover to avoid dew or rain is concerned.

FLOWERS.

Flowers are collected when they first open or immediately after—not when they are beginning to fade. To preserve the bright natural color as nearly as possible they should be carefully dried in the shade, in the same manner as directed for leaves and herbs.

SEEDS.

Seeds should be gathered just as they are ripening, before the seed pods open, and should be winnowed in order to remove fragments of stems, leaves, and shriveled specimens.

DISPOSAL OF THE DRUGS.

Samples representative of the lot of drugs to be sold should be sent to the nearest commission merchant, general store, or drug store, for inspection and for quotation on the amount of drug that can be furnished, or for information as to where to send the article. The size of the sample depends, of course, upon the kind of drug; from 3 to 4 ounces—or, say, at least a good handful—should be submitted. The package containing the sample should be plainly marked as regards contents, and the name and address of the sender given. In writing to the different dealers for information and prices, it should be stated how large a quantity of a particular drug can be furnished and how soon this can be supplied, and postage should always be inclosed for reply. In no case should the entire lot of collected drugs be sent to dealers without preliminary correspondence. The collector should bear in mind that freight is an important item, and it is best, therefore, to address such dealers as are nearest to the place of production. When ready for shipment, crude drugs may be tightly packed in burlap or gunny sacks, or in dry, clean barrels.

DESCRIPTIONS OF PLANTS.

The plants included in this bulletin are burdock, dandelion, the docks, couch grass, and pokeweed (principally root drugs); foxglove, mullein, lobelia, tansy, gum plant, scaly grindelia, boneset, catnip, hoarhound, yarrow, fleabane, blessed thistle, jimson weed, and poison hemlock (of which either the leaves, flowers, herb, or seeds are used in medicine); and also wormseed, and black and white mustards, of which the seeds only are used.

Descriptions of these plants follow, together with the common names by which they are known in different localities, the habitat (or, in other words, the kinds of places or soils in which they are likely to be found), their geographical range, information as to the parts to be collected, their uses, the extent to which they are imported and the prices usually paid by dealers.

The principal uses for which these plants are employed in medicine are briefly indicated, but none of the drugs mentioned should be taken without the advice of a physician.

With the exception of the figures for dandelion and mustard, which were obtained from the Bureau of Statistics of the Department of Commerce and Labor, the imports are based on estimates furnished by dealers, and the prices per pound, while serving to give an idea as to what may be expected for the drugs, will vary from year to year, depending principally upon supply and demand.

There are of course a large number of plants used in medicine that are not included in this bulletin, which is intended to cover only such medicinal plants as may be classed as weeds.

FIG. 1.—Burdock (*Arctium lappa* L.). Flowering plant.

BURDOCK.

Arctium lappa L.

Other common names.—Cockle button, cuckold dock, beggars' buttons, hurr-bur, stick button, hardock, and bardane. (Fig. 1.)

Habitat and range.—Burdock is one of the most common weeds. It was introduced from the Old World, and is common and often very abundant in the Eastern and Central States and in some scattered localities in the West, growing along roadsides, in fields, pastures, and waste places.

Description.—This is a coarse, unsightly biennial weed of the aster family (Asteraceæ), which produces during the first year of its growth only a rosette of large, thin leaves (fig. 2) and a long, tapering root having a diameter of from one-half to 1 inch. When full grown it measures from 3 to 7 feet high. The round, fleshy stem is branched, grooved, and hairy, with very large leaves, even in the early stages of the growth of the plant, the lower leaves often measuring 18 inches in length. The leaves are alternate, on long, solid, deeply furrowed leafstalks; thin, roundish or oval, but usually heart-shaped; with even, wavy, or toothed margins; smooth above, and pale and woolly on the under surface. The flowers are purple, in small, clustered heads, appearing in the second year, from July to frost. These flower heads are armed with hooked tips, and the burs thus formed are a great pest, attaching themselves to clothing and to the wool and hair of animals. The seed of burdock is produced in great abundance, one plant bearing as many as 400,000 seeds.

Parts used.—The root alone is recognized in the United States Pharmacopœia, but there is a limited demand for burdock seed, and the

FIG. 2.—Burdock. First year's growth.

leaves also are employed. Burdock roots and seeds are used in blood and skin diseases, and the leaves externally as a cooling poultice for swellings and ulcers, the latter being employed only in the fresh state.

Burdock has a large taproot, about 12 inches long, fleshy, the outside blackish-brown or grayish-brown, the inside light in color and spongy in the center. It is to be collected in the fall of the first year. The roots must be washed, split lengthwise, and carefully dried. Drying causes the root to lose about four-fifths of its weight, and to become scaly, and wrinkled lengthwise. Sometimes the bases of the leafstalks remain at the top of the root in the form of a small, white, silky tuft. The odor of the root is weak and unpleasant.

The seeds are oblong, curved, flattened, and angular, dark brown and sometimes spotted with black, and have no odor. These should be collected when ripe or nearly so

Imports and prices.—About 50,000 pounds of lappa or burdock root are imported annually, and the best root is said to come from Belgium, where great care is exercised in its collection.

The price of the root ranges from 3 to 8 cents per pound, and that of the seed from 5 to 10 cents.

DANDELION.

Taraxacum taraxacum (L.) Karst. (*Taraxacum officinale* Weber.)

FIG. 3.—Dandelion (*Taraxacum taraxacum* (L.) Karst). (An unusually fibrous root.)

Other common names.—Blow-ball, cankerwort, doon-head-clock, fortune-teller, horse gowan, Irish daisy, yellow gowan, one o'clock. (Fig. 3.)

Range and habitat.—Dandelion is distributed as a weed in all civilized parts of the world, and in this country is naturalized from Europe. With the exception of the South, it is very abundant throughout the United States in fields and waste places, and it is especially troublesome in lawns and meadows.

FIG. 4.—Dandelion root, 16 inches long.

Description.—The dandelion is so well known a weed, especially in lawns, that it scarcely requires a description, almost everyone being familiar with its rosette of coarsely toothed leaves, golden-yellow flowers, and round fluffy seed heads. It is a perennial plant of the chicory family (Cichoriaceæ), and it may be said to be in flower throughout almost the entire year. In spring the young leaves are collected and used for greens or salad, but the part employed in medicine is the root. The flowering stem of the dandelion is usually longer than the smooth, shining green, coarsely toothed leaves, reaching a height of from 5 to 10 inches. It is erect, smooth, naked, and hollow, bearing at the summit a solitary yellow flower head, which opens in the morning and only in fair weather. The entire plant contains a white, milky juice.

Part used.—As already stated, the root of dandelion is used medicinally. It is a large taproot, sometimes 20 inches long, thick and fleshy, dull-yellow or brownish on the outside, white inside, practically without odor, and bitter. (Fig. 4.) Dandelion is often used as a tonic in diseases of the liver and in dyspepsia.

The best time for digging dandelion root is from July to September, during which time the milky juice becomes thicker and the bitterness increases. It should be carefully washed and thoroughly dried. Dandelion roots decrease considerably in size by drying, weighing less than half as much as the fresh roots and becoming wrinkled lengthwise. The dried root should not be kept too long as drying diminishes its medicinal virtues.

Imports and prices.—During the fiscal year ended June 30, 1903, the imports of taraxacum or dandelion root into the United States amounted to 115,522 pounds. The price per pound ranges from 4 to 6 cents.

DOCKS.

Rumex species.

Several species of docks possess medicinal properties. Among these are the yellow dock (*Rumex crispus* L.), the broad-leaved dock (*R. obtusifolius* L.), and the yellow-rooted water dock (*R. britannica* L.), all more or less abundant throughout the United States. Other species are also recognized as possessing value in medicine, but those above mentioned are the kinds generally collected.

Yellow Dock.

Rumex crispus L.

Other common names.—Curled dock, narrow dock, sour dock. (Fig. 5.)

Range and habitat.—The species most commonly employed in medicine is the yellow dock, a perennial introduced from Europe and

FIG. 5.—Yellow dock (*Rumex crispus* L.). First year's growth.

now found throughout the United States as a troublesome and very persistent weed in cultivated as well as waste ground, among rubbish heaps, and along roadsides.

Description.—The deep, spindle-shaped root sends up an erect, angular, and furrowed stem about 2 to 4 feet high, leafy, branching near the top, and bearing numerous elongated clusters of inconspicuous flowers. The leaves are lance shaped, acute, with the margins strongl waved and crisped. The lower leaves are obtuse or heart shaped a the base, from 6 to 8 inches in length, and are borne on long stalk while those nearer the top are narrower and shorter, being only 3 to inches long, on short stems or stemless.

From June to August the yellow dock puts forth, interspersed wit leaves, its many long dense clusters of green, drooping groups c inconspicuous flowers placed in circles around the stem.

Broad-leaved Dock.

***Rumex obtusifolius* L.**

Other common names.—Bitter dock, common dock, blunt-leaved dock butter dock. (Fig. 6.)

FIG. 6.—Broad-leaved dock (*Rumex obtusifolius* L.). **First year's growth.**

Range and habitat.—The range of this very common weed extend from the New England States to Oregon and south to Florida an Texas; it occurs in waste places.

Description.—Broad-leaved dock differs from the yellow dock prin cipally in its more robust habit of growth. It grows to about th same height, but its stem is stouter, and the leaves, which are wav along the margin as in the yellow dock, are much broader and longe The lower leaves have long stalks, and are from 6 to 14 inches i length, with heart-shaped or roundish bases, while the upper ones a from 2 to 6 inches long and are on short stalks.

The green flowers appear from June to August, and are in rathe long, open clusters, the groups rather loose and far apart. In all c the docks here mentioned, the three inner divisions of the calyx (outer covering of flower) in fruiting form a kind of triangular nut, like the

FIG. 7.—Leaf, fruiting spike, and root of broad-leaved dock.

grain of buckwheat (to which family, Polygonaceæ, the docks belong), and one or more of these divisions bear on the back a small granule.

The difference between flower and fruit is barely distinguishable when seen from a little distance so long as the fruit is immature, both being green, but later in the season, as the fruit ripens, the spikes take on a rusty-brown color. (Fig. 7.)

Yellow-rooted Water Dock.

Rumex britannica L.

Habitat and range.—As the common name indicates, this plant frequents swampy and wet places and banks of streams. It is found from Canada to New Jersey and Pennsylvania, and westward to Minnesota, Illinois, and Iowa.

FIG. 8.—Yellow dock root.

Description.—The yellow-rooted water dock is a taller plant than either of the docks previously mentioned, its stout stem sometimes reaching a height of 6 feet. The leaves at the base of the plant are borne on long stalks, and are from 1 to 2 feet in length, but, as with the other two species, the leaves toward the top of the plant are shorter, as are also the stalks supporting them. The densely flowered clusters are not as leafy as in the preceding species mentioned. The plant flowers from July to August.

Dock Roots.

The root, which is the part to be collected for medicinal purposes, is very similar in all of these species of dock (figs. 7 and 8), usually from 8 to 12 inches long, fleshy, often somewhat branched, the outside dark reddish-brown with a rather thick bark, internally yellowish. It possesses but a very faint odor and a bitter, astringent taste. The roots should be collected in late summer or autumn after the fruiting tops have ripened, then washed, split lengthwise into halves or quarters, and carefully dried.

The docks are largely employed for purifying the blood and as a remedy in skin diseases.

Imports and prices.—Rumex or dock roots are imported into this country to the extent of about 125,000 pounds annually. The price ranges from 2 to 8 cents per pound.

COUCH GRASS.

Agropyron repens (L.) Beauv. (*Triticum repens* L.)

Other common names.—Dog-grass, quick-grass, quack-grass, quitch-grass, scutch-grass, twitch-grass, witch-grass, wheat-grass, Chandler's grass, creeping wheat-grass, devil's-grass, durfa-grass, Durfee-grass, Dutch-grass, Fin's grass, quake-grass. (Fig. 9.)

Range and habitat.—Couch grass, like so many other pernicious weeds, was introduced into this country from Europe, and is now a most troublesome pest in cultivated ground, causing the farmer a loss of thousands of dollars annually by taking possession of fields and crowding out valuable crops. It is most abundant from Maine to Maryland, and westward to Minnesota and Missouri, but is rather sparingly distributed in the South. It is gaining ground on farms on the Pacific slope.

FIG. 9.—Couch grass (*Agropyron repens* (L.) Beauv.).

Description.—This rather coarse grass produces several stems, 1 to 3 feet high, from a long, creeping, jointed rootstock, and bears densely flowered spike-like heads resembling those of rye or beardless wheat. The stems are round, smooth, thickened at the joints, and hollow, bearing from five to seven leaves. These have a long cleft sheath, and are rough on the upper surface. The heads or spikes are terminal, solitary, compressed, with two rows of spikelets on a wavy and flattened axis.

Couch grass is one of the most difficult weeds to eradicate, on account of the long jointed rootstock, each joint of which is capable of producing a new plant. Every bit of the rootstock must therefore be removed from the soil or killed in order to eradicate it.

Part used.—The most important part of this grass, not only agriculturally but also pharmaceutically, is its long, tough rhizome or rootstock, creeping along underneath the ground and pushing in every direction. It is pale yellow, smooth, about one-eighth of an inch in diameter, with joints at intervals of about an inch from which slender branching rootlets are produced.

One of the best methods of destroying this weed is to plow up the roots and burn them. They need not be burned, however, but may be saved and prepared for the drug market. After the rootstocks have been collected and washed the rootlets should be removed and the rhizome or rootstock (not the rootlets) cut into short pieces about two-fifths of an inch long. An ordinary feed-cutting machine may be used for this purpose. These should then be dried as suggested in the general instructions.

In the drug trade this plant is generally known as dog grass or triticum. As found in the stores, it is in the form of small, angular pieces, about one-eighth to one-fourth of an inch long, straw colored, shining, and hollow. These pieces are odorless but have a somewhat sweetish taste.

The fluid extract prepared from dog grass is used in kidney and bladder troubles.

Imports and prices.—Couch grass is almost wholly an imported article, some 250,000 pounds coming into this country annually from Europe. The price is about 3 to 7 cents per pound.

POKEWEED.

Phytolacca americana L. (*Phytolacca decandra* L.)

Other common names.—Poke, pigeon-berry, garget, scoke, pocan, coakum, Virginian poke, ink-berry, red-ink-berry, American nightshade, cancer jalap, redweed. (Fig. 10.)

Range and habitat.—Pokeweed is common in rich, moist soil along fence rows, margins of fields, and in uncultivated land from the New England States to Minnesota and south to Florida and Texas. It is native in this country and naturalized in Europe, where it is regarded as an ornamental garden plant.

Description.—The reddish purple stems, rich green foliage, and clusters of white flowers and dark-purple berries give to this plant a rather handsome appearance. Pokeweed attains a height of from 3 to 9 feet from a very large perennial root. It is erect, branched, the stems stout, smooth, green at first, then reddish. On examining a piece of the stem, the pith will be seen to be divided into disk-shaped pieces, with hollow spaces between them. The leaves are ovate or ovate-oblong, acute at the apex, smooth, about 5 inches long and 2 to 3 inches wide, on short stems. The margins are without indentation. About July to September the long clusters of whitish flowers are produced, followed by the green berries, which upon ripening become a rich dark-purple color. The flower clusters are from 3 to 4 inches in length and

FIG. 10.—Pokeweed (*Phytolacca americana* L.).

on long stalks, the flowers numerous and borne on reddish stems. The berries are globular, flattened both at top and bottom, smooth and shining, and contain ten black seeds imbedded in a rich crimson juice. (Fig. 11.)

Parts used.—For medicinal purposes the berries and roots are employed. Both of these should be collected when the berries are fully mature, which usually occurs about two months after flowering.

The clusters of berries should be carefully dried in the shade. They are poisonous, have no odor, a sweetish taste at first, then acrid.

FIG. 11.—Pokeweed, flowering and fruiting branch.

Pokeweed has a very large, fleshy, and poisonous root, conical in shape and branched. (Fig. 12.) It should be gathered in the latter part of the fall, thoroughly cleaned, cut into transverse slices, and carefully dried. When dry it has a grayish, wrinkled appearance, breaks with a fibrous fracture, and the slices show many concentric rings. There is a slight odor and the taste is sweetish and acrid.

FIG. 12.—Pokeroot.

Both the berries and roots are alterative, act upon the bowels and cause vomiting, and preparations made from them are used in treating various diseases of the skin and blood, and in certain cases in relieving pain and allaying inflammation.

Price.—Phytolacca or pokeroot brings from 2 to 5 cents per pound, and the dry berries about 5 cents per pound.

FOXGLOVE.

Digitalis purpurea L.

Other common names.—Purple foxglove, thimbles, fairy cap, fairy fingers, fairy thimbles, fairy bells, dog's finger, finger flower, lady's glove, ladyfingers, lady's thimble, popdock, flapdock, flopdock, lion's mouth, rabbit's flower, cottagers, throatwort, Scotch mercury. (Fig. 13.)

Range and habitat.—Foxglove was originally introduced into this country from Europe as an ornamental garden plant, but has now

FIG. 13.—Foxglove (*Digitalis purpurea* L.).

escaped from cultivation in a few localities and is assuming the character of a weed. This is the case in parts of Oregon, Washington, and West Virginia, where the plant is found in great abundance in dry, sandy soil, along roads and fence rows, on the borders of timber land, and in small cleared places.

Description.—This is a very handsome plant of the figwort family (Scrophulariaceæ), biennial, and the first year forms only a rosette of dense leaves, but in the second year of its growth the simple erect flowering stalk is produced, attaining a height of from 3 to 4 feet. This is round, indistinctly angled toward the top, leafy and downy. The leaves are oblong-ovate, narrowed at the base into long winged stalks; the upper surface of the leaves is dull-green and wrinkled, while the under side is grayish, with short, soft hairs and a thick network of prominent veins. The root leaves are rather large and are borne on long stalks, but as the leaves approach the top of the plant they become smaller and the leafstalks shorter.

The plant is in flower about June, and the long clusters of numerous tubular bell-shaped flowers are very showy. The clusters are terminal, and about 14 inches in length. The flowers are large, about 2 inches long, the color ranging from white through lavender to purple, the inside of the lower lobe bearing long, soft, white hairs and crimson spots on a white ground.

Part used.—Leaves of the second year's growth only are employed, and these should be collected when about two-thirds of the flowers have expanded. They should be very carefully dried in the shade and then kept in close boxes or barrels so as to keep out all moisture. The greatest care is necessary in curing, as the leaves soon lose their medicinal properties if not properly dried.

Preparations made from foxglove are of great value in heart troubles, but they are poisonous and should never be used except on the advice of a physician.

Imports and prices.—From 40,000 to 60,000 pounds of digitalis or foxglove are annually imported into this country from Europe, where the plant is cultivated. The American-grown product has so far never been used, but leaves from the wild American plant have been assayed and found to be equally as good as the European article.

The price per pound ranges from about 6 to 8 cents.

MULLEIN.

Verbascum thapsus L.

Other common names.—Great mullein, velvet or mullein dock, Aaron's rod, Adam's flannel, blanket leaf, bullock's lungwort, cow's or clown's lungwort, candlewick, feltwort, flannel leaf, old-man's flannel, hare's beard, hedge taper, ice leaf, Jacob's staff, Jupiter's staff, lady's foxglove, Peter's staff, shepherd's club, torches, torchwort, velvet plant. (Fig. 14.)

Range and habitat.—Mullein is a native of Europe, and occurs in this country as a troublesome weed in fields and pastures, waste places, and along roadsides from Maine to Minnesota and southward, and it is also spreading in the far Western States. It produces great quantities of seed, and, if allowed to persist, will soon stock the ground with seeds which may retain their vitality and germinate at intervals for a number of years.

FIG. 14.—Mullein (*Verbascum thapsus* L.).

Description.—Mullein can be easily recognized by its tall, erect habit of growth, the white-woolly or felty appearance of the entire plant, and its spike of golden-yellow flowers. It is a biennial belonging to the figwort family (Scrophulariaceæ).

This plant has a stout, straight stem, which sometimes grows as tall as 7 feet. The stem and also the leaves are densely hairy, the latter alternate, sessile (stemless), their margins extending in wings along down the stem. The rather thick, rough leaves are from 4 to 12 inches in length, oblong, acute, and densely hairy above and below.

In the first year of its growth only a rosette of downy leaves is produced, but during the second year the flower stalk with its densely flowered spike appears. The golden-yellow flowers are produced from June to August.

Parts used.—As the leaves and flowers are to be collected at the time when the plant is in bloom, the propagation of the plant by the dissemination of its seed is prevented. The leaves are cured in the usual manner. They are practically inodorous, and have a somewhat bitter, mucilaginous taste.

It is very desirable to have the flowers retain their bright yellow color; they must therefore be thoroughly dried, and then kept free from moisture in well-stoppered bottles. They readily absorb moisture and if allowed to become damp will turn black. The corolla (petals), with the adhering stamens only, is dried, the calyx being rejected. Mullein flowers have a sweetish, pleasant odor.

Mullein is used in coughs and catarrh, to quiet nervous irritation, and to relieve pain and inflammation. According to some authors the dried leaves are often smoked like tobacco to relieve nasal catarrh and throat affections.

Imports and prices.—About 5,000 pounds of verbascum or mullein flowers are annually imported, chiefly from Germany, in which country this plant is cultivated. The leaves are also imported to a small extent.

The price paid for the leaves ranges from 2½ to 5 cents per pound, and that for the flowers may range from 25 to 75 cents per pound.

FIG. 15.—Lobelia (*Lobelia inflata* L.).

LOBELIA.

Lobelia inflata L.

Other common names.—Indian tobacco, wild tobacco, bladder pod, asthma weed, gagroot, pukeweed, vomitwort, low belia, eyebright. (Fig. 15.)

Range and habitat.—This poisonous weed occurs nearly everywhere throughout the United States, being most plentiful east of the Mississippi River, and thriving in dry, clayey, or siliceous soil in sunny situations along roadsides, and in old fields and pastures.

Description.—The erect leafy stem of this annual herbaceous plant is from 1 to 3 feet high, from a fibrous root. It is simple and rough-hairy below, smooth above, and bears a few short branches. The entire plant contains an acrid milky juice. It belongs to the bellflower family (Campanulaceæ).

The pale-green leaves are alternate, from 1 to 2½ inches long, gradually diminishing in size as they reach the summit of the plant, the lower leaves being borne on stalks, while the upper ones are stemless. They are thin, oblong or oval, blunt, irregularly toothed, and almost wavy, with short hairs on both surfaces.

From July until frost the rather inconspicuous, very small pale-blue flowers appear. These are very numerous, each one borne in the axils of the upper leaves on very short stems, all together forming a long, spike-like head. The lower lip of the flower has three lobes, the upper one two segments, and from the center of the latter the tube of the flower is cleft to the base. The seed pods are in the form of inflated capsules, nearly globular, striated (grooved or marked with parallel lines), and contain very numerous minute dark-brown seeds.

Parts used.—The leaves and flowering tops are used in medicine, and there is also a good demand for the seed. The leaves and tops should be gathered after some of the pods have become inflated, should be dried in the shade, and when dry kept in covered vessels. The dried leaves and tops have a rather disagreeable, somewhat sickening odor, and the taste, though mild at first, soon becomes strongly acrid and nauseous. The seeds are extremely minute, and each capsule is said to contain from 450 to 500 seeds.

Lobelia is an expectorant, acts upon the nervous system and bowels, causes vomiting, and is poisonous.

Price.—The price paid for the dried leaves and tops ranges from 3 to 8 cents per pound, and that for the seed from 15 to 20 cents per pound.

TANSY.

Tanacetum vulgare L.

Other common names.—Bitter buttons, ginger plant, parsley fern, scented fern. (Fig. 16.)

Range and habitat.—Tansy was originally introduced into this country as a garden plant from Europe, where it is native. It has now escaped from cultivation and is found as a weed along waysides and fences in many places from New England to Minnesota and southward to North Carolina and Missouri.

Description.—This strong-scented perennial herb belongs to the aster family (Asteraceæ). The stout, erect stem is from 1½ to 3 feet high, branching near the top, somewhat reddish, and usually smooth. The general outline of the leaf is oval, and it is divided nearly to the midrib into about seven pairs of segments, which, like the terminal one, are again divided for about two-thirds of the distance to the mid-vein into smaller lobes having saw-toothed margins. The entire leaf is about 6 inches in length.

Tansy is in flower from July to September, and the roundish but flat-topped yellow flower heads are produced in dense terminal clusters.

Parts used.—At the time of flowering the leaves and tops are collected for medicinal purposes and are dried in the usual manner. The odor of tansy is strongly aromatic and the taste bitter. In drying, tansy loses about four-fifths of its weight.

Tansy is employed in derangements of women, and has stimulant and tonic properties. It is also used for expelling worms. This drug is poisonous and has been known to produce fatal results.

FIG. 16.—Tansy (*Tanacetum vulgare* L.).

FIG. 17.—Gum plant (*Grindelia robusta* Nutt.).

Imports and prices.—About 30,000 pounds of tanacetum or tansy are imported annually. The price paid per pound ranges from 3 to 6 cents.

GUM PLANT.

Grindelia robusta Nutt.

Range.—The gum plant (fig. 17) occurs in the States west of the Rocky Mountains.

Description.—The entire plant is covered with a resinous substance, which gives it a gummy, varnished appearance, whence its common name, gum plant, is derived.

This perennial of the aster family of plants has an erect habit of growth, and sends up a round, smooth stem about a foot and a half high, narrowly grooved and freely branching near the top, each branch terminating in a large yellow flower. The branches near the flower heads have a slightly reddish appearance.

The pale-green leaves are about an inch long, of a leathery texture, rather rigid, coated with resin, and show numerous translucent dots. The leaves are oblong-spatulate (having a gradually narrowed base below the broader rounded summit) and are more or less clasping at the base, the lower ones somewhat saw-toothed.

The yellow flowers are borne singly at the ends of the branches and measure about three-quarters of an inch across. The involucre (set of small leaves immediately beneath the flower) is very resinous and consists of numerous thick, overlapping scales, the tips of which are rolled forward.

Parts used and prices.—The flowering tops and leaves of this and of the scaly grindelia are collected indiscriminately, and bring from 5 to 12 cents per pound.

They are used in asthma and similar affections, and externally in cases of poisoning by poison ivy.

FIG. 18.—Scaly grindelia (*Grindelia squarrosa* (Pursh) Dunal).

SCALY GRINDELIA.

Grindelia squarrosa (Pursh) Dunal.

Range.—Scaly grindelia (fig. 18) has a wider distribution than the gum plant, being quite common on the plains and prairies from the Saskatchewan to Minnesota, south to Texas and Mexico, and westward to California.

Description.—This species is very similar to the gum plant, with the exception that it is smaller and does not have the gummy appearance of the former. The slender, erect stems are from 1 to 2 feet high and somewhat sparingly branched near the top. The branches near the flower heads appear to be somewhat more reddish than in the species previously mentioned. In this species, also, the leaves are not borne on stalks, but are somewhat clasping at the base, and they are longer (about 2 inches long), not rigid, thinner, and more prominently toothed. The flowers are also very similar to those of the gum plant, but are smaller, the scales narrower, and the recurved tips longer and more slender.

Parts used.—The leaves and flowering tops are collected with those of the gum plant, *Grindelia robusta.*

BONESET.

Eupatorium perfoliatum L.

FIG. 19.—Boneset (*Eupatorium perfoliatum* L.).

Other common names.—Thoroughwort, crosswort, wood boneset, teasel, ague-weed, feverwort, thorough-stem or thorough-wax, vegetable antimony, sweating plant, Indian sage, wild sage, tearal, wild Isaac. (Fig. 19.)

Range and habitat.—Boneset delights in moist situations, and is common as a weed in clayey or sandy soil, in low, wet ground, and along streams, on the edges of swamps and in thickets from the New England States west to Nebraska and south to Texas and Florida.

Description.—One of the features which will aid in recognizing this plant is the peculiar arrangement of the leaves. These are opposite each other and joined together at the base around the stem, and therefore have the appearance of a single leaf with the stem passing through the center of it.

Boneset is a perennial herb of the aster family of plants (Asteraceæ), with stout, rough, hairy stems 1 to 5 feet high, from a horizontal, crooked root. The leaves are opposite, united at the base, lance shaped, tapering to a point, bluntly toothed, rough with prominent veins, wrinkled, dark green on the upper surface, downy and paler green on the lower surface. Both leaves together measure from 8 to 14 inches from point to point and 1 to 1½ inches wide. The flowers are white, tubular, ten to twenty or more united in dense heads, and the heads are borne in rather crowded flat-topped clusters, appearing from July to September.

Parts used.—The leaves and flowering tops are the parts used in medicine, and these should be collected when the plants are in flower, stripped from the stalk, and carefully dried. They lose about three-fourths of their weight in drying. The odor is faintly aromatic, the taste bitter and astringent.

As indicated by the common names "ague-weed" and "feverwort," this is a popular remedy in fever and ague. It is used also in colds, dyspepsia, jaundice, and for toning up the system. In large doses it is an emetic and cathartic.

Prices.—Eupatorium or boneset leaves and tops bring from 2 to 8 cents per pound.

CATNIP.

Nepeta cataria L.

Other common names.—Catmint, catrup, cat's wort, field mint. (Fig. 20.)

Range and habitat.—This very common weed is naturalized from Europe, and is found in rather dry soil in waste places and cultivated land, about old buildings and along fences, from Canada to Minnesota and southward to Virginia and Arkansas.

Description.—The erect, square stems of this perennial herb of the mint family (Menthaceæ) grow to a height of 2 to 3 feet, are branched, and somewhat whitish in appearance from the covering of fine white hairs.

The leaves are opposite and borne on stems, heart shaped or oblong, with an acute apex, 1 to 2½ inches long, evenly and finely scalloped, green above, beneath grayish-green with fine white hairs. The many-flowered clusters appear from June to September, and are borne in thick spikes 1 to 5 inches long at the top of the stems and branches. The flowers are white or somewhat purple, two-lipped, the upper lip two-cleft, the lower one three-lobed and sometimes spotted with red, the middle lobe broadest and round-toothed.

FIG. 20.—Catnip (*Nepeta cataria* L.).

Parts used.—The flowering tops and leaves are to be collected when the plant is in flower and carefully dried. They have a strong mint-like odor and a bitter taste. The coarser stems and branches should be rejected.

Catnip is used in derangements of women, as a mild stimulant and tonic, and has a quieting effect on the nervous system.

Imports and prices.—Cataria or catnip is imported in but small quantities. The price paid for the flowering tops and leaves is from 2 to 8 cents per pound.

HOARHOUND.

Marrubium vulgare L.

Other common names.—Houndsbene, marvel, marrube. (Fig. 21.)

Range and habitat.—Hoarhound has been naturalized from Europe, and has escaped from gardens in this country, being found now rather abundantly in dry sandy or stony soil in waste places, pastures, fields, along roadsides, and near dwellings, from Maine to South Carolina, Texas, and westward to California and Oregon. It is very abundant in pastures in California, Oregon, and in limited areas in Indiana, Missouri, Ohio, and Michigan. In southern California this plant has proved a most troublesome weed, occurring almost everywhere and growing in such dense masses as to crowd out all other vegetation. It has spread rapidly over thousands of acres, taking complete possession of the land and destroying pastures.

Description.—The entire plant has a whitish, woolly appearance, caused by the dense covering of hairs. It is a perennial plant, and as will be seen from the characteristic lip-shaped flowers, is a member of the mint family (Menthaceæ). The whole plant has a rather pleasant, balsamic odor.

Hoarhound is a bushy, branching herb, with fibrous roots sending up numerous woolly stems about 1 to 3 feet high, rounded below and

FIG. 21.—Hoarhound (*Marrubium vulgare* L.).

four-angled above. The leaves are opposite each other, 1 to 2 inches long, oval or nearly round, wrinkled, somewhat blunt at the apex, narrowed or somewhat heart shaped at the base, with rounded teeth, somewhat hairy and wrinkled on the upper surface, and prominently veined and very hoary on the lower surface. The flowers are whitish, two-lipped, the upper lip two-lobed, the lower three-lobed, and are borne in dense, woolly clusters in the axils of the leaves. (Fig. 22.) The plant flowers from June to September, and the characteristic hooked calyx teeth of the mature flower clusters cling to the wool of sheep like a bur, resulting in the scattering of the seeds.

Parts used.—The leaves and tops are used in medicine. These should be gathered just before the herb is in flower, rejecting the coarse stalks, and should be dried in the shade in the usual manner.

The balsamic odor diminishes in drying. The herb has a bitter, persistent taste.

Hoarhound is well known as a remedy for colds, and is also used in dyspepsia and for expelling worms.

Imports and prices.—A considerable quantity of marrubium or hoarhound is imported, about 125,000 pounds coming into this country annually. Three to 8 cents is the price paid per pound.

FIG. 22.—Hoarhound, flowering top.

BLESSED THISTLE.

Cnicus benedictus L.

Other common names.—Holy thistle, bitter thistle, Our Lady's thistle, St. Benedict's thistle, cursed thistle, spotted thistle. (Fig. 23.)

Range and habitat.—This weed has been introduced from Europe and occurs in stony, uncultivated localities and waste places in the Southern States and in California and Utah.

Description.—Blessed thistle is an annual plant belonging to the aster family (Asteraceæ). The round stems are erect, about 1 to 2 feet high, branched, and rather woolly. The leaves are more or less hairy, the lower ones borne on petioles (leaf stems), the upper ones sessile (stemless) and clasping the stem. They are oblong-lanceolate and wavy-lobed. The terminal yellow flower heads are surrounded by scales of a leathery texture, which are prolonged into long, hard, branching spines.

Parts used.—The leaves and tops should be collected when the plant is in flower, about June, thoroughly and quickly dried, and kept in a vessel from which moisture, light, and air should be excluded. They have a somewhat disagreeable odor and the taste is very bitter.

Blessed thistle is employed in fevers, dyspepsia, and as a tonic to restore the appetite.

Imports and prices.—This plant is cultivated in Germany, from which ountry it is imported to a limited extent. The price per pound anges from 8 to 10 cents.

YARROW.

Achillea millefolium L.

Other common names.—Iilfoil, thousand leaf, thouand-leaved clover, green rrow, gordoloba, noseleed, bloodwort, carpen er's grass, sanguinary, soliers' woundwort, old man's epper. (Fig. 24.)

Range and habitat.—This erb is a common weed from he New England States to Missouri and in scattered ocalities in other parts of the country, occurring long roadsides, in old fields, astures, and meadows.

Description.—Yarrow is a perennial belonging to the ster family (Asteraceæ). It is about 10 to 20 inches n height, its numerous lark-green feathery leaves livided into very fine rowded parts. The flowers re produced in abundance from June to September. These are small, white (sometimes rose-colored), and are crowded in dense flat-topped heads.

FIG. 23.—Blessed thistle (*Cnicus benedictus* L.).

The odor of yarrow is strong and aromatic, very similar to that of chamomile, and the taste is sharp and bitter. When this plant is eaten by cows its bitter taste and strong odor are imparted to dairy products.

Parts used.—The entire plant is collected when in flower, and is carefully dried. The coarser stems should be rejected. The plant loses nearly four-fifths of its weight in drying.

Yarrow is a stimulant tonic, acts upon the bladder, and checks excessive discharges.

Imports and prices.—This is an imported article, though not brought into the United States in large quantities. The price of achillea or yarrow ranges from 2 to 5 cents per pound.

FIG. 24.—Yarrow (*Achillea millefolium* L.).

CANADA FLEABANE.

Leptilon canadense (L.) Britton. (*Erigeron canadensis* L.)

Other common names.—Horseweed, colt's tail, scabious, prideweed, butter weed, fireweed, blood-stanch, cow's tail, bitter weed. (Fig. 25.)

Range and habitat.—This weed is common in damp, sandy soils in fields and waste places and along roadsides in many parts of the United States, especially throughout the northern Mississippi Valley.

Description.—Canada fleabane is an annual weed belonging to the ster family (Asteraceæ). The stem, which is bristly-hairy, or some imes smooth, varies greatly in height, according to the soil, being ometimes only 3 inches high, and in favorable soil often reaching a eight of 10 feet. The larger plants are branched near the top. The eaves are usually somewhat hairy, those scattered along the stem being ather narrow, with unbroken margins, and the lower ones slightly othed. From June to November numerous heads of small incon picuous white flowers are produced, followed by an abundance of seed.

Parts used.—The entire herb is medicinal, and hould be gathered during the flowering period nd carefully dried. It has a faint, agreeable dor and a somewhat astringent and bitter aste. The fresh herb on distillation yields volatile oil which is sold as oil of fleabane. The common name "blood stanch" indi ates the use of this plant for arresting hem rrhages from various sources and the bleed ng of wounds. It is useful also in diarrhea nd dropsy.

Price.—The price paid for erigeron or flea ane ranges from 6 to 8 cents per pound.

FIG. 25.—Canada fleabane (*Leptilon canadense* (L.) Britton).

JIMSON WEED.

Datura stramonium L.

Other common names.—Jamestown weed from which "jimson" weed is derived), thorn pple, stinkweed, stinkwort, devil's apple, nad-apple, devil's trumpet, fireweed, James own lily, dewtry, apple of Peru. (Fig. 26).

Range and habitat.—Jimson weed is exceed ngly common in fields and waste places hroughout the entire country with the excep ion of the North and West. It is native in the Tropics and widely scattered in nearly ll warm countries.

Description.—This well-known rank and ill-scented poisonous weed is an annual about 2 to 5 feet in height, and belongs to the potato family (Solanaceæ). Its yellowish-green stems are stout, leafy, and much forked. The leaves are large, 3 to 8 inches long, thin, smooth, pointed at the apex and usually narrowed at the base, irregularly waved and toothed, veiny, dark green on the upper surface and paler green beneath. The rather large, showy flowers are produced from May to September. They are white, funnel shaped, about 3 inches long, and have a heavy odor. The seed pod is a dry, oval, prickly capsule, which, when quite ripe, bursts open and discloses four valves, containing numerous black, kidney-shaped seeds. (Fig. 27.) The seeds are ill-smelling when fresh, as is the entire plant. They are dull black, about one-sixth of an inch long, flattened, wrinkled, and marked with small depressions.

Parts used.—Both the leaves and seeds are medicinal. The leaves are collected at the time of flowering, the entire plant being cut or pulled up and the leaves stripped and dried in the shade. The unpleasant narcotic odor diminishes upon drying. The leaves are poisonous, cause dilation of the pupil of the eye, and are used principally in asthma.

FIG. 26.—Jimson weed (*Datura stramonium* L.).

For the collection of the seeds the capsules should be taken from the plants when they are quite ripe, but still of a green color. The capsules should then be dried for a few days, when they will burst open and the seeds can be readily shaken out. These should now be carefully dried. The seeds like the leaves are poisonous and possess the same properties.

Occasional cases of poisoning of children occur from eating the seeds of jimson weed and taking the flowers in their mouths.

Imports and prices.—From 100,000 to 150,000 pounds of stramonium leaves (the name by which they are designated in the drug trade) are imported into this country annually, and about 10,000 pounds of seeds are imported.

The leaves will bring from 2½ to 8 cents per pound, and stramonium seeds from 3 to 7 cents per pound.

Purple thorn-apple.

The purple thorn-apple, technically known as *Datura tatula*, is very similar to the jimson weed, possesses the same properties, and is dis-

FIG. 27.—Leaves, flower, and capsules of jimson weed.

tinguished from it merely by its reddish stems and purplish flowers. The leaves and seeds may be gathered with those of the jimson weed.

POISON HEMLOCK.

Conium maculatum L.

Other common names.—Spotted parsley, St. Bennet's herb, bad-man's oatmeal, heck-how, wode whistle, cashes, bunk, poison parsley, spotted cowbane. (Fig. 28.)

Range and habitat.—Poison hemlock is rather common in waste places and along roadsides, principally in the Eastern and Middle States. It has been naturalized in this country from Europe.

Description.—From the close resemblance of the leaves of this plant to parsley, it is sometimes mistaken for the latter and fatal cases of poisoning have occurred. All parts of the plant are exceedingly poisonous.

Poison hemlock belongs to the same family as the parsley, namely, the Apiaceæ. It is a biennial, about 2 to 6 feet in height, with a smooth, hollow stem dotted with purple, and large leaves very much like those of parsley. The numerous small white flowers are borne in rather showy umbels (flat-topped clusters, with stems from one point) and appear in June and July. The fruit ripens in August and September. The fruit is grayish-green, ribbed, about one-eighth of an inch long, ovate, laterally flattened, and smooth.

FIG. 28.—Poison hemlock (*Conium maculatum* L.).

The entire plant possesses a disagreeable mousy odor, which is especially noticeable when bruised.

Parts used.—The fruit and leaves are the parts used. The fruit should be collected while still green but full grown, which in most localities is some time in August. It should be dried in dark but well ventilated places, and then stored in tight cans or boxes where it will not be exposed to the action of light and air.

The poison hemlock leaves should be collected when the plant is in flower, which will be in the second year of its growth. The stems should be rejected. Contrary to the usual method of drying leaves and herbs, the poison hemlock leaves may be quickly dried in the sun and then kept in tightly closed vessels. The leaves will retain their green color if properly cured. The odor is still very disagreeable, but not so pronounced as in the fresh plant.

This very poisonous drug is used in rheumatism, neuralgia, asthma and in cases where the nervous system is in an excited condition.

Imports and prices.—The imports of conium or poison hemlock seed mount to about 20,000 pounds annually, and from 10,000 to 20,000 ounds of the leaves are imported. The price paid for the seed is bout 3 cents per pound, and for the leaves about 4 cents.

AMERICAN WORMSEED.

Chenopodium ambrosioides L.

Other commmon names.—Mexican tea, Spanish tea, Jerusalem tea, esuit tea, ambrosia. (Fig. 29.)

FIG. 29.—American wormseed (*Chenopodium ambrosioides* L.).

Range and habitat.—This strong-scented herb, naturalized in this ountry from tropical America, frequents waste places around dwell- ngs and is found in streets, meadows, pastures, and grain fields from ew England to Florida, and westward to California.

Description.—American wormseed is an annual plant of the goosefoot amily (Chenopodiaceæ), attaining a height of from 2 to 3 feet. The stem is grooved, usually much branched and leafy, the leaves oblong or oblong lance-shaped, somewhat acute at the apex, the lower ones 1 to 3 inches long and wavy-toothed, the numerous upper leaves much smaller and usually entire. From July to September the flowers are produced, followed throughout the autumn by the fruits, both of which are green and borne in crowded leafy spikes. The whole plant has a powerful, disagreeable odor, due to the essential oil which it contains.

Part used.—The entire leafy part of the plant is sometimes employed for the distillation of the oil, although the fruit alone is listed in the Pharmacopœia of the United States. The fruit is distilled for the oil, which it contains in large quantities.

The fruits are in the form of small grains, about the size of a pin head, globular but slightly flattened, greenish; and inclosing the small shining black seeds. They have the same powerful odor as the plant, which does not diminish when the fruit is dried, and the taste is bitter and pungent. American wormseed is an anthelmintic, that is, it has the property of expelling worms.

The fruits of *Chenopodium anthelminticum*, another species of wormseed, are collected with those of the species just described. This plant is very similar to the American wormseed, the fruits being alike, and the only differences being that in *Chenopodium anthelminticum* the stem is slightly taller, from 2½ to 3½ feet high, the leaves are more coarsely toothed, the flowers are borne in more elongated, usually leafless spikes, the odor is more pronounced and disagreeable, and the range and distribution of the plant are more limited.

Wormseed is cultivated to a considerable extent in parts of Maryland, where the distillation of the plant for the oil is carried on.

Price.—In ordinary seasons the price paid for chenopodium or wormseed ranges from 6 to 8 cents per pound. The oil distilled from wormseed is at present selling at $1.50 per pound.

BLACK MUSTARD.

Brassica nigra (L.) Koch. (*Sinapis nigra* L.)

Other common names.—Brown mustard, red mustard. (Fig. 30.)

Range and habitat.—Black mustard, introduced from Europe, is a troublesome weed in many parts of the United States. It is common in almost every State in the Union along roadsides, in cultivated ground, and in waste places, being especially troublesome in grain fields and pastures. Both black and white mustards are cultivated in California.

This plant is a great pest in southern California, covering thousands of acres and forming dense, impenetrable thickets over 6 feet in height, in which birds have their nesting places, and, by eating and excreting the seeds, help to spread this pernicious weed.

Description.—The rather stiff, dark-green, branching stem of black mustard is from 4 to 6 feet in height. The lower part of the stems and branches is more or less bristly hairy, but the upper part is usually smooth.

The leaves are dark green, somewhat rough, with bristly hairs, and are all borne on stalks. The lower leaves are lobed, the terminal lobe being the largest and the two or more lateral ones smaller. The leaves toward the top of the plant become lance shaped and are slightly toothed.

The flowers of black mustard appear from June to September, and are of a bright yellow color. They are rather small, scarcely a quarter of an inch in diameter, the four petals spreading and each consisting of a rounded blade with a narrow claw. The petals alternate with the pale-green sepals or calyx lobes. The flowers appear in clusters at the ends of the elongating stems, followed from July to November by the numerous erect pods crowded against the stem in dense narrow clusters. The pods are about 1 inch in length, quadrangular, smooth, and tipped at the apex by the short, persistent style. The seeds contained in the pods are very numerous, small, about one twenty-fifth of an inch in diameter, globular, blackish brown, and finely pitted.

FIG. 30.—Black mustard (*Brassica nigra* (L.) Koch).

The plant is an annual, and if care is taken to prevent the distribution of the seeds it is not difficult to exterminate. The seeds possess great vitality, and may remain in the ground for years before germinating.

Collection of seeds.—The tops may be pulled when most of the pods are nearly mature, but before they are ready to spring open. They should then be placed on a clean, dry floor or shelf, allowing the pods to ripen and dry out, when they will burst open and the seeds can be readily shaken out.

Mustard seed has no odor whatever when collected, not even when it is powdered in its dry state, but as soon as water is added in grinding it, the powerful, penetrating mustard odor is developed. The taste is sharp and pungent.

WHITE MUSTARD.

Sinapis alba L.

Another common name.—Yellow mustard. (Fig. 31.)

Range and habitat.—White mustard is a weed found in cultivated

FIG. 31.—White mustard (*Sinapis alba* L.).

land along waysides and fence rows, but is not so abundant nor so widely distributed as the black mustard. It is naturalized in this country from Europe.

Description.—This plant is very similar to black mustard, but is smaller (growing only about 1 to 2 feet tall), bright green, but the flowers and seeds are much larger, and the rough-hairy pods with their long, sickle-shaped beaks are spreading instead of being pressed against the stem. The flowers are paler yellow than those of the foregoing species. The divisions of the leaves reach to the midrib, the leaves are rough-hairy, and the pods bristly. The seeds are pale yellow and smooth.

Collection and uses of seeds.—The seeds are to be collected in the same manner as those of black mustard. White mustard seed has no odor in its entire state, and when water is added in grinding it the odor does not become so pronounced as in the case of black mustard, neither is the taste so pungent.

In medicine mustard seeds are used principally in the preparation of plasters and poultices. They are used also in dyspepsia, and in large doses act as an emetic.

Imports and prices.—The imports into the United States of black and white mustard together during the fiscal year ended June 30, 1903, amounted to 5,302,876 pounds. The price ranges from 3 to 6 cents per pound for both the black and white mustard seeds.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 195.

ANNUAL FLOWERING PLANTS.

BY

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., March 17, 1904.

SIR: I have the honor to transmit herewith a paper relating to the cultivation and uses of annual flowering plants, prepared by Prof. L. C. Corbett, Horticulturist of this Bureau, and recommend that it be published as a Farmers' Bulletin.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

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ILLUSTRATIONS.

ANNUAL FLOWERING PLANTS.

INTRODUCTION.

The more fully the observer is familiar with the functions of plants nd the structure and purpose of their leaves and flowers the more ully and completely will he appreciate and interpret their beauty and he refined sentiments they represent.

Plants are the missionaries of nature constantly at work attempting o cover some ugly scar which civilized man has made in his struggle o wrest from the earth the living which he claims she owes him. If ou will but give nature the suggestion of your wishes in the form of few choice seeds she will paint for you the rich shades of the pansy r the phlox; she will carpet your floor with a velvet rug of green nd strew upon its surface in bold contrast the golden disks of the andelion or the bright, saucy faces of the crocus. She will drape our walls with a festoon of green and hide therein rich gems of purle, of crimson, and of white, and, if you ask it, she will screen one partment from another with barriers of green which may or may not arry bright floral gems.

While flowers are primarily utilitarian in purpose, the end is attained y attractive and alluring means. The beauty, fragrance, and sweetess of the flower are not vain attributes; each is designed for a subtle urpose. The bright colors are the gala-day attire of these natural airies to attract and allure the passer by, be he insect, bird, or man. The perfume wafted upon the still night air suggests the whereabouts f the fragrant night-blooming flowers to moths and other night-flying nsects, while the cups of honey at the base of the petals hold a reward or those who have heeded the signal of the color or the odor. The ot of nectar is a sufficient reward for the insect, and the transfer of ollen from anther to stigma by the clumsy but welcome guest is the nd for which all this beauty, fragrance, and sweetness have been roduced.

Beautiful plants and flowers naturally grouped are pleasing because hey are restful. Association with nature is soothing because the rudities of man's invention in which friction is such a large factor are ll eliminated. The sounds in the woods are musical, harmonious, and hythmical, soothing and pleasing in effect, while the colors are eautifully blended, holding the eye and the attention without effort nd without fatigue. Nature in such moods is restful.

TREATMENT OF SMALL PLACES.

While man can not call in upon a small place these larger and broader expressions of nature, he can pleasingly use a limited number of the factors which go to make up this final result for the purpose of adding beauty to his abiding place. Trees may be used to give protection from wind and sun. The varieties may be so chosen as to give expressions of pleasure, of restfulness, of sprightliness, or of sorrow. Trees have all these expressions, and they influence to a great degree the lives and characters of the persons who daily go among them. It therefore behooves us in selecting trees for the adornment of our home grounds to choose those with pleasant and elevating rather than those with somber and depressing expressions.

While trees must be relied upon as the general structural or framework parts in the adornment of a place, shrubs, grass, and annual flowering plants make up the detail. And it is the detail which gives finish and completeness to the place as a whole. It frequently happens that in attempting to recall a particular building, room, or painting some one detail may serve to give the mind a clew to the whole. The general plan or outline may be lost and a single factor of the finish serve to identify the whole; hence the importance of these finishing factors.

Shrubs are important and satisfactory, because when once established in their proper relations to one another and to the general scheme of improvement each year adds to their beauty and their value. Not so with the annual planting. It is the one factor through which novelty and variety may be introduced. Trees and shrubs may be considered fixtures, while annual plants serve as pictures which may be shifted from season to season to suit the pleasure of the occupant of the dwelling whose grounds they beautify. Annual plants, too, are the only form of embellishment which a tenant will ever care to bestow upon a place. Such plants give quick returns and large profits from a small outlay of time and labor.

The range of size and the variety of foliage and of bloom afforded in the list of annual plants which can be successfully grown from seeds each year is sufficient to enable one to quite successfully secure by their use temporary effects which it would take many years to obtain from shrubs. While no one should feel content with this form of emergency planting, new places and temporary locations can be greatly softened and beautified by a judicious use of these annual plants.

USE OF PLANTS ABOUT A DWELLING.

Annual plants which have a suitable habit of growth and adequate foliage may be made to do duty about the dwelling and upon the grounds in the place of the more appropriate shrubs and perennials.

'he one great drawback to which such annual plantations are subjected s their yearly destruction by the first hard frosts of the season. ınnual plants, such as cosmos, castor bean, sunflower, aster, zinnia, nd flowering sage, may all be made to serve as substitutes for shrubery plantations until the shrubs themselves have grown to sufficient ize to command the situation.

Tall-growing, broad-leaved plants, like the castor bean, can be used vith advantage as screens for driveways or walks by placing a mass f the plants in the bay of the walk or drive. The tall-growing plants f this description when massed against buildings, fences, or other btrusive objects serve as attractive and efficient temporary screens. Lower-growing plants when massed in borders along the boundary of he place, with taller-growing annuals or shrubs as a background, re more effective than when used in beds at the front or side of a lwelling. In fact, the formal bed, either in the shape of an oval, ircle, or star, in the center of a greensward, is generally more obtrusive than pleasing. The next best place for the annuals after the order is in masses about the foundation of a building; and if vines f a temporary nature are desired, some of the rapid-growing sorts, uch as Cobæa scandens, the moonflower, morning-glory, or cypress vine, may be appropriately used for training over fences or walls, or ıbout porches.

When annual plants are desired for the bloom which they produce for use as cut flowers, the best disposition of them is to plant them in an area set apart for a flower garden or to devote a portion of the vegetable garden proper to the purpose. When grown for cut bloom merely, the most satisfactory and economical plan is to plant them in long rows, with ample space both between the rows and the individuals in the row. Unless the plants are given sufficient room for full development the flowers which they produce will be inferior in size and form. To secure the best results from plants to be used in this way rich soil, ample space, and good culture are essential. While it is advantageous to sow the seed thickly at planting time in order to insure a good stand of plants, it is equally desirable to have the plants thoroughly thinned so as to provide ample space for their full development.

If the flower garden is a distinct feature of the place and its mission is to furnish an attractive retreat, as well as cut flowers, its general plan may be more pretentious; the straight rows may give place to irregular groups or masses, or even to formal beds and designs, so long as these are not made the leading feature in the general adornment of the place. In fact, curved pathways in the flower garden allow an opportunity for demonstrating the fitness of certain plants for special purposes. The bays of the curves can be filled with tall-growing, dense-foliaged plants for the purpose of hiding the beds or groups which lie farther on. Curved walks are more pleasing than straight ones, and lend themselves more kindly to the needs of the different classes of plants which find a place in the home flower garden. If the flower garden is to be a permanent feature of the adornment of a place, the walks may be arranged to conform to the contour of the land, or if level may be given some geometrical character or design and made permanent by the use of gravel and grass borders.

If a fixed design is to be adopted, the soil in various areas of the garden may be modified by the addition of sand, muck, or clay, and by the use of plant foods to suit these particular areas to the needs of special plants. Those which enjoy a dry, sandy soil can be provided for, while those which thrive best in a heavy soil can also be accommodated. If, on the other hand, a less formal and fixed character in the garden seems desirable, the whole area may be annually spaded or plowed up, the walks given a new course, and the general scheme of planting changed. Such an arrangement will give variety and novelty to the garden, and for most purposes will prove quite as successful as the more formal arrangement. During wet periods, unless the soil is of a sandy character, the lack of graveled walks will prove a disadvantage.

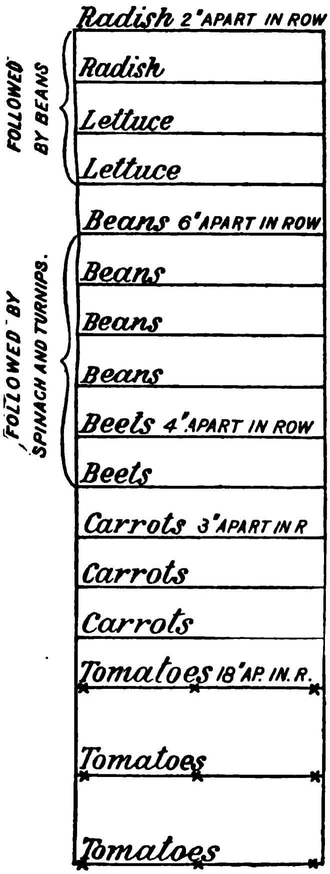

FIG. 1.—Plan of a vegetable school garden.

SCHOOL GARDENS.

The cultural suggestions contained in this bulletin may be found of advantage to those engaged in school-garden work. It is suggested, however, that for use in school gardens plants with a low, bush type of growth be selected rather than those which are tall, broad-leaved, or of a climbing habit, particularly when the plants are to be used in small individual gardens. Tall-growing, broad-leaved plants are appropriate for use in a scheme for the general improvement and decoration of the grounds, but they are not well suited for individual gardens. In most cases the allotment of ground to each individual must be small, not more than 5 by 10 or 15 feet.

. order, therefore, to allow the individual a variety of plants it is ısolutely necessary that they be of compact habit and adapted to ›se planting. A single well-grown castor bean would entirely cover e area above-mentioned. Such plants are therefore excluded from e individual school garden on account of their size. The verbena, ılox, petunia, aster, zinnia, portulaca, larkspur, pot marigold, and varf nasturtium are, however, well suited for the small areas of the dividual garden.

Plan of a school garden.—The individual garden when used for flowers ill admit of little opportunity for rotation succession among the crops in any one ason unless bulbs be introduced for fall anting and early spring bloom. If this an is followed, a cold frame or window ›x will become almost a necessity, be- use the blooming season of the bulbs will ›t be over at the time when, for best re- ılts, some of the most desirable of our ırden annuals should be planted in the ›en. For most complete returns from ıe area at one's command this method of sing bulbs in the autumn, followed by ›tbed or cold-frame grown plants for ›ring planting, is advised. For it should › the aim not only to interest children in lants, but to teach them how to make the ost out of a given area. The rule of eeping a crop constantly upon the ground as important in the management of dec- rative as it is in purely commercial plan- ıtions.

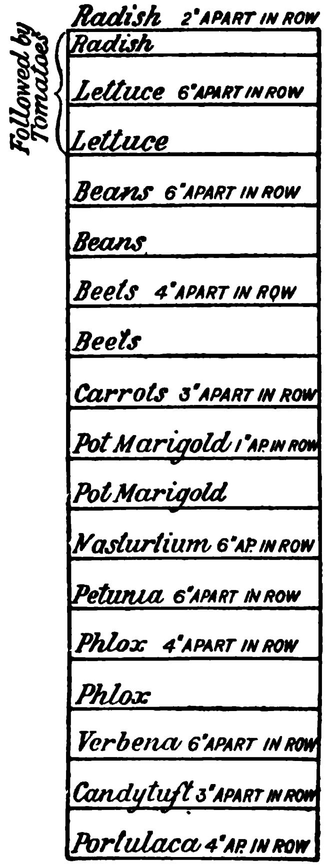

FIG. 2.—Plan of a combined vegetable and flower school garden.

Form of a school garden.—The rectangu- r form is undoubtedly most satisfactory ›r an individual school garden. It is ıost economical of space and if the gar- ens are not more than 5 feet wide the ›ws can be planted crosswise of the area ıd all cultivation given by the student om the walks and alleys without tramping upon the soil of the ırden proper. The plan of a garden 5 feet wide and 16½ feet long shown in fig. 1, and a satisfactory collection of plants is enumerated. f, as is desired in most cases, the flower garden and the vegetable arden are to be combined, an arrangement such as is indicated in g. 2 can be substituted.

GENERAL CULTURAL SUGGESTIONS.

The dates for planting the seed of each of the varieties enumerated in this publication, as well as the particular requirements in their cultivation, are stated in the discussion of each species. General cultural directions, for convenience and economy of space, are brought together here.

Seed sowing.—All of the crops mentioned can be propagated from seed. In some cases, however, the seeds require special care in order to insure a good stand of plants, and it is for that reason that the special devices needed for that purpose are described.

Germination.—The germination of seeds depends upon a proper degree of heat, moisture, and air (oxygen). All three of these conditions must be present in normal proportions with each of the others in order to insure the best germination of the seed. Some seeds germinate best under a maximum degree of heat (80° to 90° F.) while others do best at a low temperature (40° to 60° F.). For most seeds, however, a soil temperature a few degrees higher than that of the surrounding air is desirable. A soil temperature of from 65° to 70° F. for an air temperature of 60° F. will prove very satisfactory for the germination of most seeds. It will be difficult to secure these conditions, however, without artificial means, such as a greenhouse, hotbed, or cold frame. Strange as it may seem, nature maintains conditions during the early part of the growing season approximating those above specified.[a]

Moisture.—Seed in a majority of cases grow best when the moisture in the soil is slight rather than when present in excess. A good test for moisture is to take a handful of soil and compact it gently in the palm of the hand by closing the fingers. If when released the soil remains solid and retains the impressions of the hand, it is too wet; but if when released it springs back and slowly crumbles or parts, it is in ideal condition for seed sowing. Such soil is well aerated, while the soil containing an excess of moisture has the air largely replaced by water.

The seed bed should be carefully guarded against extremes of moisture. It should not be allowed to get too wet and remain in that condition for any length of time, neither should it be allowed to get too dry. In the open these conditions are not likely to occur during a normal season. However, there are frequent exceptions. If too wet little can be done to overcome the bad results, but if drought occurs irrigation will remedy the evil. Under artificial conditions, such as obtain in a greenhouse, hotbed, or cold frame, the moisture content of the soil of the seed bed can be very carefully controlled. The con-

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[a] See soil temperature records, New York State Experiment Station.

›d atmosphere of such a structure prevents rapid or excessive ›poration, while any loss of moisture from the soil can be made good watering. On a small scale the same results can be approached by ‹cing a pane of glass over the receptacle in which the seeds are ›n.

›oil temperature.—Slight variations in the temperature of the soil in ›ich seeds are sown are usually a benefit rather than a hindrance to rmination. With the grasses and clovers germination is more rapid d more complete in seeds subjected to alternations of temperature ›n in those kept under constant temperatures. This applies to pracally all seeds. Under normal conditions the warming of the soil ›ring the day and the cooling at night furnish sufficiently wide variaons. While these variations are less easily controlled than are the ›riations in moisture, yet in structures such as hotbeds and cold ames the change from day to night temperature will be perceptible. Seeds in order to germinate promptly must be placed under condi›ns which will enable them to take up moisture readily and at the me time they must have a temperature which will be congenial to ›e young plant when it appears. The soil is the medium by which ›at and moisture are, under normal conditions, transferred to the ›ed. In order to insure a quick exchange of moisture from the soil › the seed the soil should be carefully firmed or compacted about the ›ed. By compacting the soil about the seed the capillary power of ›e soil is increased and as the seed becomes an intimate part of the ›il the soil moisture is thus more quickly brought to the seed. In utdoor operations large seeds may have the soil ompacted about them by tramping the row with the ›et, while fine seeds may be treated by resting a oard over the row and walking upon it from end to nd. In hotbeds, greenhouses, and cold frames the ompacting of the soil is usually accomplished by the ›se of a float, which consists of a piece of board ›bout 6 inches wide and 9 or 10 inches long, with a handle attached, ›s shown in fig. 3.

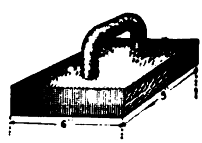

FIG. 3.—A float for firming the soil.

For all conditions save in the open, seeds may be sown in seed pans or in flats, such as shown in fig. 4. These boxes can be very conveniently and cheaply made from the pine boxes largely used for packing canned goods, soaps, etc., usually 9 or 10 inches deep, which is sufficient to allow of cutting them with a ripsaw into three sections each about 3 inches high. The top and bottom of the box will each make a complete flat, while the middle section will be a frame which can be provided

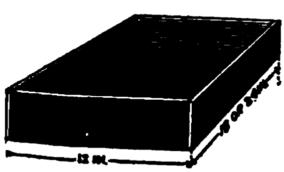

FIG. 4.—A flat.

with a bottom by the destruction of a box for each three secti.
Seeds may also be planted directly in the soil of the hotbed, o
frame, or in that upon the greenhouse bench. They may be s
broadcast or, preferably, in rows.

In covering seeds the rule under artificial conditions is to bury
seed to the depth of its greatest diameter. In outdoor culture, h
ever, this is not the practice; seeds are usually covered about thr
five times their diameter. With seeds the size of a grain of whea
is, in general, safe to plant them 1 inch deep, and for those the size
beans 2 inches deep. Small seeds like those of petunia, tobacco, et
should be scattered over the surface and the soil compacted wi
float.

Transplanting.—The young seedling plants which are to be gro
for their bloom should, as soon as the first true leaves are formed,
transplanted so that they will stand at some distance from one anot
For small, rather slow-growing, plants, such as pansies, 1 inch ap
each way will afford ample room, but with most plants 2 inches e
way will be best, while with robust-growing plants, like the cas
bean, 4 inches will not be too much. With such plants, however,
is best to place the seeds directly in pots or cans in order to prev
disturbing the roots of the young seedlings and to afford them am
space. Transplanting has a tendency to make the plants stocky a
affords opportunity for the development of an extensive root syst

The pleasure derived from floral decorations depends not only up
the perfection of the flowers, but upon having a continuous disp
throughout the season. With most of the garden annuals early bl
can not be secured if seed sowing in the open must be relied up
exclusively. Fortunately the gardener's art has devised cheap a
efficient means for, as it were, anticipating nature. By the use of c
frames at the South and hotbeds at the North the season can
advanced several weeks. In the latitude of Washington, D. C., t
period of growth can be advanced from the normal date of s
sowing in the open—May 1—to March 1, or a gain of two mont
Seed sown in a gentle hotbed at this date will give plants which,
properly handled, will forward the season of bloom as many weeks

HOTBEDS.

Hotbeds are usually constructed in one or the other of the follo
ing ways:

Temporary hotbeds.—A temporary hotbed may be made by us
fermenting stable manure, preferably that with a small amount
straw or litter in it, from grain-fed horses. The manure may b

. in a broad, flat heap and thoroughly compacted by tramping. .p 8 or 9 feet wide and any multiple of 3 feet in length, with ınure 14 to 16 inches deep, will give sufficient heat for the latitude w York City. Farther north the heap should be made deeper and .er. Upon the surface of the manure heap, a frame made 8 inches at the front and 12 inches high at the back, with tapered boards ıds, will give sufficient fall to the sash to carry off the water and afford ample space for the development of the plants within. n completed, a surface hotbed will appear as shown in fig. 5. A

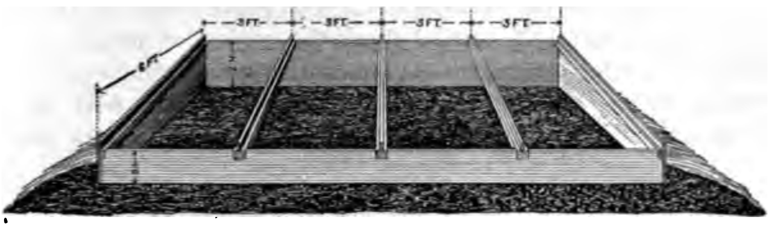

FIG. 5.—Frame to carry the sash of a hotbed or cold frame.

ss section is illustrated by fig. 6. If severe weather is likely to ır during the time the hotbed is in use, the frame should be banked h manure to give additional heat and protection. After placing frame upon the manure heap, about 3 inches of good garden loam uld be scattered uniformly over the area inclosed by the frame. ce the sash in position immediately and allow the bed to heat up. not plant any seeds in the bed until the temperature begins to sub-·, which will be in about three days after the sash are put in place.

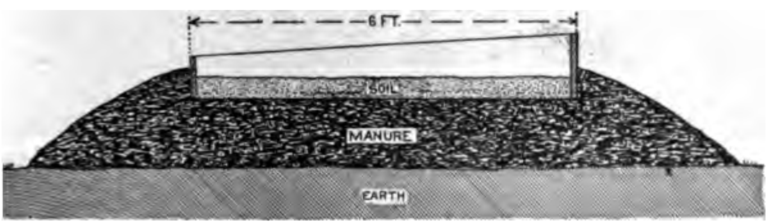

FIG. 6.—Cross section of a temporary hotbed.

en the temperature has fallen to 85° or 90° F. planting may be ·ly begun.

ermanent hotbeds.—A permanent hotbed may be so constructed as ıe heated either with fermenting manure or by radiating pipes from dwelling or greenhouse heating plant. For a permanent bed in ch manure is to supply the heat a pit 2 to 2½ feet in depth, according to the latitude in which the work is to be done, should be provided. . sides and ends may be supported by a lining of plank supported by posts 4 feet apart, or, what is better still, a brick wall 9 inches thick, as shown in fig. 7, may be used. In either case the pit lining should come flush with the surface of the soil. The site for the pit should be on naturally well-drained land, and a tile drain from the bottom of the excavation should be provided to prevent water from accumulating in the pit and stopping the fermentation of the manure during the period the hotbed is in use.

Standard hotbed sash are 3 by 6 feet in size. The pit, therefore, should be some multiple of 3 feet in length and the width should be the same as the length of the sash—6 feet. The plank frame or the brickwork of the pit may be extended above the surface of the ground sufficiently to allow for placing the sash immediately upon these permanent structures, or a frame such as is described in connection with the construction of a temporary hotbed (fig. 5) may be used. In the autumn

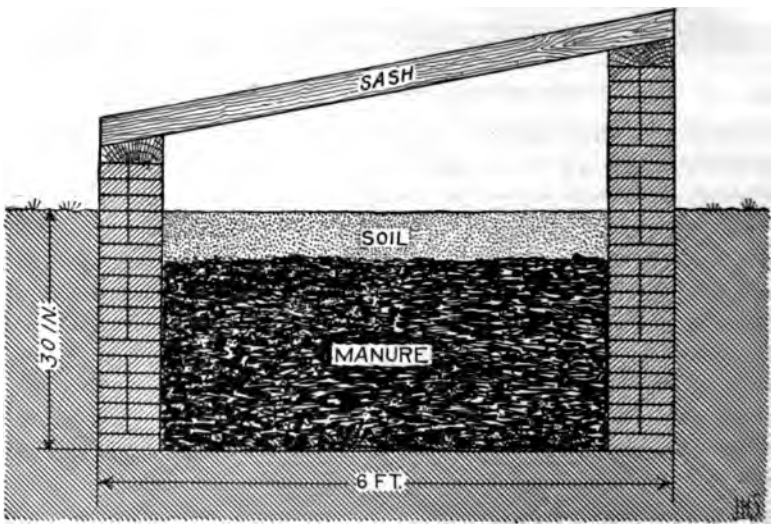

FIG. 7.—Cross section of a permanent hotbed or pit.

the pit should be filled with leaves or straw and covered with loose boards or shutters to prevent it from becoming filled with snow and ice and in order that it may be ready for use early in March.

Sash.—Hotbed sash should be constructed of white pine or of cypress, and the sash bars should run in one direction only and that lengthwise of the sash. The bars may be braced through the middle by a transverse bar placed through the long bars below the plane occupied by the glass. The two ends of the sash should be made of sound timber, 3 inches wide at the top and 4 inches wide at the bottom end, mortised to receive the ends of the sash bars, and with a tenon at the ends to pass through the side pieces, which should be 2½ inches wide.

Glazing.—Placing the glass in hotbed sash is one of the most impor-nt operations in the construction of a hotbed and is also one of the ctors which largely determines the success or failure of the hotbed. ıe glass should be bedded in putty, i. e., the rabbet in the sash bar hich is made to carry the glass should be filled with soft putty, and e glass, crowning side up, pressed firmly into the bed of putty and curely fastened with shoe nails or wire brads. Glazing points are ›t sufficiently secure. The first glass to be placed in any frame is a ›ttom light, i. e., the pane nearest to the front or lowest side of the ›tbed when the sash is in place. The next light should be bedded in ıe same manner as the first and so placed as to lap about three-xteenths of an inch over the top edge of the one first placed, like ıingles on a roof. Brads should be driven below the lower corners f the second pane in order to prevent it from slipping down over the nder one. The same method of procedure should be continued until ıe frame is filled with glass.

Size of glass.—While a frame with two courses of glass will admit a ttle more light than one with three, the breakage is somewhat less ith small glass and the cost of repairing correspondingly less, and for ıese reasons the three-course frame is more desirable. Nowadays many otbed sash are made with a groove or slot into which the glass may e slipped and fastened at the bottom by brads to prevent them from lipping out. Grooved sash have the commendable feature of being heaply and quickly glazed, but as the glass can not be lapped and as o putty is used the sash are not water-tight and do not furnish as ood protection from the wind as sash in which the glass is bedded in ›utty.

Care of a hotbed.—At the North, in addition to the glazed sash, board hutters, straw mats, or mats of burlap or carpet will be needed as an dditional protection during cold nights. During bright days, even vhen the temperature outside is near the freezing point, it will be ıecessary to lift the sash a little at the high side of the frame to allow he hot air to escape and prevent injury to the young plants.

Watering.—Hotbeds should be watered in the morning only, and hen only on bright days. Watering at night is dangerous, as the ›peration necessitates the lifting of the sash and the loss of the accumu-lated heated air, and the water itself lowers the temperature of the soil so that in cold weather there is greatly increased danger to the plants from frost. Then, too, the excessive moisture resulting from dampening the leaves and confining them during the night pro-vides congenial conditions for the development of mildew and the damping-off fungus.

COLD FRAMES.

Cold frames are devices intended to protect plants from cold, without forcing them into growth. They differ from hotbeds in that no artificial means of heating are employed. The cold frame in its simplest form consists of a frame constructed like the one described in the chapter on hotbeds and illustrated in fig. 5. The back board is usually 12 inches and the front 8 inches wide, and the two are connected by a tapered board 12 inches wide at one end, 8 inches wide at the other, and 6 feet in length. The back and front of the frame are made in multiples of 3 feet in length, with an inch added for each division space between sash, which is provided for by the use of a T-shaped piece let into the frame to stiffen it and serve as a guide for the sash. The manner of making the guide, as well as its appearance when in place, is shown in fig. 5. When complete, the frame is placed upon a sheltered, well-drained piece of ground convenient to some main line of traffic between the house and some other important and frequently visited portion of the grounds. The frame, as above stated, is made to carry hotbed sash. The glass allows the sun during bright days to temper the air of the frames, so that by properly covering them at night with shutters, straw, or jute mats the heat can be retained and the plants within safely carried through severe weather. The frames may be banked with earth as an added precaution against cold.

Care of cold frames.—The chief precaution which must be observed in the management of a cold frame is that of proper ventilation. The object of this device is to retain plants in a healthy condition without adding to their growth. It is therefore very essential that the temperature of the frame at all times be kept at a degree which will not induce rapid growth. High temperatures and abundant humidity induce growth. The management of the frame should be so directed that during bright, sunny weather the sash may be lifted sufficiently to admit outside air in order to preserve a low temperature about the leaves of the plants. In some cases it will be found that during bright days even in midwinter the sash will have to be removed from th frame for a few hours at midday in order to preserve a sufficiently low temperature. On the other hand, care should be exercised in ventilation and watering so as not to reduce the temperature of the frame late in the afternoon, as such treatment is liable to lead to frost injury.

Plants for cold frames.—It stands to reason that only the hardiest plants can safely be carried over winter in a cold frame. Many of the plants which are grown as annuals will, with protection, become perennials, or can be made to give a much longer period of bloom if sown e autumn and carried over winter in a cold frame. Among plants h will be greatly benefited by such treatment are pansies, dianthus, ›hrysanthemums.

PITS.

ıe pit is a more elaborate and efficient cold frame which, as its e indicates, consists of an excavation. This excavation may be ı 2 to 4 feet in depth, with sides protected by plank or brick walls, ıown in fig. 7, upon which a frame similar to the one described for cold frame is placed and covered with sash. The pit has an advan- ᐧ over the cold frame for some purposes. It can be used, for ance, to store some of the hardier flowering plants which are to ›laced in tubs or vases about the lawn during summer. Plants in t are protected by the warmth of the soil. In latitudes where the will be found of greatest use the soil does not freeze to a depth of re than 10 to 15 inches. Seedling plants may be held over winter rays or flats in pits as safely as in frames.

Ianagement.—The same precautions in regard to ventilation, cover- , and watering must be observed in the care of a pit as in the case a cold frame.

E CULTIVATION AND USES OF ANNUAL FLOWERING PLANTS.

AGERATUM.

"For strengthening the garden's color forces in blue, no annual is good as the ageratum." Though ordinarily used in bedding and rders in contrast with such plants as raniums, perillas, amaranthus, etc., e rose, white, and blue ageratums are ceedingly attractive when mingled ith alyssum, candytuft, and similar ants. They grow well upon almost all ils and through a wide range of climate; r that reason many combinations with ıem are possible. The plants are neat, ıshy, and erect, with a continual pro- ıse clustering of pretty brushlike flowers ıroughout the season. The dwarf blue

FIG. 8.—Ageratum.

›rts make fine borders and are much used wnere contrasting color effects re desired. For early bloom the seed should be sown in cold frames r in boxes in the house early in the season—March—but for summer nd fall bloom the seeds may be sown in well prepared beds in the open. eeds sown in August will produce good plants for winter flowering.

ALTHÆA ROSEA. (See HOLLYHOCK.)

ALYSSUM.

For borders, edgings, baskets, pots, rockwork, and for cutting, a liberal use of this dainty little flower is recommended. For borders the seed should be sown thickly so as to form masses. For winter bloom, sow in August and thin the seedlings so as to stand about 4 inches apart, but for spring bloom or for borders the seeds should be sown in the open early in the spring, or even late in the preceding autumn in some localities. Where the plant will not endure the winter, however, early spring planting under cover, either in a cold frame or spent hotbed, or in boxes in the dwelling, is most to be relied upon. Alyssum can also be increased from cuttings made from strong new side shoots, as well as by division of the roots. By cutting back after the first flowers fade others will be produced. While white is the most common and popular color, there are yellow varieties of alyssum.

FIG. 9.—Alyssum.

ANTIRRHINUM. (See SNAPDRAGON.)

AQUILEGIA. (See COLUMBINE.)

ASTER.

The aster is certainly one of the most satisfactory of the annual flowering plants. The great variety in its size, color, form, and season of blooming makes it a most satisfactory plant for supplying cut flowers. In fact, many of the improved sorts produce flowers equal in form and size to some of the better sorts of chrysanthemums. The range of color presented in this group is one of its chief merits. Strange as it may appear, the plant world is not very well supplied with blue flowers possessing characters which render them suited to domestic or commercial uses. In the aster, however, are found many shades of blue and purple and for this reason, if for no other, the aster should prove an attractive decorative plant. The habit of growth adapts the aster not only to close planting for cut bloom, but such

FIG. 10.—Aster.

ms are robust, tall-growing plants, well adapted for use in an herba-
ıus border where late bloom and careless effects are desired. The
re compact-growing, large-flowered forms are most desirable for
blooms, while the tall-growing, open types are most useful in wild
rdens or for screens. The wild aster (*Aster novæ-angliæ*) is one of
most beautiful and most satisfactory of this latter class. The
;or and ease of culture of the aster are factors which contribute to
popularity.

Plants from seed sown in the open ground in May bloom finely September and October, when the flowers are seen at their st. For July and August bloom, seeds should be sown in March April in a cold frame, spent hotbed, or in pots or boxes in a 'ing room. Cover the seeds about half an inch deep with rich, ;ht soil and when the plants have three or four leaves transfer them thumb pots or to other boxes, setting the plants about 2 inches apart ch way. After all danger of frost is past transplant the plants so eated to their permanent home, where they should stand about 18 ches apart each way in well-prepared beds. Fresh manure or manure ıed in too large quantities sometimes proves injurious to asters. nly thoroughly composted manure mixed with the soil is safe for ıese plants. Small quantities of air-slaked lime, or of fresh wood shes, stirred into the surface of the aster beds prove beneficial to the lants. When given plenty of water and rich, ne soil asters can be grown into beautiful pot lants.

FIG. 11.—Balsam.

In some localities and during some seasons he aster is seriously attacked by the so-called lack potato beetle or blister beetle (*Epicauta ennsylvanica*), an insect which feeds upon the artly developed buds, causing them to develop, f at all, into deformed, irregular blossoms. In such localities asters can be successfully grown under screens of mosquito netting or other thin cloth.

BALSAM (Impatiens balsamina).

A native of India, the garden balsam loves a hot sun, rich soil, and plenty of water. The young plants are quick, sure growers, and from seed sown in the open ground in May soon form handsome bushes thickly massed with large, rose-like flowers. Transplanting two or three times has a tendency to dwarf the plants into better shape and to make the flowers more double. Balsams are not often given room for perfect development; they will easily cover 12 to 18 inches of space each way. For the finest flowers choice seed is more than usually essential, for cultivation and selection have wrought wonders with this plant. The one objection to the balsam is its habit of producing its flowers, as it were, on the underside of the leaves, or inside the plant. While the individual flowers are beautiful, the obscure manner in which they are borne detracts considerably from the value of the plants. When used at the margin of groups or to crown a terrace they are shown at best advantage.

For early bloom the seeds should be sown about the middle of March in a gentle hotbed or in the dwelling house. As soon as the first true leaves have developed the young plants should be transplanted to thumb pots or to boxes where they will stand about 2 inches apart each way. An abundance of light and water is at all times necessary for success with these plants. Care should be exercised to prevent them from becoming drawn, as stocky, symmetrical plants produce the best flowers.

CALENDULA or POT MARIGOLD.

The calendula or pot marigold is a hardy annual about a foot high. A moderately rich, light soil is most congenial to these plants, which should be placed about 8 or 10 inches apart, if planted in mass or in borders. The seed may be sown in the open ground quite early in spring, and the plants will be in bloom early in summer and continue to bloom until late in the autumn. The coloring of the flowers ranges through all shades of yellow from ivory to deep orange. The plants bloom freely and earlier than the marigold, and are useful in beds, borders, or backgrounds. The dried flowers are sometimes used for flavoring soups and stews. There are both single and double forms of the pot marigold. One of the most satisfactory methods of propagating this plant is from seeds sown about April 1 in the North in spent hotbeds or cold frames. After the middle of May, in localities north of Washington it will be safe to transfer the young plants to their permanent summer quarters.

FIG. 12.—Calendula.

CALIFORNIA POPPY (Eschscholtzia).

The eschscholtzia is the State flower of California, and an annual of :riking character both as regards the ɔrm and color of its flowers, which re bright and rich in their tints of ellow and orange. The plants average bout a foot in height, have attractive ilvery foliage, and produce their large ›oppy-like flowers quite lavishly from arly spring until frost. They are most ffective when grown in beds of considerable size, over which the seed may ›e thinly sown broadcast and lightly 'aked in. These sowings may be made :arly in spring, or late in autumn for :arlier germination and bloom the next ›pring. The eschscholtzia is also very ıseful as a pot plant and for cut flowers.

FIG. 13.—California poppy.

CALLIOPSIS (Coreopsis).

Coreopsis is a genus of showy annual or perennial herbaceous plants, with graceful long-stemmed flowers well suited for bouquets. The hardy annuals of this genus are generally known by the name calliopsis. This is one of the garden's great forces in yellows, strengthened with rich maroons and browns. Seeds of the calliopsis for summer flowering in situations north of New York City should be sown in March in boxes in a living room or in a gentle heat in a greenhouse or hotbed. In localities south of New York the seeds may be sown in the open in May in good garden soil, with the hope of an abundance of flowers from August until frost. The plants should be thinned or transplanted to at least 10 inches apart each way. Their tall, slender habit makes neat staking and tying necessary. All are fine for cutting, especially *Coreopsis grandiflora* and *C. lanceolata*.

FIG. 14.—Calliopsis.

CAMPANULA (Canterbury Bells, Bell Flower, Slipperwort.)

Campanula is a genus comprising both perennial, biennial, and annual flowering plants. These fine old plants are rich in color, profuse in bloom, and of easy culture. For outdoor effects, when planted in quantity, they are glorious, and finest full-blown specimens of such varieties as *calycanthema* or Canterbury bells can be transplanted to pots for house decoration by soaking the soil about them with water and lifting with a ball of earth. The seeds of the annuals should be sown in April or early in May. The seeds of biennials should be sown outdoors early in July, and the plants may be thinned or transplanted to temporary quarters as late as October.

FIG. 15.—Campanula.

The old practice of covering Canterbury bells with leaves through the winter is not satisfactory. Transplant them 6 or 8 inches apart in a cold frame, where they will make large plants by spring and are as easily cared for as pansies. In the spring set them 18 to 20 inches apart in beds where they are to bloom. In June and July they flower most profusely, and are in fine form a long time. They also make beautiful pot plants for Easter. If sown early in good soil the hardy perennials will bloom early the next year. All varieties like a rich, sandy soil, with good drainage.

CANDYTUFT (Iberis).

The candytufts are among the best white flowers for edging beds, for planting in belts, beds, or massing, for rockeries, and for cutting. Several of the varieties are fragrant, and all are profuse bloomers. The seed should be sown outdoors in April where the plants are to bloom, and well thinned when they have grown about an inch high. Make a second planting a month later, and a third late in July for fall flowers. September sowings will give winter-blooming plants. The soil for best results should be rich, and the plants given an abundance of water. They branch freely, and if some are removed the flowers will be larger.

FIG. 16.—Candytuft.

CANTERBURY BELLS. (See CAMPANULA).

CARNATION. (See PINKS.)

CASTOR BEAN (Ricinus).

rhe castor-oil plant, commonly spoken of as the castor bean, is espe-
lly valuable because it is one of the few annuals which can be used to
oduce a semitropical effect. Its rapid growth and large size make
valuable as the central object in groups where rich, luxuriant
owth is required. The variety of color in the foliage of the different
ts of castor bean is of value in giving contrast, and when used in
mbination with cannas, caladiums, coleus, or scarlet sage most
iking effects of contrast can be produced. As a background for
ver-growing plants the castor bean has no equal among garden
nuals. Only the annual climbing vines,
ien provided with suitable supports,
ual it as a low screen. It can be used
th good effect in groups, as masses
ong shrubbery borders, or as belts for
vering and shutting out an undesirable
ew.

FIG. 17.—Castor bean.

At the North, the castor bean is most
tisfactory when started in March or
rly in April in a gentle heat. A hot-
d, greenhouse, or living room can be
ade use of for the purpose. As soon
the first true leaves have formed, the
oung plants should be pricked out into
nall boxes or pots, where they should
kept growing slowly until all danger of frost has passed, when
ey may be transferred to the open. After transplanting the young
ants, it is desirable that they have sufficient room to prevent them
om growing too tall and consequently from losing their lower leaves.
If planted in the open ground at the same time garden beans are
lanted, the castor bean will make a growth of from 4 to 6 feet by the
iddle of August. This plant loves a rich soil, plenty of moisture,
ill sunlight, and great heat. The varieties range in height from 3 to
) feet and have leaves of corresponding size.

CENTAUREA. (See CORN-FLOWER.)

CHRYSANTHEMUMS.

The chrysanthemums, like the pinks, contain some of the most
aluable of the commercial florists' products, both hardy perennial
nd annual flowering plants.

The large-flowered types of chrysanthemums, which each autumn

produce such gorgeous shows in the stores, florists' establishments, a
conservatories, are not hardy, and since they are treated as gre
house plants by the florists they are only mentioned in this list. Th

FIG. 18.—Chrysanthemum.

class of hardy chrysanthemums, whi should be more commonly seen in eve flower garden, and which are known pompons, are simply noted to give prop relation to the annual chrysanthemu which are the subject of this sketch.

These plants bloom most satisfactor if the seeds are sown early in a hotbed cold frame and the young plants tra ferred to the open as soon as the soil h become sufficiently warm to keep th growing without check. If started in hotbed the young plants should stand to 12 inches apart when set in their pe manent locations. Somewhat less sati factory results can be secured by sowi the seed about corn-planting time in th open where the plants are to bloom. Th seedlings should be thinned to stand least 8 inches apart. If the same care in regard to disbudding an pinching back is taken with the annual plants as with the large-flowere perennials the work will be rewarded by greatly increased size of the flowers.

CLARKIA.

The clarkia is one of the prettiest hardy native annuals that comes to us from beyond the Rocky Mountains. It blooms freely, which characteristic, taken in connection with the variety and brightness of its flowers, makes a bed of them in full bloom an attracti . e sight. They are useful, too, for hanging baskets, for vases, as edging plants, for low massing, or for borders.

FIG ..—Clarkia.

The seeds should be sown outdoors in early spring and the plants grown in partial shade. The clarkias thrive in a warm, light soil, and their period of bloom is midsummer and late autumn. The average height of the plant is 1½ feet.

COBÆA SCANDENS.

Cobæa scandens is a rapid-growing, climbing vine which is easily ropagated from seed. The dark color and refined character of its oliage, together with its bell-shaped flowers, render it a very satisfac- ory vine for covering broad areas. It is a less rampant grower than he moonflower, but furnishes quite as satisfactory a screen made up f much finer leaves. The flowers are ot conspicuous, because of their modest olors and because they are hidden by the oliage. Their form, however, is pleas- ng and they are open during the day.

FIG. 20.—Cobæa scandens.

For success in the climate of Wash- ngton, D. C., seeds of the Cobæa scan- lens should be sown about March 15 in rich compost. When the young seed- ings have developed their first true eaves they should be transferred to -inch pots or to tomato cans and kept growing slowly until danger of frost is ast. In the open, a rich border should be provided, for as soon as ot weather comes on the plants grow very rapidly if ample food is at heir command. A rabbit-netting trellis or support is more satis- actory than cords or smooth wire for this plant, as it fastens itself hiefly by tendrils rather than by twining, as does the morning-glory.

COCKSCOMB (Celosia crista).

The cockscombs are prized and planted as an odd and picturesque lecorative feature of the garden. The dwarf varieties make novel and attractive borders; the tall ones form striking groups, and when interspersed with other lower-growing plants in a border they produce a pleas- ing contrast. There are both red and yellow forms of the cockscomb, but the bright red and crimson varieties are most effective in gardens and also in winter bouquets, for which they are cut before fully ripe and dried in the house. The young plants can be grown from seeds sown in gentle heat in April and transplanted to the open ground the mid- dle or last of May, or the seeds may be sown early in May in the open where the plants are to stand. Trans- planting into rich soil about the time the combs begin to form makes the flower-heads much larger. They are bright from midsummer until frost.

FIG. 21.—Cockscomb.

COLUMBINE (Aquilegia).

The columbine is a hardy perennial, with many horticultural varieties, and is a desirable border plant. Its habit of growth is to form large clumps. It blooms profusely early in the season and remains in bloom for a considerable period. It is quite hardy, and is useful for cutting. The peculiar pendant flowers are interesting in themselves because of their unusual form, and this feature, taken in connection with the graceful habit of the plant, gives each clump of columbine a striking and interesting appearance.

FIG. 22.—Columbine.

Sow the seed in the open ground in spring, preferably where the plants are to grow, and thin the young seedlings to about a foot apart. Seeds may also be sown in the autumn for flowering the following season. The plants thrive well under good garden culture, but such rare sorts as *Aquilegia cœrulea* and *A. chrysantha* do best in partially shaded, well-drained nooks. Few hardy perennials are so easily grown from seed.

CONE-FLOWER (Rudbeckia).

Many of the rudbeckias are hardy and perennial, but they may be treated as annuals. The flowers are quite showy and usually have yellow rays, though some are crimson and others more or less covered with brown toward the base. The rudbeckias are of very easy cultivation, thriving in almost any soil and climate. Most of them prefer a moist soil, but will thrive in the garden under ordinary cultivation. *Rudbeckia hirta*—the Black-eyed Susans, or "nigger-heads," as they are sometimes called—will thrive in the hottest and driest situations. *Rudbeckia triloba*, a biennial, perpetuates itself through self-sown plants. The *triloba* may be used quite effectively as a border to a large bed of delphiniums or as a screen, as it forms a dense bush between 3 and 4 feet high. The rudbeckias are propagated by means of seeds or cuttings, or by division. The Golden Glow, one of the most satisfactory plants of this group, is well adapted for planting in a shrubbery or herbaceous

FIG. 23.—Cone-flower.

›order. It grows to a height of from 3 to 4 feet, and may be used as screen when lower-growing plants are placed in the foreground.

COREOPSIS. (See **CALLIOPSIS.**)

CORN-FLOWER (Centaurea).

FIG. 24.—Corn-flower.

Centaurea cyanus is also known as 'blue bottle," "ragged sailor," "kaiser ›lumen," and sometimes as "bachelor's ›utton." These bright-flowered plants ıre of a hardy nature, requiring sim›le culture, yet they are among the nost attractive and graceful of all the ›ld-fashioned flowers. When placed n water after cutting, the flowers in:rease in size. Seed of the annual ›orts should be sown in the open in April or May and the young plants thinned to 4 to 6 inches apart. They thrive well on all moderately rich garden soils. The perennials may be grown from seeds sown in gentle heat in March and planted out in May or June.

COSMOS.

Cosmos is now one of the notable fall flowers. It is a strong, tall-growing annual, yet its bright, bold flowers have a daintiness and airiness which is heightened in effect by the feathery green foliage. It is most effective when planted in broad masses or long background borders against evergreens or fences at some distance from the house and the garden walks. From seed started in the house in March or April the plants will have reached 3 or 4 feet in height by September. The bright-colored, daisy-like flowers are borne in great profusion and come at a season when they are very acceptable. Because of the robust habit of the plant the young seedlings should be thinned to 18 inches apart when grown on moderately good soil. Sowing the seed late and in poor soil will dwarf the plants. In the latitude of Washington, D. C., the plants perpetuate themselves from self-sown seed. These volunteer plants can be taken advantage of for early bloom.

FIG. 25.—Cosmos.

CYPRESS VINE. (See IPOMŒA.)

DELPHINIUM. (See LARKSPUR.)

DIANTHUS. (See PINKS.)

DIGITALIS. (See FOXGLOVE.)

ESCHSCHOLTZIA. (See CALIFORNIA POPPY.)

EVENING PRIMROSE (Godetia).

The evening primroses are choice, free-blooming annuals, with widely opened flowers of satiny texture, with delicate colors. They are suited for solid beds, border lines, for pots, and to grow in shrubbery borders in shaded places, where few other flowers will flourish. The seed should be sown in an open border or in a cold frame in spring. If the latter, the seedlings should be transplanted to stand about a foot apart in rather thin or sandy soil. These plants are also successfully treated as biennials by sowing the seed in July and transplanting the young plants to a cold frame, to be placed in the open the following May. The blooming season is from early spring until frost, and the average height of the plants is 1½ feet.

FIG. 26.—Evening primrose.

FORGET-ME-NOT (Myosotis).

The dainty little flowers commonly known as forget-me-nots are hardy perennials that love cool, moist soils, and, like pansies, bloom most freely in fall and early spring. They make a satisfactory close border, the beauty of which is heightened by abundant bloom. The forget-me-not is also satisfactory as a winter-blooming plant for growing in cool rooms or cold frames. Another feature characteristic of this plant is that, after once having been introduced into a garden, it perpetuates itself from year to year by self-seeding like the poppy, portulaca, and several of the other desirable annuals. Sow the seeds in spring in a warm, sunny border. Most varieties bloom freely the first season and profusely the second year. The average height of the plant is 6 inches.

FIG. 27.—Forget-me-not.

FOUR-O'CLOCK (Mirabilis jalapa).

ıe mirabilis, sometimes called the "Marvel of Peru," is normally :rennial in its native region, the warmer parts of America, but ɛr garden culture it gives satisfactory results when treated as ınnual. The seed may be sown in the early spring under glass the plants set out in May. The ·-o'clock is often used as a screen ı good results. The colored part .he flower, which is white, various les of red, and striped, is the calyx, wn out in the semblance of a corolla surrounded at the base by a leafy olucre. In some cases, as in *Mira-* ·s *jalapa*, only one flower is borne on involucre.

FIG. 28.—Four-o'clock.

Γhe plant is a quick-growing, erect, shy herb, attaining to a height of ›m 2 to 3 feet. Its blooming period luring the late summer and autumn. cause of its habit of opening its flow- ₃ only late in the afternoon and on ›udy days the popular name, four- :lock, has been given. While this ant is a tender annual in the northern ırt of the United States, it frequently reproduces itself from self- wn seed, and even as far north as New York City it frequently manifests its perennial habit of developing tuberous roots sufficiently large to be lifted and stored like those of the canna.

FIG. 29.—Foxglove.

FOXGLOVE (Digitalis).

The tall flower-stems of the foxgloves are particularly attractive when seen growing among shrubbery or in bold masses along walks or drives. As a background for lower-growing plants the foxgloves are also very useful and interesting. The spikes are frequently a foot or more in length and thickly strung with many showy, thimble-shaped flowers. Some of the new sorts rival gloxinias in shadings and markings.

Plants may be grown from seeds sown in the open in May and the seedlings transplanted where they are to grow in the open or, preferably, to a cold frame, where they make extra-strong plants that will fl profusely the next season. They are most satisfactory when tr as biennials, sowing the seed every year in rich, deep soil partial shade. The average height of the plants is from 2 to 3 f When the center spike begins to fade it should be cut out and the shoots will, in consequence, grow more vigorously.

GAILLARDIA.

In the gaillardias are found both annual and perennial plants offer a wide selection of varieties and a profusion of bloom over a l period. The blooming period beg early and continues late in autu They are well adapted to mixed bord and are very satisfactory as cut flowe The stems are of good length, carry t flowers well, and keep fresh as cut flo for a long time when placed in water.

FIG. 30.—Gaillardia.

The annual gaillardias are all propa gated readily from seeds sown in t open, but earlier flowers will be secur by sowing seeds in a hotbed and tra planting the plants to the open as so as killing frosts have passed. In eith case the blooming plants should n stand closer than 10 or 12 inches. The grow and bloom best when fully expo to sun and air, and when planted on a fertile but light and well drained soil.

GODETIA. (See EVENING PRIMROSE.)

HELIANTHUS. (See SUNFLOWER.)

HOLLYHOCK (Althæa rosea).

These too frequently neglected old-fashioned perennials are most pleasing and attractive when seen in groups or long rows against ever green hedges or shrubbery as a background, and, in turn, form a ver satisfactory background setting for plants of lower growth. The col variety in these plants is very great, ranging from pure white throug almost every conceivable shade of yellow, red, and rose to ashen-gr and almost black. Although hollyhocks are permanent and hardy even during the first winter, it is advisable to make seed sowin every year, as the flowers on young, vigorous plants are much fine than those upon old ones. Seed sowings should be made in April or May, and not later than June, to flower the next year. In the fir nsplanting each seedling should be given a foot or more space each r to allow for full development. The average height of the holly-k is 4 feet; many sorts, however, are much shorter, while an equal nber are taller than the average above stated.

IPOMŒA (Morning-glory, Moonflower, and Cypress Vine).

The plants included under the names morning-glory, moonflower, l cypress vine, while all classed together botanically, are quite ied in form of flower and foliage. eir chief merit rests in the fact of ir rapid growth and ability to cover ge spaces in a short time. The ots grow long and are well provided h foliage, two factors which adapt m well for temporary uses, such as ering structures and summerhouses, d for immediate effect upon new ildings. All three of the above-med types grow readily from seed, morning-glory and cypress vine th giving good returns from seeds wn in rich borders about corn-plant-g time. The moonflower can be prop-ated either from seeds sown in a tbed about the first of March in the imate of Washington, or from cut-ngs carried over winter in a green-use. For best success with the nperial Japanese morning-glories and e moonflowers the seeds should be ed to make a slight aperture in the rd, horny covering, or they should be aked for several hours in warm water. f these precautions are not observed a oor stand will usually be the result.

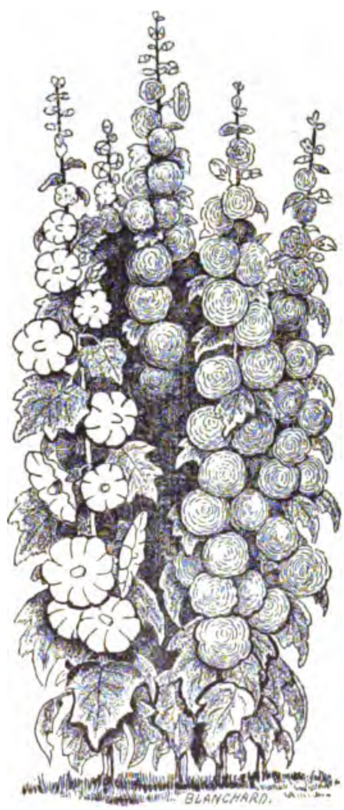

FIG. 31.—Hollyhock.

oth these groups profit by being started in a hotbed or greenhouse in larch or April, and are then transplanted to the open only after all anger of frost has passed.

Morning-glory.

The Imperial morning-glory is the most varied and most beautiful f the group. One of its interesting features is the variety of its flowers and leaves. The latter differ greatly in shape, as well as in size; some are plain green, while others are oddly marbled and blotched with white or yellow. The colors and markings of the flowers vary from pure white to rose, crimson, and carmine through blues and purples of every shade to almost black. There are velvety single self-colors, a few doubles and semidoubles, others with quilled or feathered petals, many fancifully bordered, blotched, striped, penciled, and marbled—hardly any two plants from a seed packet seeming alike. The vines are vigorous, growing rapidly to a height of 30 or 40 feet. In sowing or planting they should be allowed about twice as much space as the ordinary morning-glory, and in the open should not be sown quite as early in the year.

FIG. 32.—Ipomœa: Morning-glory.

Moonflower.

The moonflowers (*Ipomœa bona-nox*) are the most vigorous in growth of any subdivisons of the genus included in the above list. The leaves are large, frequently 5 or 6 inches across, and the large white flowers, which open soon after sundown, are frequently 4 to 6 inches across. These plants with good soil conditions and plenty of moisture will make a growth of from 40 to 50 feet during the season.

FIG. 33.—Ipomœa; Moonflower.

Cypress vine.

The cypress vine (*Ipomœa quamoclit*) is very distinct both in foliage and flower from the moonflower and the morning-glories. The flowers are small, star-shaped, and usually pink in color; they are feather-like both in form and delicacy. The leaflets being fine, the general appearance of the plant is light and airy. While the plant does not grow as robustly as those named above, it is well adapted for covering low screens and arbors. It grows readily from seed, which should be sown in a rich border rather thickly, about corn-planting time, and the young plants thinned to stand 4 to 6 inches apart in the row.

FIG. 34.—Ipomœa: Cypress vine.

35

LARKSPUR (Delphinium).

ßlue is a comparatively rare color among our cultivated plants, and · that reason the delphinium, which shows this color in great variety, particularly valuable. The brilliant flower-spikes can be seen from listance and are strikingly effective in beds or masses, in borders, rubberies, or in combination with white lilies or other plants where ıigh contrast is desirable. The tall sorts should be planted among rubbery or used as a background for other low-growing plants whose ɔom will produce a pleasing contrast with the larkspur. The dwarf pes are better suited for bedding and for low borders. Improve- ᴈnts are continually being made in the size of the flowers, as well as the length and fullness of the spikes. Some of the species flower ›th early and late, and the season for all can be prolonged by care in ıtting away withered flower-stems as fast as they appear. The del- ıinium is sometimes increased by divi- on, but like most other plants they are ore robust when grown from seed. his plant is easily propagated and lapts itself to many conditions, but in soil deeply dug and well enriched with ne old manure their blooms are largest ıd best. For best results the plants ıust have ample room to grow; 1½ to 2 ᴈet each way is not too much for the ıller sorts.

Fig. 35.—Larkspur.

Annual varieties.—These include the ocket and hyacinth-flowered larkspurs, o called from their long, narrow flower pikes. They bloom best in a rather ool, moist soil. The seed may be sown n the open border, either in spring or fall, preferably the latter, so hat germination may take place very early in spring. As the seedlings grow, thin them to stand 6 to 18 inches apart, according to variety. The shades of color include light, dark, and azure blue, white, buff, rose, apple blossom, pink, brick red, red lilac, dark lilac, violet, and fawn. The varieties are seldom kept separate, as they are quite as pretty and convenient for cutting when sown in mixture. Some of these are really hardy biennials, but because they bloom the first season they are treated as hardy annuals.

Perennial varieties.—These are usually taller than the annuals, requiring more space between the plants. If sown in the autumn or very early in spring many will bloom the first season. The foliage is clean and attractive and the habit of growth strong, producing long flower-spikes.

36

LOBELIA.

The Erinus varieties (lobelias) are charming little plants that bloom very quickly from the seed and continue gay with flowers all through the season. For beds, edgings, baskets, and pots there is nothing prettier; their clear colors and generous bloom make them welcome anywhere.

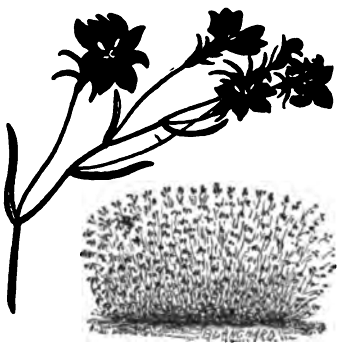

FIG. 36.—Lobelia.

The seeds may be sown outdoors in early spring where the plants are to grow. As the plants appear they should be thinned moderately, or transplanted several inches apart in rich, open soil. Liquid manure given while they are in bloom greatly improves the flowers. Many sorts are also good winter conservatory plants of trailing habit. The perennial or tall varieties are handsome, showy plants, found quite effective for backgrounds and grouping.

MARIGOLD (Tagetes).

There are two distinct types of garden marigolds, each with numerous horticultural varieties, derived from two distinct species.

The French marigold, which is the most compact and regular in growth, and consequently the most valuable as a bedding or a border plant, has been developed from *Tagetes patula*, while the African marigold, which is of a more spreading and open habit of growth and therefore less suited for bedding purposes, but well adapted for herbaceous or shrubbery borders, has been developed from *Tagetes erecta*. The common names of these plants give no clew to their nativity, both being tropical American plants, in spite of common names to the contrary.

FIG. 37.—Marigold.

The French marigolds are all useful bedding plants. The habit of growth is erect and compact, with good foliage. The flowers are well formed, bright in color, and occur from June until frost. While these plants can be grown and successfully brought into bloom from seeds sown in the open in April in the latitude of Washington, such plants do not give as early bloom or the profusion of bloom which will be borne by plants started in a house and shifted for a time into pots which confine the roots of the plant and check it, so that when set in the open the increased food supply has a tendency to induce the

›velopment of flowers rather than wood, a tendency which is main-ined, much to the gratification of the gardener, throughout the season. 'hen transferred to the open the plants should be set at least a foot›art each way. The same distance should also be given plants grown 'om seed sown in the open. There are both double and single forms f the French marigold. The named varieties are especially good, ıt very satisfactory results are obtained from mixed seeds.

The African marigolds frequently grow two or more feet in height, nd for this reason are better suited for planting in mixed borders or long belts of trees and shrubs than in beds or masses in small areas. 'his is, however, the common marigold of the garden in America. 'he leaves and flowers are strong scented. The range of color in the owers of this type of marigold is from sulphur yellow to orange, the arker shades being more commonly met with than the lighter ones.

MIGNONETTE (Reseda).

Every indoor or outdoor garden must have mignonette in plentiful upply. The seed can be sown at any ime, and if successive plantings are nade, its fragrant, modest-colored flow-›rs may be gathered outdoors until No-vember. For early bloom in the open, ›ow seed in pots or boxes under glass in February or March and thin or pot off the seedlings, to make stocky plants for bedding out, as soon as severe frosts are past. To insure a succession of bloom throughout the season, sow a row or two at a time in the open about April 15 in the vicinity of New York, and earlier southward, repeating regularly at intervals of about three weeks till August. The July sowing will make good winter-flowering plants. The average height of mignonettes is 1 foot.

FIG. 38.—Mignonette.

MOONFLOWER. (See IPOMŒA.)

MORNING-GLORY. (See IPOMŒA.)

NASTURTIUMS.

A wide range of colors has been developed in this favorite flower, the nasturtium, which for three or four months of the season makes a better display than almost any other plant. No other annual will produce such a profusion of flowers for so long a time with the same outlay of time and labor. The maximum of bloom is produced on thin soils, and the plant never flags through the hottest weather; in fact, too much rain or moisture greatly reduces the supply of flowers soils too rich the leaves predominate and the plants are apt to r in wet weather, especially if standing too close. The seeds shou planted an inch deep, and the seedlings thinned to 10 or 12 i apart. The rows for bedding varieties should not be less than a apart, and for tall varieties 4 feet.

Dwarf or Tom Thumb nasturtiums (*Tropæolum minus*).—These p have a neat, compact habit of gr and attractive foliage, and are no fested by insects. Blossoms appe two months from the date of seed ing, and continue throughout the v season. A bed of dwarf nasturtiu full bloom is a sea of color. It is that a good bed, 6 by 20 feet in will yield about 1,000 flowers per The average height of the dwarf va is 9 inches.

FIG. 39.—Nasturtium.

Tall or climbing nasturtiums (*æolum majus*).—Besides their ordinary garden use for trailing fences, trellises, stone walls, etc., the climbing nasturtiums can al grown as pot plants for winter-flowering as screens, or as trailer hanging baskets and vases. Sow plenty of seed in drills, and th 6 inches apart in the row. Like the dwarf forms, these plants b most quickly and profusely in poor soil. Their flowers are usu little larger than those of the dwarf sorts. The average height o plant is 5 feet.

NEMOPHILA.

The representatives of the genus Nemophila are dwarf, com growing, hardy, annual herbs, which produce an abundance of sl bell-shaped flowers from early spring to late autumn, for which reason they are esteemed for borders and for bedding purposes. All the species may be propagated from seed. If the seeds are sown in the open about the middle of August and then transplanted in late autumn very early flowers may be obtained. For summer and late fall blooms the seed may be sown in the open in April and not transplanted. The nemophilas love a moist loam, with partial shade, and produce an abundance of showy flowers, which are valuable for bedding and for cut flowers. The whole plant is mc less hairy.

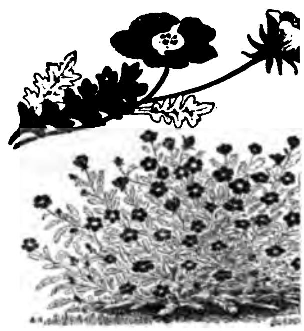

FIG. 40.—Nemophila.

39

PANSY (Viola tricolor).

Πhe pansy, sometimes called heart's-ease, is a favorite with almost ›ryone. It is a plant that demands more than ordinary atten- n, but none repays such attention more liberally. For very early tdoor bedding the seed is sown in the autumn—September—in :old frame, or in rich, moist garden beds, from which the plants ı be transferred to a cold frame, setting them 2 or 3 inches apart ·h way before severe winter weather begins. In spring three- ırths of them can be lifted out for bedding, and the rest left to bloom the frame. For winter bloom in a ›me, set the plants about twice as far art, and thin out half of them in ring. Cover the blooming plants with ;h, adding a covering of matting or ·aw in very cold weather. In mild ·ather remove the mats and tilt the ;hes to admit light and fresh air and prevent the plants from becoming awn. In outdoor beds raised a few ·hes above the ground, with a mulch of y leaves and some brush to hold them place, pansies will often winter nicely d bloom until midsummer, when a lay of young, vigorous plants should ready to replace them.

FIG. 41.—Pansy.

Spring sowings should be made early, as to secure good flowers during the early rains. Seed sown in a ›ol, moist place in June and July, and well tended, will give good ›wering plants for fall. If they come into bloom in the heat of ımmer the flowers may be small at first, but as the weather becomes ›oler they will increase in size and beauty. Through summer heat ıe flowers are finer in a somewhat shaded place, but in almost any tuation good pansy seed will give fine flowers in spring and fall. arly fall sowings give the finest spring flowers.

PETUNIA.

Because of the ease and facility with which all of the single-flowered ırieties of the petunia can be grown from seed this plant commands :tention as a worthy candidate for the summer flower garden. The oung plants grow rapidly and come into bloom early, and in addi- on to this they furnish a continuous wealth of blossoms until de- :royed by frost. The large-flowered strains are very beautiful and f great variety. While the single sorts are common and inexpensive, the double giant-flowered varieties are rendered expensive because they must be reproduced from seed which sets only after careful hand pollination of the flowers, which is in itself an expensive operation, or from cuttings, of which an individual plant can supply but a limited number.

For best results the seeds of all sorts should be sown in a gentle hotbed, cold frame, or in fine soil in a box placed in a sunny window in March or early in April for localities north of Washington, D. C. When the soil has warmed sufficiently and the danger of frost has passed, the seedling plants should be transplanted to a rich garden loam and placed about a foot apart each way. The seed of the double varieties is less vigorous than that of the single sorts and therefore requires more attention to prevent extremes of temperature and of moisture to insure good germination. If the seeds are sown in boxes in the living room, a pane of glass may with advantage be kept over the top to maintain a close atmosphere, and thus prevent the loss of moisture until the young plants are well out of the ground. In planting, the seeds should be scattered over the surface of the soil and brought in contact with it by firming. They should not, like most other seeds, be covered.


FIG. 42.—Petunia.

Petunias are attractive in beds and masses, serve well for broad borders or bands, and thrive well in window boxes. They are not exacting as regards soil conditions, thriving well in almost any arable soil, and they endure drought well and bloom profusely

PHLOX (Phlox drummondii).


FIG. 43.—Phlox.

The annual phlox, sometimes called flame flower, is particularly useful and attractive when sown in masses or ribbon beds of contrasting colors. Few annual plants are more easily grown from seed, give a quicker return of bloom, or offer such a variety to choose from as do the phloxes. There are few desirable colors beyond their range and if given good soil and plenty of water they furnish a supply of cate flowers for cutting throughout the season. The phloxes are › useful as window-garden plants, and may be used as an under-wth for tall, bare-stemmed plants. The first sowing of seed should nade as soon as the frost is out of the ground in the spring; later s in May, either where the plants are to bloom or in a seed bed, he phlox transplants readily. In transplanting set the taller kinds ›ut a foot apart; if planted too thickly they suffer from mildew. e removal of flowers and seed-pods makes the plants more bushy l compact and lengthens their blooming period. The average height the plant is about a foot.

PINKS (Dianthus).

The large and varied genus of Dianthus contains some of our most autiful and most profitable flowers. The most of them are hardy rennials that bloom freely the first season, the plants remaining green winter and blossoming the next year also if lightly protected by a ılch of straw, cut fodder, or leaves. Old plants flower the earliest, ıt as young ones give the largest, finest flowers, sowings are made ery year. Seed can be sown under glass or in an open sheltered d in March. The seedlings are easily transplanted and should stand to 12 inches apart; dwarf ones, about 6 inches. If especially large, illiant flowers are desired, a bed of well-mixed turfy loam, leaf-old, and well decayed manure should be prepared for them. Good ainage should be provided, as the plants are impatient of too much oisture and are more liable to winter-ill in moist than in well-drained situa-ons. In fact, the plant is hardy to vere cold, but succumbs when exposed › low temperatures in wet places.

The carnation pink.

This plant, *Dianthus caryophyllus*, hich is the forcing carnation of the merican florist, can be grown from seeds own early in the season in hotbeds, the oung plants being given frequent shifts o pots of increased size as they grow until ll danger of frost is past and the grow-ng season is well on, when they may be ransferred to the border where they are o bloom. If they are given a rich soil and an abundance of moisture, the bloom will more than repay the extra trouble taken. Seedling plants are more variable in character

FIG. 44.—Carnation pink.

than plants propagated from cuttings, and for that reason are not well suited for commercial purposes.

On the continent of Europe this type of dianthus is more commonly used as a garden annual than in America. The form known as "Marguerite carnation," which has recently come into popular favor, is well adapted to cultivation as an annual. The majority of its flowers come double, and it has a pleasing habit of growth.

Sweet william.

The sweet william, *Dianthus barbatus*, which is to be found in every grandmother's garden, is one of the most satisfactory members of this group for annual planting. While seed can be sown in the open early in the season, about corn-planting time, the best results in the way of early bloom come from plants produced from seeds sown in a hotbed not later than the 10th of March in the latitude of New York, the young plants being pricked out into flats or, preferably, into thumb pots, and later shifted to 3-inch pots before planting in the flowering border. The outside planting of hotbed-grown plants should be delayed until the season has advanced sufficiently to prevent the plants suffering from a check by cold after being placed in the open. The pot-grown plants should be set at least 10 inches apart and seedlings from seeds sown in the open had best be thinned to stand at least 8 inches apart.

FIG. 45.—Sweet william.

The Scotch pink, or grass pink.

The Scotch pink, *Dianthus plumarius*, is a hardy dianthus, which, when treated as an annual in like manner as the sweet william, gives very satisfactory results. The delicately fringed, variously colored, fragrant flowers give the plant an odd yet attractive appearance.

FIG. 46.—Scotch or grass pink.

The flowers of all the plants of this group are most satisfactory for bouquets and table decoration because of the length of time they will keep in a fresh and attractive condition after being cut and placed in water.

POPPY (Papaver).

In the spring, even before the tulips are fairly gone, old gardens gin to be gay with poppies, which, in some one or other of their ıny forms, continue a procession of ight blooms until frost. No other ınts possess so bold and brilliant a ›wer, coupled with the same grace of ›m, airiness of poise, and delicacy of ssue as the poppy. For beds and bor›rs, with a background of green, there nothing which will produce a more riking contrast. Some sorts are adirable for naturalizing in open wooded rounds; others, like the Shirley, are eautiful for cutting. A sandy loam suits oppies best, and as their strong tap ›ots are difficult to transplant it is well › sow seed where the plants are to bloom. eed sowings made in the autumn and at ıtervals in spring will provide a long ıccession of flowers. The seeds should e sown thinly and covered very lightly, s the seed is quite small. As soon as he young seedlings are well established thin the plants to stand about foot apart. The plants which bloom most profusely are those grown rom fall or early spring sowings while the earth is cool and moist.


FIG. 47.—Poppy.

PORTULACA.

This bright-flowered, thick-leaved annual (portulaca) is unrivaled 'or brilliancy among plants of low growth. It possesses the ability to flourish under extremely adverse conditions; even the hot sun and a light sandy soil, with sparse water supply, will not destroy it. It is satisfactory for beds, edgings, and rockwork, and for filling up irregular spaces or unexpected gaps in flower beds. As an undergrowth for taller plants it is also valuable. It flourishes, carpeting the ground with a mat of succulent foliage that in the forenoon is hidden by the gayest flowers. The plant is particularly useful in the Northwest. The seed does not germinate until hot weather, and should be sown late. Beyond the sowing, this plant requires little care. The hardy character of the plant is shown


FIG. 48.—Portulaca.

by the fact that it can be transplanted while in full flower throug- the driest, hottest seasons. The average height of the portulaca i- inches.

At Washington and southward this plant will perpetuate itself b- self-sown seeds. In some soils this is sufficient to cause the plant to assume a weedy character. It never becomes troublesome like it- near relative, the weedy garden purslane, or "pusley" (*Portul- obracea.*)

POT MARIGOLD. (See CALENDULA.)

RICINUS. (See CASTOR BEAN.)

RUDBECKIA. (See CONE-FLOWER.)

SALVIA. (See SCARLET SAGE.)

SCARLET SAGE (Salvia).

The *Salvia splendens*, or scarlet sage, is a standard bedding plan- that keeps the garden bright with color until late in autumn. This plant lends itself to many uses; it makes a good pot plant, does well in window boxes, and is useful for cutting to give color. Its best use, however, is as a hedge or border plant where long broad bands of intense color are desirable.

Fig. 49.—Scarlet sage.

In the climate of Washington, D. C., seeds should be sown in window boxes or frames in March or April and the plants set outdoors during the latter part of May, or the seed may be sown outdoors after the first of June if protected from heavy rains and strong winds. The plants grow and bloom profusely in any light, rich soil. Both the tender and hardy perennial sorts bloom the first year and all are treated as annuals.

SCOTCH PINK. (See PINKS.)

SNAPDRAGON (Antirrhinum).

The snapdragon is a valuable border plant. It flowers the first year om seed sown as an annual. The bright lor and peculiar form of the flowers ways attract attention. The newer rts offer variety of colors and of markgs. The spikes are useful for cutting ıd keep fresh a long time. From seed wn in the open ground in May plants ill bloom in July and August. For .rly flowers the seed should be sown ıder glass in February or March and ansplanted into beds of warm, dry soil oderately enriched. If protected by a ›ld frame or even a mulch of leaves, the lants will winter well and bloom early ıe following year. The snapdragon, ke most perennials and biennials which loom the first year, and of which a particlar display is desired, should be treated ke an annual and sown every year. The lant blooms freely and continually until rost, its average height being 1½ feet.


FIG. 50.—Snapdragon.

STOCKS (Matthiola).

The group of plants known as stocks offers many desirable qualities. The plants are vigorous, have a good habit of growth, fragrant flowers in various colors, a long season of bloom, and are adapted to a wide range of cultural conditions. Stocks are suitable for bedding, edgings, pot culture, house or conservatory use, and for cutting. For bouquets and floral work the double white sorts are especially useful. To secure early flowers, seeds should be sown under glass in March or April, and the young seedlings transplanted when an inch high into other pots or boxes, or into the fine soil of a spent hotbed. Advantage should be taken of showery May weather to transfer the plants to garden beds or deep, rich soil, setting them about a foot apart each way. As with other plants, frequent transplantings during the early stages of growth tend to give them a more dwarf and compact habit. For late flowers seed sowings may be made in the open ground in May. If plants that began to bloom late are


FIG. 51.—Stocks.

carefully lifted and potted in the fall they will flower freely during the winter in a house or room that is tolerably cool and moist. The blossoms are very lasting. The average height of the stocks is from 1 foot to 1½ feet.

SUNFLOWER (Helianthus).

These tall-growing, bright-flowered annual plants have not received the attention they deserve. They have suffered the misfortune of having been cheapened by use as a burlesque. In reality, however, the tall-growing, large-flowered sorts, as well as the dwarf, many-flowered varieties, are useful when skillfully employed in mixed plantations with other herbaceous annuals. The golden yellow disks are like sunbursts among the shrubbery. The tall habit of the plant and the dense foliage of some varieties suit them well for backgrounds and screens. Their long stems and extraordinary lasting qualities make them of value as cut flowers.

FIG. 52.—Sunflower.

The seed should be planted in the open garden in spring, at about the same time that corn is planted, and the plants thinned to stand from 2 to 4 feet apart, according as the plant is dwarf or tall growing. There is wide variation in the height and habit of growth of the different varieties, which range from 2 to 10 feet in height, with from one to many flowers.

SWEET PEAS (Lathyrus odoratus).

The sweet pea during the last decade has been greatly modified and improved by careful selection and cultivation, the flowers being larger and more varied in color and marking than formerly. The result is that the sweet pea has come to be one of the most popular annual flowering plants. It repays well the attention given it. The flowers are well suited for bouquets, and lend themselves well to table decoration. While the climbing habit of the plant is such as to prevent its use in groups and borders, its height is not sufficient to allow its use as a cover or screen for a lattice. The most satisfactory method of growing it is in long rows provided with rabbit-netting wire, supported by strong anchor posts and intermediate stakes, to prevent the wire from sagging between its supports.

FIG. 53.—Sweet pea.

·et peas require a soil deeply tilled and well supplied with plant A satisfactory method is to open a trench about a foot wide 0 inches deep in rich garden loam, in the bottom of which about hes of well-rotted manure are placed, with 2 inches of fine top scattered immediately over it. Upon this bed sow the peas in ɩle rows about 8 inches apart, the seeds being placed from half an to ar inch apart in the row. Cover the seed about 3 inches deep, after the young plants appear and have attained sufficient height the trench completely.

ɩs the sweet pea can hardly be placed in the soil too early in the ing, all general preparatory work should be done in the autumn, l the seeds sown as early in March as practicable. In sections with vinter temperature less severe than that of Washington the best ults will undoubtedly be obtained from fall sowing.

SWEET WILLIAM. (See **PINKS.**)

VERBENA.

The verbena is a low-growing annual, with a decumbent or creeping bit. The flowers are borne on terminal or lateral shoots, which lift emselves from 5 to 7 inches off the ground, and when grown in mass e plants will form a mat which in full bloom will give the soil the pearance of having a carpet of flowers. ecause of the ability of the plant to rm a compact growth and produce a ealth of flowers over a long period, the erbena is frequently used as a bedding lant where carpet bedding effects are esired. The contrasting colors in the arieties which come true from seed llow of securing pleasing combinations f colors which are effective where low-growing plants can be used. The length f stem and the texture of the flower are ɩch that the verbena is of value for ouquets and table decorations. The erbena can be used with good effect in eds, borders, mounds, and in window oxes.

FIG. 54.—Verbena.

While the verbena grows readily from cuttings and from layers, edling plants are more vigorous and as a rule produce better flowers. r the earliest bloom in the latitude of Washington, D. C., sow the eds early in February in a moderately warm living room or green-use. For general outdoor planting the seeds may be sown about arch 10, either in a living room, hotbed, or greenhouse. [illegible] ɔd a few hours in tepid water and sow in seed-boxes [illegible] rich soil; cover one-fourth of an inch deep, press down firmly, and water sparingly. When the seedlings are about an inch high transplant them into other boxes, placing the young plants 2 or 3 inches apart each way. If thumb pots are available use these in place of boxes. When planting-out time arrives choose a bright, sunny situation. Make the soil rich and compact rather than light, but in all cases provide good drainage. Set the young plants 10 to 15 inches apart each way and give good cultivation until they cover the ground. With such treatment the verbena should give continuous bloom from early summer until killed by frost.

ZINNIA (YOUTH-AND-OLD-AGE).

The zinnia is easily grown from seed sown in the open ground. When sown in April the plants will bloom abundantly and continuously through the entire season. Of late great improvements have been wrought both in the color and form of the flower. During the month of August zinnias are at their best. To secure large flowers and a profusion of bloom the plants must be given ample room for full development, as well as an abundant supply of food. Strong, rich soils suit the zinnia. If the seeds are sown in a dwelling house or in a hotbed in March and the young plants are pricked out once or twice before being planted in their permanent situations more satisfactory results will be secured than from outdoor-sown seeds unless equal care in thinning or transplanting is given. The plants can be used for groups, beds, borders, garden lines, and summer hedges. The average height is 1½ feet.

FIG. 55.—Zinnia.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 196.

EFULNESS OF THE AMERICAN TOAD.

BY

A. H. KIRKLAND, M. S.

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LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOL...,
Washington, D. C., April ...

DEAR SIR: I submit herewith a short paper on The Usefulness of the A... Toad, prepared by A. H. Kirkland, M. S., of Boston, Mass., an entomolog... writer on entomological subjects. Mr. Kirkland has made a somewhat ... and extended study of the toad as a destroyer of insects, arriving at the ... that this little animal is a valuable friend to all who are engaged in agricult... supporting this conclusion with evidence derived from his investigations. ... hope that the toad's life history and habits may be better understood, its u... more fully appreciated, and its protection from wanton destruction secure... recommended that this paper be published as a Farmers' Bulletin.

Respectfully,

L. O. HOWA...
Ento...

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

USEFULNESS OF THE AMERICAN TOAD.

INTRODUCTION.

he heavy tax levied by insects on nearly all agricultural crops is l known to farmers. Nearly as well known, thanks to Experiment tion experts and others, are the principal remedies for combating se pests. But in the long run nature provides the most efficient cks on insect increase and these often are but little understood or reciated. While the value of birds as destroyers of noxious ects is now becoming generally recognized, the silent, inconspicuous rk of insect parasites and certain predaceous animals receives but ht recognition even from those who are most directly benefited. us the common toad,[a] nocturnal, of quiet habit and appearance, ders notable service to farmers and gardeners throughout the entire owing season; yet to many its worth is unknown, while to others it even an object of disgust, if not of fear. It must be admitted that some the toad can never be an attractive animal. Nature has denied he gay colors of bird life or even the sinuous beauty of some of its otilian relatives. Yet, judged by the standard of good works, the d does not suffer by comparison with any of the lower animals.

The toad has always borne the burden of false and even ludicrous srepresentations. We have adopted in their entirety the principal ropean traditions concerning the toad as set forth by the early iters on natural history. These ancient savants, who did so much establish the study of nature, had the failing, not confined to that e, of confounding fancy with fact. Thus the popular superstitions that time are curiously interwoven with their statements concerning e life history and habits of the toad. The early writings on this bject teem with vague and ludicrous fancies of the toad's venous qualities, its medicinal virtues, and more commonly of the valble toadstone or jewel to be found in its head. All these tradins are to be met with even in this era of progress, and coupled with em we hear of the equally surprising ability of the toad to produce

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[a] The information given in this bulletin relates chiefly to our common eastern toad Bufo lentiginosus americanus Le C. Other species have similar habits where the me classes of insects are available for food.—Editor.

warts on the hands; to poison infants by its breath; to bring good fortune to the house in whose new-made cellar it takes up its abode; and finally, to cause bloody milk in cows if killed by accident or design. The writer well recalls the shock his credulity received when in the inquisitive stage of boyhood he faithfully tested several of these superstitions with only negative results. When so much that is false has been written about the toad it may not be amiss to increase the scanty literature of facts concerning this humble servant of man as determined by a somewhat intimate acquaintance extending over a decade or more.

LIFE HISTORY AND HABITS.

To the nature lover there are few more interesting subjects than the development and habits of the toad. In New England toads do not bestir themselves until April or May, but in more southern latitudes March finds them wakening from their winter's sleep and beginning their annual migration toward the breeding ponds, where a little later is heard the soft, drowsy, musical trilling of the males, so described by Gibson as the "sweetest sound in nature." The number of toads which migrate even to a small pond is remarkable. The writer once counted 356 toads on the shores of a pond containing scarcely half an acre. Mating is commenced as soon as the water is reached, or even before. The tiny black eggs, with their gelatinous covering, are laid in long "ropes," the envelope swelling to a notable degree as soon as it comes in contact with the water, thus forming a mass many times larger than the body of the parent toad. In two weeks, or even sooner if the water be warm, the eggs hatch and the young tadpoles feed greedily upon the gelatinous envelope. Next the slimy deposits common to ponds are attacked. The tadpoles grow rapidly, until by June or July the legs develop, the tail is absorbed, and the young toads leave the pond which has sheltered them, never to return except for brief visits at the mating season.

The little toads are very sensitive to heat and secrete themselves under leaves, rubbish, stones, etc., during the day; but let a vigorous shower descend and frequently walks, roads, and gardens at once become peopled with these thirsty leaping creatures. So sudden is their appearance under these conditions as to lead to the popular belief that they rain down. The inability of toads to endure heat serves as an indirect protection for them at this stage. They are delicate morsels to many birds, and, were it not for the fact that they are obliged to seek shelter by day, large numbers would be destroyed. As it is, many are devoured by the predaceous birds and mammals which prowl at night.

It seems probable that the toad does not begin to reproduce until the fourth year. The number of eggs laid by a full-grown female l is remarkable. It is a rule of nature that where the chance for ›ecies reaching maturity is small the fecundity is large, and this is well illustrated in the case of the animal under discussion. The :er once removed 1,279 eggs from a female toad which had already menced laying. The total egg production is better indicated by record of 7,587 and 11,545 eggs obtained from two toads by Dr. '. Hodge, Clark University, Worcester, Mass., as recorded in his k entitled "Nature Study and Life."

[any stories are extant concerning the longevity of the toad. These nals are said to have been found embedded in rocks, trees, masonry, , thus indicating that it was possible for them to exist in dormant lition for many years. The writer has gone to some trouble to :stigate statements of this kind coming to his attention without ing a single case where there was conclusive evidence of such a longed dormant state. On the other hand, we have the experiment M. Herrisant, who in 1777 embedded three toads in plaster and :ed them in the archives of the French Academy of Sciences. At end of eighteen months two of the toads were still alive. In 1817 :tor Edwards repeated this experiment, but submerged the plaster :ks in water, with the result that all of the toads died. Buckland ied toads in cavities in sandstone and limestone and found that all toads in sandstone were dead in thirteen months, while those in estone survived for nearly two years.

'he toad has a strong "homing" instinct, and lives year after year the same locality. Convincing evidence has been furnished the ter of two toads that have occupied dooryards in two different towns twelve and twenty-three years, respectively, while Mr. F. H. sher, Westport, Mass., has positive knowledge of a toad which upied a certain feeding ground for at least eight years. In view :hese facts, there can be little doubt that the toad attains to a con- :rable age.

'he belief that the toad is venomous probably arises from its habit, en disturbed or roughly handled, of ejecting through the skin a tain milky acrid fluid. No harm attends contact with the fluid on hands, but dogs attempting to bite toads show signs of discomfort, l even distress, due to this acrid skin secretion. That the fluid is : objectionable to all animals is shown by the avidity with which tain hawks and owls capture and eat toads.

t is not uncommon to find during the summer certain toads of much ghter colors than their fellows. This is due to the casting or molt- ; of the skin, which takes place several times annually. Previous molting, the toad seeks shelter and remains quiet for some time. e skin then splits, peels off, or is removed by aid of the forelegs, l is often eaten by the toad, which soon goes forth clad in fresher ors.

Though living alone through the summer, it is not an uncomm[illegible] thing to find a dozen or more toads hibernating in a colony under [illegible] convenient rock or board. Winter quarters are sought quite early [illegible] the fall beneath rocks, leaves, or rubbish, or in other places where [illegible] action of the frost will not be severely felt. Figuier states that th[illegible] animals freeze without being killed, and it is not unusual to find t[illegible] in winter apparently frozen stiff some distance below the surfac[illegible] the soil.

FEEDING HABITS.

Soon after sundown, or even before on cool evenings, the t[illegible] emerges from its shelter and sallies forth in search of food. I[illegible] country districts it nightly patrols over roadsides, gardens, cultiva[illegible] and new-mown fields—in short, all places where insect life abou[illegible] and long grass or herbage does not obstruct its travel. In citie[illegible] villages the spots beneath electric lights are particularly favor[illegible] while lawns and walks also receive attention. The toad has learn[illegible] that electric and other lights attract large numbers of flying ins[illegible] many of which fall injured to the ground below. At Amherst, Ma[illegible] the writer once observed eight well-fed toads holding festival bene[illegible] an arc light. During the flying season of the brown-tail moth [illegible] Massachusetts there is no more common night scene than that of [illegible] toads devouring the white moths which fall fluttering from the la[illegible] above.

For two successive summers the writer had opportunity to ma[illegible] numerous observations on toads feeding under natural condition[illegible] all hours of the night. From these observations and from stom[illegible] examinations it was apparent that the toad feeds continuously throu[illegible] out the night, except when its food supply is unusually abunda[illegible] when periods of feeding and resting alternate. From such obser[illegible] tions, as well as by studying toads confined in cages, it was found th[illegible] in twenty-four hours the toad consumed a quantity of insect fo[illegible] equal to about four times its stomach capacity. In other words, t[illegible] toad's stomach is practically filled and emptied four times in [illegible] twenty-four hours.

Dead or motionless food has little attraction for the toad. O[illegible] living and moving insects, centipedes, etc., are devoured. Cutworm[illegible] for example, are safe while they remain curled up, but let them c[illegible] mence crawling and they are soon snapped up by the toad. At fi[illegible] thought it strikes one as odd that the toad's tongue is attached in fr[illegible] and free behind, particularly as the tongue is its only means for c[illegible] turing food. However, one needs only to watch the feeding of a t[illegible] for a few minutes to satisfy himself that this organ is well adapted [illegible] its work. The tongue is coated with a glutinous secretion and adhe[illegible] firmly to the food it seizes. When the writer first took up the st[illegible] he toad he confined a large specimen in a well-shaded box out of rs. So ravenous was its appetite that to provide sufficient insect l was quite a task until a satisfactory expedient suggested itself. en a hard bread crust was soaked in molasses and placed in the e it attracted a sufficient number of flies, bees, ants, beetles, etc., eep the toad well supplied with food. The toad would sit motion- beside the bread crust until a moving insect came within range, n its tongue would be thrown out with lightning-like rapidity and insect, often on the wing, would suddenly disappear within the l. The diet of this toad was varied with occasional fish worms, ch, being too large to swallow at once, were forced down the gullet means of the fore limbs.

THE FOOD OF THE TOAD.

s pointed out previously, the toad is of direct service to man by son of the noxious insects which it destroys. Should it feed on eficial insects, it would be to that extent an injurious animal. There nly one way to determine accurately to what extent an insectivo- s animal is beneficial or injurious, and that is by a careful examina- n of the contents of a sufficiently large number of stomachs collected lifferent dates and over a suitable range of territory. While field ervations furnish important circumstantial evidence and aid to an lerstanding of the kind and condition of food found, the stomach uminations, as Prof. F. E. L. Beal has so aptly put it, "constitute court of final appeal." Patience, strategy, and good eyesight will ble one to study the feeding habits of such animals, but the absolute ntification of the kind and quantity of their food can not be made long range. For accurate results the material devoured must be ilable for careful analysis, often under a microscope.

The writer a few years ago collected and examined 149 toads' machs, particular effort being made to secure representatives from ferent sections and from a wide range of places, i. e., gardens, fields, ls, woodlands, city streets, etc., during every month of the feeding son. This number is doubtless too small to show the exact status of toad in the region covered, yet it is sufficient to afford interesting ta for some general conclusions. With the exception of a few machs preserved in formalin, all were examined while fresh, the machs being split along the outer curvature and the contents care- lly washed into a glass dish. The material thus obtained was sepa- ted into its proper groups, identified, and its percentage of the entire lk estimated and noted. The number of stomachs examined, by onths, was as follows: April, 7; May, 30; June, 66; July, 29; August, ; September, 7; total, 149.

Stomach contents of 149 toads, with percentage, by bulk, of each food element.

Food elements.	Part, by bulk.	Food elements.	Pa-
	Per cent.		*P-*
Ants	19	Spiders	
Cutworms	16	Sow-bugs	
Thousand-legged worms	10	Potato beetles and allies	
Tent caterpillars	9	Carrion beetles	
Ground beetles and allies	8	Miscellaneous beetles	
May beetles and allies	6	Snails	
Wireworm beetles and allies	5	Angleworms	
Weevils	5	Vegetable detritus	
Miscellaneous caterpillars	3	Gravel	
Grasshoppers, crickets	3	Unidentified animal matter	

This table shows that at least 98 per cent of the toad's food is of animal origin. The vegetable matter (1 per cent) was composed of bits of grass, leaves, rotten wood, etc., evidently swept in by accident along with the insect food. It is in this way, doubtless, that gravel (1 per cent) found its way into the stomachs. The unidentified material consisted of broken parts of insects, animal tissue, etc., which were so finely ground as to be beyond recognition and probably represented injurious species in great part, although not so considered in the table.

The nature of the vegetable and mineral matter found in the stomachs needs no further mention. The animal matter recognized constitutes 93 per cent of the total food, of which 77 per cent was insects and 16 per cent other forms. As might be expected, nearly all the animal matter is composed of terrestrial species or of forms which at some time frequent the ground for shelter or migration.

Worms.—The common angleworm was present in 14 stomachs, principally in toads taken soon after showers, and formed 1 per cent of the total food. Rains drive the worms to the surface, where they fall easy victims to a particularly hungry toad. From studying toads in confinement, it appears that worms are not preferred by that animal as an article of diet, but may be eaten. Worms are of great service in tilling and aerating the soil, as Darwin has so well shown. On the other hand, they often cause great annoyance in greenhouses and flower beds out of doors. Since the toad frequents the abodes of man it seems probable that the good done by worms in such localities may well be offset by their damage as above mentioned.

Snails.—Snails are a serious pest in greenhouses and gardens, where their depredations on lettuce and other succulent plants are well known. Several of the large naked snails common in gardens were found in the stomachs, while, in the case of the shell-bearing snails, it was found that the acid stomach juices of the toad were sufficient to dissolve the shell in a short time. It seems a little strange that such slow-moving animals should attract the attention of the toad, yet it is apparent that the animal finds them suitable articles of food, as shown by their constituting 1 per cent of the total stomach contents.

Sow bugs.—These small creatures were most numerous in stomachs taken in the late summer, and made up 2 per cent of the food for the season. Their damage to the roots of orchids, violets, pansies, roses, etc., has been frequently noted by florists. By destroying them the toad renders a distinct service.

Thousand-legged worms.—These form a constant article of diet, as many as 77 having been found in a stomach. Ten per cent of the food of the toad was of this class. They are frequently called "wire-worms," although this name belongs properly to the young of the "click beetles." Farmers often find the attacks of these myriapods on potatoes a serious matter. The late Dr. J. A. Lintner has recorded an instance where for two years in succession a potato crop was severely injured by these "worms." Many cases of injury to newly planted potatoes have come to the writer's attention, while others have recorded the partial destruction of cucumbers, tomatoes, etc., from this cause.

Spiders.—It is not strange that such active creatures as spiders form 2 per cent of the toad's food. Naturally most of the spiders were of terrestrial species. How much good spiders accomplish is an open question, but since they destroy large numbers of flies we have included them in the column of beneficial insects. It should be noted, however, that the spider's web often catches those active parasitic flies which would otherwise serve man through the destruction of injurious caterpillars. Perhaps a fair statement would be that the harm the toad may do by including 2 per cent of spiders in its menu is offset by the 13 per cent of snails, sow bugs, and "thousand legs" which it destroys. This brings us, then, with a clean balance sheet to a consideration of its insect food in the strict sense of the term.

Grasshoppers, crickets, etc.—These insects were found to make up 3 per cent of the food of the toad, and included several of the common species of the hay field as well as house crickets, tree crickets, and cockroaches. The damage to grass and grain crops by grasshoppers is too well known to require more than mere mention. The black house cricket is often a nuisance, while the cockroaches and water bugs are even worse. The small roach or water bug was often found in stomachs of toads taken on city streets. The toad is entitled to unstinted praise for its work in destroying these insects.

Ants.—We come on debatable ground when we take up the economic importance of ants. The writer for the purposes of this paper has regarded them as of neutral value. Most entomological writers regard lightly the shortcomings of these industrious and highly intelligent creatures. Certainly one can not observe their systematic domestic arrangements and evident reasoning powers without a feeling of sincere admiration. During the season of their activities they destroy a certain number of soft-bodied insects and carry off more dead ones as a provision against future need. On the other hand, they care for and distribute plant lice and certain other related insects, infest lawns, walks, and dwellings, attack cooked food, and often make of themselves an unmitigated nuisance, as many a perplexed housekeeper can attest.

Ants constituted 19 per cent of the total contents of the stomachs examined. The greatest number was found in the May examinations, when they were present in 70 per cent of the stomachs and formed 23 per cent of the food for that month. Aside from ants a few allied insects—such as bumble bees, honey bees, wasps, and hornets—and two ichneumon flies were noted in the examinations. The latter insects are beneficial as parasites on certain caterpillars. Beekeepers have informed the writer of cases where toads had taken position at the entrance of hives, and thus destroyed a large number of bees. This loss might have been avoided by raising the hives above the surface of the ground. Since the toads feed principally at night, such cases are probably of rare occurrence.

Beetles.—There is a certain family of active black or metallic ground beetles, which are usually present in gardens, fields, or woodlands, feeding for the most part on soft-bodied insects, and occasionally varying their diet by attacking low-growing fruits. These ground beetles undoubtedly are beneficial, as a whole, although the damage to strawberries by certain species has caused considerable loss at times. The most serious charge to be laid against the toad is the destruction of these ground beetles, which make up 8 per cent of the total food.

On the other hand, the members of the May-beetle and click-beetle families are commonly present, and furnish 6 and 5 per cent, respectively. The May beetle, or June bug, is unfavorably known as the parent of the white grub, which, in certain years, destroys large areas of grass land and lawns, and also works havoc on the potato crop. Promiscuous shooting of crows has removed one of the principal checks on this insect; hence the service of the toad in this connection is of especial value. The "rose bug," or rose-chafer, was found in several stomachs.

The common wireworms, which attack newly planted corn, are the progeny of the click-beetles, and these insects were present in large numbers in the stomachs examined. Wireworms also attack potatoes, lettuce, cabbage, and other garden crops.

Snout-beetles, or weevils, make up 5 per cent of the toad's food. These insects, of which the plum curculio is a good type, are among the most difficult pests to combat. Nearly all have the habit of dropping to the ground and feigning death when disturbed, thus giving the toad a chance to capture them. Among the species found in the stomachs were two specimens of the plum curculio, and many which bore in standing timber and shade trees.

Potato bugs, cucumber beetles, and their allies amounted to 1 per ent of the total food. The injurious habits of these species need no omment. Of equal rank were the carrion beetles (1 per cent) of posibly beneficial habits, and miscellaneous beetles (1 per cent). The atter, aside from an occasional ladybug (beneficial), are of no special mportance. The sole value of the carrion beetles lies in their habit of burying or devouring dead animal matter which might otherwise become offensive.

Cutworms and army worms.—The young or larvæ of moths formed 28 per cent of the total food; cutworms forming 16 per cent, tent caterpillars 9 per cent, and miscellaneous caterpillars 3 per cent. The destruction of cutworms is of special importance. These insects feed by night, and the grower only learns of their presence through the loss of his lettuce, cabbage, and other plants. Hand labor offers the most practical remedy, and this is ably assisted by the efforts of the toad. To appreciate fully the number of cutworms a full-grown toad may consume, one should watch these animals in a field infested by army worms, which are members of the cutworm family. Three toads taken under such conditions contained, respectively, 9, 11, and 55 army worms. These soft-bodied insects are quickly digested, and the toad's capacity for cutworms seems only limited by the supply.

Tent caterpillars.—The insects consumed by the toad are chiefly those of terrestrial habit. Yet the good work of the toad is not confined to insects of this class. There are a large number of caterpillars which feed ordinarily on trees, yet seek the ground when ready to transform, and these fall easy victims to the toad. The common tent caterpillar of the wild cherry and apple well illustrates this point. These caterpillars when full grown often travel considerable distances in search of suitable places for cocoon making.

In May these insects formed 18 per cent of the food, and for the season 9 per cent. This insect is a pest of the first rank on apple trees and occasionally works on cherry, plum, and peach. It is much preyed upon by the cuckoo and oriole, while the toad secures a fair proportion of those that escape the birds. From 15 to 20 were often found in the stomachs, 37 being the largest number noted. The writer once saw a black-billed cuckoo eat 35 of these insects at one meal. That bird is well protected by wise laws. The toad has equally as good a record, but receives no legal protection from wanton cruelty.

Miscellaneous caterpillars.—Among these insects, which formed 3 per cent of the food, were noted such injurious species as the gypsy moth, canker-worm, Vanessa, grape and celery caterpillars, tomato worms, cabbage worms, etc. An abundance of active gypsy-moth caterpillars in certain Massachusetts localities often proves sufficient to tempt the toad from retirement even at midday. Three of the toads' stomachs examined contained, respectively, 7, 15, and 65 gypsy caterpillars. As a means of checking the increase of such a serious pest the value of the toad is small, but the case is of interest as showing that tree-infesting caterpillars are often captured by this animal.

It would seem that such heavily armored insects as the spiny Vanessa caterpillars would escape the toad, yet in spite of their natural protection they are gathered in without apparent discomfort. The damage caused to the elm, willow, and apple by these insects is a matter of common knowledge.

Elsewhere mention has been made of the capture by the toad of the winged brown-tail moths as they fall partially stunned from the street lamps. The lamps have a strong attraction for the moths, and the toad makes sure that few if any escape. This imported European pest has now become well established in several New England States, particularly in residential districts. It is here that the toad is most valuable as a destroyer of the moths. Four toads taken under electric lamps contained 10, 11, 15, and 17 moths, respectively. The caterpillars of this insect are but little more fortunate than the moths. Six toads taken in infested orchards contained, respectively, 3, 3, 5, 7, 8, and 12 caterpillars. When we consider that the hair with which these insects are clothed produces a most intense irritation whenever it comes in contact with the human flesh, it would seem that the toad is practically immune from injuries of this class, and that few if any caterpillars are well enough protected to escape its rapacious appetite once they come within its reach.

ECONOMIC STATUS OF INSECTS DESTROYED BY THE TOAD.

In the following table an attempt is made to strike a balance between the good accomplished by the toad through its ravages on injurious species and the harm it does by destroying beneficial species:

Insect food of the toad classified as regards economic status.

	Beneficial.	Neutral.	Inju[illegible]
	Per cent.	*Per cent.*	*Per [illegible]*
Cutworms, caterpillars, etc			[illegible]
Ants		19	
Injurious beetles			[illegible]
Sow bugs, myriapods, snails, etc			[illegible]
Ground beetles	8		
Grasshoppers, etc			
Spiders	2		
Carrion beetles	1		
Worms		1	
Vegetable matter		1	
Mineral matter		1	
Total[a]	11	22	[illegible]

[a] The 5 per cent unidentified has been excluded from this classification.

To summarize: Against the toad must be reckoned the destruction of many beneficial ground beetles, a few spiders, an occasional carrion beetle, ladybird, and ichneumon fly, forming as a whole 11 per cent of [illegible]'s food.

To the credit of the toad we must place the destruction of a remarkably large number of particularly injurious insects, such as cutworms, army worms, caterpillars, gypsy moths, brown-tail moths, May beetles, rose-chafers, wireworms, cucumber and potato beetles; also snails, thousand-legged worms, and sow bugs. The quantity of injurious species destroyed forms 62 per cent of its total food. Should ants be included as injurious, as many housekeepers would think proper, this figure would be increased to 81 per cent. These figures, derived from careful examinations, show the toad to be a highly beneficial animal and well entitled to man's protection in every possible way.

THE TOAD'S CAPACITY FOR GOOD.

The amount of food consumed by the toad is remarkable. Elsewhere records have been given of finding 77 thousand-legged worms in one stomach, 37 tent caterpillars in another, 65 gypsy moth caterpillars in a third, and 55 army worms in a fourth. Under the writer's direction, 24 medium-sized gypsy moth caterpillars were fed to a toad under observation before its appetite was appeased, while Mr. F. H. Mosher fed over 30 full-grown celery caterpillars to another in less than three hours. Doctor Hodge has seen a toad "snap up 86 house flies in less than ten minutes," while he has also published an interesting observation by Ellen M. Foskett, Worcester, Mass., who fed 90 rose bugs to a toad without satisfying its appetite.

The number of insects a toad consumes in a season is conjectural. The writer is satisfied that the amount of food taken in twenty-four hours amounts to about four times the stomach capacity. In cold weather this figure would be lower, while in midsummer, when insect life is at its height, the quantity would probably be larger. A typical stomach examination as taken from the writer's notes is given below.

Specimen 43, taken 9 p. m. May 11, 1896:

	Per cent by bulk.
6 cutworms	50
5 thousand-legged worms	20
6 sow bugs	20
9 ants	6
1 weevil	2
1 ground beetle	2

On the basis of the above data the amount of food consumed in certain periods would stand as follows:

Numbers of insects which one toad may destroy.

Period.	Cutworms.	Myriapods.	Sow bugs.	Ants.	Weevils.	Ground beetles.
24 hours	24	20	24	36	4	4
30 days	720	600	720	1,080	120	120
90 days	2,160	1,800	2,160	3,240	360	360

In ninety days (a period selected because May, June, and July represent the time of the toad's greatest activity) it would destroy 360 beneficial insects (ground beetles) and 9,720 injurious or noxious insects. Take the single item of cutworms. These insects are preyed upon by ground beetles. Let us assume that the ground beetles, if spared, would have succeeded in capturing 10 per cent of the cutworms. This would leave a net balance of 1,944 cutworms to the toad's credit. Many gardeners give their children one cent apiece for each cutworm found and destroyed, considering this a low estimate of the damage caused by the insects. Even at this nominal figure, without considering the importance of the destruction of other injurious insects, the toad's services on this one item would figure $19.44.

NATURAL ENEMIES OF THE TOAD.

The toad suffers from enemies both natural and unnatural. Of those provided by Nature a few internal parasites are sometimes found, while hawks, owls, crows, snakes, and skunks yearly destroy large numbers. The marsh hawk kills a great many toads during the spawning season, while hens, ducks, geese, and guinea fowls feed on the young toads as they migrate from the breeding pools.

It is perhaps the irony of fate that large numbers of the toad should be killed annually by man, the one most benefited by its life. Lawn mowers work great slaughter among them, while the practice of burning over lawns and fields kills more. The killing of toads in this way is largely unnecessary and the extra labor involved in protecting their lives will be more than repaid by their services.

The heaviest charge of wrongdoing must be entered against the small boy, ubiquitous, inquisitive, and often thoughtlessly cruel. In a case coming under the writer's notice two boys in one afternoon established the disreputable record of 17 dead and mutilated toads captured at a breeding pool. Such a wanton and expensive exhibition of cruelty may be unique, but it is certain that thousands of toads are killed in this way annually, and this practice will continue until our boys are taught to recognize the value of the toad and to respect its rights. Laws protect our insectivorous birds as well as others whose worth to man is, to say the least, a debatable question. The toad's worth is an established fact. Should it not receive a similar protection?

HOW THE TOAD MAY BE MADE USEFUL.

Elsewhere reference has been made to the strong homing instinct of the toad. This makes it difficult to establish toad colonies unless the animals are brought from a considerable distance. It is said that English gardeners often pay as high as $25 per hundred for toads for colonizing purposes. That such a procedure is sometimes successful is shown by the experience of the well-known authoress, Celia Thaxter, who at one time found her beautiful gardens at the Isles of Shoals overrun by insects and snails. A considerable number of toads were imported from the mainland, with the result that in a short time the pests were suppressed and the flowers preserved from harm.

A better plan is to provide a breeding place for toads and carry them to it at the mating time, so that later in the season the young toads leaving the water may establish themselves in the locality. A shallow pool having a small but constant water supply is all that is needed. Stagnant rather than running water is desirable, since the growths in which the tadpoles feed do not develop so well where there is a current. Further, the stagnant pools usually have a higher temperature, thus favoring the growth of the tadpoles. Against this plan may be urged the breeding of mosquitoes in such pools, and under some circumstances this objection may prove an important one. It is entirely possible, however, that the tadpoles would keep down the mosquito larvæ, and in any case the young toads will leave the water by midsummer or before the mosquitoes become abundant, when the pools may be drained.

It is always well to provide artificial shelters for toads in gardens. These are easily made by digging shallow holes and partially covering them with a board or flat stone. Toads will use these shelters for weeks, sallying forth by night and returning at daybreak. Greenhouse owners will find toads particularly useful as destroyers of snails, sow bugs, weevils, and other injurious forms of animal life. The well-known entomologist, Dr. Ritzema Bos, writes: "In the research garden of the Rouen entomological laboratory the snails were entirely exterminated in 1891 as a result of introducing 100 toads and 90 frogs." At Malden, Mass., a collection of valuable orchids were severely injured through the attacks of myriapods and sow bugs. On the writer's advice a number of toads were introduced and all damage from this cause soon ceased. Many other cases where the toad may be made useful will suggest themselves. The common greenhouse rose weevil (Fuller's beetle) can doubtless be controlled in greenhouses by aid of toads, particularly if the beetles be jarred from the bushes at occasional intervals.

THE STUDY OF THE TOAD.

"Go to the ant, thou sluggard," was Solomon's dictum. One may find profit and pleasure in studying any of the common forms of animal life, but few offer a more attractive field than the subject of this paper. Abundant everywhere, harmless, easy to obtain and rear, the toad is one of the best objects for class-room work in nature study. A small aquarium and a pair of toads or a mass of toad's eggs are all that are required. Let the aquarium be of glass, earthenware, or wood, shallow, and supplied with plenty of water plants, a few fresh-water clams or mussels to keep the water in circulation, and a small quantity of dog biscuit or chopped fresh meat if needed when the tadpoles are half grown. Care must be taken not to supply more meat than they will devour, since otherwise the water may become fouled. Such an aquarium makes an object of unfailing interest in the schoolroom or home, and by summer will yield hundreds of small toads for colonizing gardens and farms. The value of such a study to the children can not be overestimated.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 198.

STRAWBERRIES.

BY

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., May 6, 1904.

SIR: I have the honor to transmit herewith a paper on strawberries prepared by Prof. L. C. Corbett, Horticulturist of this Bureau, and recommend that it be published as a Farmers' Bulletin.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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STRAWBERRIES.

INTRODUCTION.

The story of the origin and evolution of the garden strawberry forms a chapter in the history of economic plants which is of more than ordinary interest to American horticulturists. Although this fruit has been in cultivation nearly two hundred and fifty years, its origin and history were obscure until within the last decade. Botanists passed the garden strawberry and left it without a name. Horticulturists contented themselves with giving the plant its generic name, Fragaria. During the early nineties Bailey interested himself in the history and development of many of the garden plants, among which he included the strawberry, and as a result of his studies the cultivated strawberry has been assigned to a well-recognized botanical species, *Fragaria chiloensis*.

FIG. 1.—Type of *Fragaria virginiana*.

This plant reached Europe about the year 1712, but attracted little attention and made little progress until about 1750 or 1760, when another berry, having a pleasant, pineapple-like aroma, found its way into Europe under the name of Pine or Pine Strawberry. This strain produced cultural varieties rapidly and soon gained a wide distribution, gradually replacing sorts previously in cultivation which had come from the scarlet class of North America, the parents of which were *Fragaria virginiana* and the ever-bearing type, *Fragaria vesca*, which is native to Europe.

During early Colonial days the wild strawberries of the field, *F. virginiana* (fig. 1) and *F. americana* (fig. 2), were abundant and furnished a much prized article of diet. The plants were transplanted to the garden and gave fruits of increased size, but only a few commercial varieties resulted. Hovey, who may be considered the father of the American strawberry industry, used these native plants along with imported plants of the Pine type as the foundation of a number of crosses, which resulted in the production of two varieties, the Hovey and the Boston Pine. Owing to the loss of records the true parentage of these could never be determined. It was Mr. Hovey's opinion that the Hovey sprang from a cross of Mulberry and Keen's Seedling, both of the Pine type. The Hovey did for the strawberry what the Cape Grape did for viticulture. It formed the main nucleus for the development of commercial sorts, although the scarlet type was long held in high esteem.

FIG. 2.—Type of *Fragaria americana.*

The garden strawberries of this country have come chiefly from the so-called Pine type of berries, which has been proved beyond question to have sprung from *Fragaria chiloensis* (fig. 3), a plant originally brought to Europe from Chile, but which is now known to be native to the western mountain regions of both North and South America. The first native strawberries to be brought under cultivation, however, were those of eastern North America, which belong to the scarlet class, the species being known to botanists as *Fragaria virginiana.* This class, as has been stated, has contributed only sparingly to our present variety list. The wild berry of Europe, which has always been held in more or less esteem because of its ever-bearing tendencies, has likewise contributed only meagerly to the garden sorts of its native countries and none whatever to the American list. The burden of the industry rests upon the Chilean plant.

FIG. 3.—Type of *Fragaria chiloensis.*

The garden strawberry is an American product. It adapts itself to wider range of latitude and to greater extremes in environment than any other cultivated fruit. It is universally liked and is cosmopolitan in its adaptations.

PROPAGATION.

THE DEVELOPMENT OF NEW SORTS.

The factor of uncertainty and chance which goes with the propagation of plants for the purpose of securing new varieties makes this one of the most fascinating branches of horticultural work. During recent years this line of endeavor has become of such great moment that some men have given their whole time and attention to it. The increased importance attached to this work is not so much the result of a demand for new sorts, as for sorts carrying certain advantageous attributes. The knowledge that certain colors, flavors, and types of fruit are in greater demand than others has created a sentiment in favor of breeding varieties possessing such peculiarities. A more important consideration even than this is the fact that certain strains and varieties of plants are found to resist diseases better than others, to be better fitted to withstand adverse climatic and soil conditions, and to be richer in certain elements—such as sugar, acid, or oil—which may

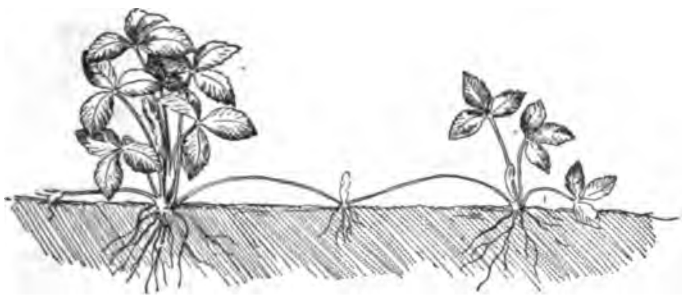


FIG. 4.—Reproduction by means of stolons or runners.

give an advantage over other sorts. The work of determining qualities which are of special advantage and of securing varieties which possess these characteristics in a marked degree has come to be the task of the variety maker.

In the strawberry a very attractive subject for such efforts is presented. It is a plant which is readily propagated by seeds, which is, of course, the only means of securing new forms. The seeds may be selected from plants showing the desired tendencies, or they may be produced by crossing two plants possessing characteristics which it would be desirable to combine in one plant. In any event the seed is the medium through which variation in any direction is expected. But fortunately for the breeder the strawberry is provided with a means of self-preservation through the agency of runners (stolons), as shown in figure 4, which enables the propagator to perpetuate any plant he may develop without fear of loss or change of characters. This feature of the plant, which provides for direct vegetative reproduction, renders it unnecessary to attempt to fix the type in any strain or creation, as is the case with plants propagated exclusively by seeds. New varieties then are secured through seed propagation, while the desirable horticultural sorts thus secured are propagated by runners.

COMMERCIAL PERPETUATION OF DESIRABLE KINDS.

The commercial propagation of the strawberry naturally proceeds along two lines: (1) The production of standard and novel sorts in large numbers to be sold to local or distant purchasers; and (2) the production of a few standard kinds for the perpetuation of an industry in which fruit production is the chief end. In the first instance fruit production is only a side issue. The main crop is the plants. The

FIG. 5.—A bunch of plants ready for shipment.

aim is to get these as large and strong as possible, and to this end the ground is made rich and put in good tilth by frequent cultivation early in the season. Figure 5 shows a bunch of well-grown plants ready for shipment.

The home production of runners for one's own planting is quite another matter; the fruit crop is the chief object and the production of runners prior to harvesting the fruit is discouraged. The difficulty with this method is to secure strong, well-developed plants for August and September planting. When the main planting is done in the spring the earliness of the plants is of less importance. In favorable seasons, however, strong plants for August and September planting an be secured even in the New England States. The question of the esirability of purchasing or of growing one's own plants must be ecided by the planter. There is this to be said in favor of home-rown plants as compared with plants shipped from a distance, that ven in favorable seasons a better stand of plants is always secured rom the use of home-grown stock when lifted and immediately reset, rhile in trying seasons the difference is very considerable, even mounting to as much as success or failure in the stand. Then, too, ome-grown plants can be lifted with a ball of earth by means of a ransplanting device and reset without a shock during extremely dverse weather conditions. Small home-grown plants are in most ases more to be relied upon than large plants shipped from a distance. n regions along the South Atlantic coast where the fruit matures arly the immediate removal of the mulch and preparation of the soil or the roots of the new plants will afford time to secure plants for fall etting, and by special attention to the matter it is possible to have he new plants ready for use in June.

FIELD CULTURE.

Field practices in the cultivation of strawberries vary in different ections of the country to conform to climatic and soil conditions. The factor most influenced by conditions of soil and climate is the time of setting. In some sections the rainfall will permit of either spring or autumn planting, while in other equally good strawberry-producing regions, plants can only be successfully set during the fall. The demands of the market also influence the date of field planting.

SELECTION OF SOIL.

The soil considered best suited to the cultivation of the strawberry in the northeastern part of the United States is what is known as a sandy or gravelly loam. A warm, quick soil, although naturally poor, is to be preferred to a heavy, retentive soil well supplied with plant food. The lacking plant food can easily be supplied by the addition of fertilizers, while the physical characteristics of the soil can only be modified with great difficulty by cultivation, drainage, and the addition of organic matter. Congenial soil and exposure are, therefore, important considerations. The plants not only thrive better on light soils, but the crop is more abundant and the berries are larger and sweeter. The period of maturity can also be modified within reasonable limits by selecting soils which force or retard ripening, by securing southern or eastern exposures which give the plants the advantage of the first warm days of spring, or by placing them on northern and western slopes where, by the use of heavy mulches, the time of ripening may be delayed as much as ten days; and by the use of late-ripening sorts this time can be extended even longer. This is of more importance at the North than are extra early maturing sorts, because it puts the crop more completely out of competition with the southern product.

PREPARATION OF THE SOIL.

The land to be devoted to the growing of strawberries should, if possible, be planted in a cultivated crop, such as potatoes, beans, or corn, at least one year previous to setting the plants, in order that the larvæ of such insects as wireworms, white grubs, cutworms, etc., may be as completely eliminated as possible. Sod land is a favorite breeding ground for such insects, and should therefore be avoided unless it be new clover sod, which can be turned under with good results.

Fig. 6.—A well-rooted plant with small crown.

Previous to setting the plants the soil should be deeply plowed in order that all organic matter of whatever nature on the surface may be completely turned under. Immediately following the plow the land should be thoroughly pulverized by the use of the harrow, and the surface should be reduced to a condition which would form an ideal seed bed.

FERTILIZERS.

If the soil is not rich, for best results it should have a dressing of at least 20 cartloads of well-decomposed stable manure per acre, either plowed under or incorporated with the soil by surface culture after plowing. If stable manure is not available, plant food should be supplied by a liberal use of fine ground bone and chemical manures rich in nitrogen and potash. The use upon the plants at blooming time of highly nitrogenous manures, such as nitrate of soda, at the rate of about 100 pounds per acre often proves of great value. If it can be applied in solution it will give quicker results than if put on in the form of a salt. If the fertility of the soil is little more than sufficient to support the plant, when the heavy strain of fruit production comes on, the plant will only perfect the number of fruits its food supply will allow; hence the advantage of applying quickly available plant foods just at this critical time.

SELECTING AND PREPARING THE PLANTS.

Plants with small crowns, i. e., a moderate growth of leaves, and with abundant development of fibrous roots (fig. 6), are the most desira-ɜ. If the leaf area seems to be too great for the root system of the ınt, the removal of two or three of the older leaves will prove an vantage, as this will reduce the surface of evaporation (transpira-ɪn) and will lessen the demand upon the roots, which, because of ving been disturbed, are not in a position to perform their normal nctions in full measure. During a drought this is more important an during periods of frequent showers. If the crown and the roots the plant are in good condition, the success of the plantation is sured provided the ground has been well prepared and the work of anting is done with care.

PERFECT AND IMPERFECT FLOWERED PLANTS.

Horticultural varieties of strawberries occur with imperfect (or pis-late) flowers as well as with perfect flowers (those containing both amens and pistils). It is important that the planter give careful tention to this point in aking his plantation, as a ıtch made up of pistillate ɪrts alone will be unpro-ıctive, while many such ɪrts when properly inter-ɔersed with perfect-flow-red varieties have proved ɔ be our largest fruited ɪrts and most prolific bear-

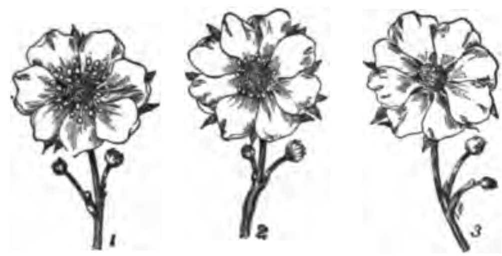


FIG. 7.—Flowers: 1 and 2 perfect; 3, pistillate flower.

rs. There is no way of distinguishing the perfect from the imperfect lants when not in bloom. The purchaser must rely for such infor-ıation upon the description of the variety and the honesty of the rower; but as soon as the blossoms appear the absence of the promi-ent border of yellow pollen-bearing stamens about the pistil is vidence of the imperfect or pistillate form. While many sorts elonging to this class bear profusely and are large-fruited, the fruits rill be abortive unless perfect-flowered sorts are interspersed among hem in the plantation. A common practice is to set every fourth r fifth row with a perfect-flowered sort which blooms at the same eriod as the pistillate variety of which the plantation is chiefly com-osed. Figure 7, showing perfect and imperfect flowers, will serve o aid the observer in distinguishing these forms.

POLLINATION.

The transfer of the pollen from the anther to the pistil is called pol-ination. This is an exceedingly important operation in nature, for ıpon it hinges the success or failure of the crop. It is even important in plantations where pistillate varieties predominate than where perfect-flowered sorts are chiefly used. In the first case there must be a transfer of pollen from plant to plant, while in the second it is merely from flower to flower. Though all are provided with both stamens and pistils, as a rule self-fertilization is guarded against by the pollen and pistil of the same flower maturing at different times.

The agencies in nature which assist in pollination are chiefly two, insects and the wind. Good weather and an abundance of bees are desirable during the blooming season to insure a good set of fruit. Heavy rains at blooming time destroy the pollen, injure the stigmas, and interfere with complete fertilization with the result that "nubbins" are more abundant during such seasons than when the weather conditions are more favorable. A frost during the blooming period may be just sufficient to injure the blossoms open on that day without injury to those not yet expanded. The result is a large number of deformed lopsided fruits and nubbins. The blossoms which expand after the frost will produce perfect fruits under suitable weather conditions.

As the distance over which pollen is carried by the wind is not great, practice has demonstrated that every fourth or fifth row of a plantation should contain a perfect-flowered sort.

WHEN TO SET THE PLANTS.

There are several considerations which govern the time and manner of setting strawberry plants. The time to plant depends in humid regions more upon the rainfall than upon any other factor. If there are not timely rains at the planting season to give the plants an opportunity to establish themselves, the stand will be uneven, with the result that more work will be required to keep the land free from weeds and more trouble will be necessary to get the blank spaces occupied by runners from the plants that survive. The plants that withstand the drought are checked and dwarfed. They seldom recover so as to make either satisfactory croppers or plant producers. It is most satisfactory and most economical, therefore, to choose that season which offers most advantages at planting time, other things being equal. It is impossible to specify the season for each locality or even for large areas, as local conditions of soil and climate necessitate different practices in localities only a short distance apart. In general there are only two seasons for planting—spring and fall—but in some localities spring planting should be done in April or May by the use of the preceding season's plants, while in others it may be done in June from the crop of runners of the same season.

In irrigated regions planting can be done at whatever season the work will give best results in future crop production. In humid regions rainfall is a determining factor. In the northern half of the rairie region west of the Mississippi spring planting gives best esults. In the Middle Atlantic States the work is divided between pring and August planting, with the balance in favor of the latter in ome localities. In New England the work is chiefly confined to the pring months, although there are enthusiastic advocates of fall plant-ng, especially among those who combine strawberry growing with he trucking business on expensive lands near the large cities. In the Atlantic Coast States south of New York, August and September lanting is most extensively practiced, particularly upon the more etentive soils. In the trucking region on the islands about Charles-on, S. C., spring planting is extensively practiced, as it results in a aying crop the following year, while only a small crop can be har-ested from fall-set plants. On these quick soils the plant can be grown as an annual, and farther south, in Georgia and Florida, the all-set plants will return a profitable crop the following spring. On he heavier soils of South Carolina, however, fall planting, with the aying crop one year from the following spring, is the most profitable nethod. The particular time during the summer or fall when the planting should be done will be governed by the occurrence of the seasonal rains—if in July and August, plant then; if in September and October, plant at that time. If the earlier date can be taken advantage of, so much the better; the plants will have a longer period in which to grow, and they will be stronger and the crop heavier in consequence.

HOW TO SET THE PLANTS.

Success in transplanting strawberry plants depends, first, on the quality of the plant, and, second, upon the time and manner of doing the work. If the plants are good, the stand, other conditions being favorable, depends upon care in setting them. The success of this operation is measured by the degree of compactness of the soil about the roots of the plant. If the plant has many roots and these are thrust into a hole made by an ordinary dibble, it is more difficult to get the earth in contact with the roots than when the plant has fewer roots. The plant with the greatest number of feeding roots is, however, the most desirable if properly handled. Such plants should be set in a broad, flat hole where the roots can be spread out in natural form. By giving the crown of the plant a whirl between the thumb and finger to throw the roots out like the ribs of an umbrella and quickly putting it in place while the roots are still thrown out from the crown, the normal position of the root system can be closely approached.

Another very satisfactory method is to open a hole by thrusting the blade of a bright spade into the soil, move the handle forward, thus opening a broad, wedge-shaped hole, spread the roots of the plant in fan shape, and place them in the hole; then withdraw the spade and insert it about 6 inches farther forward, and by a backward movement of the handle firmly press the earth against the roots of the plant. Two persons—a man to operate the spade and a boy to place the plants—can set plants very rapidly in this manner. This practice is particularly well suited to localities with sparse rainfall, as it thoroughly compacts the earth about the roots of the plant and allows the roots to extend full length into the moist soil. Plants set in this way have their roots more deeply inserted in the soil than when the roots are spread out in umbrella fashion and as deeply as when set with a dibble. They also have the additional advantage of being

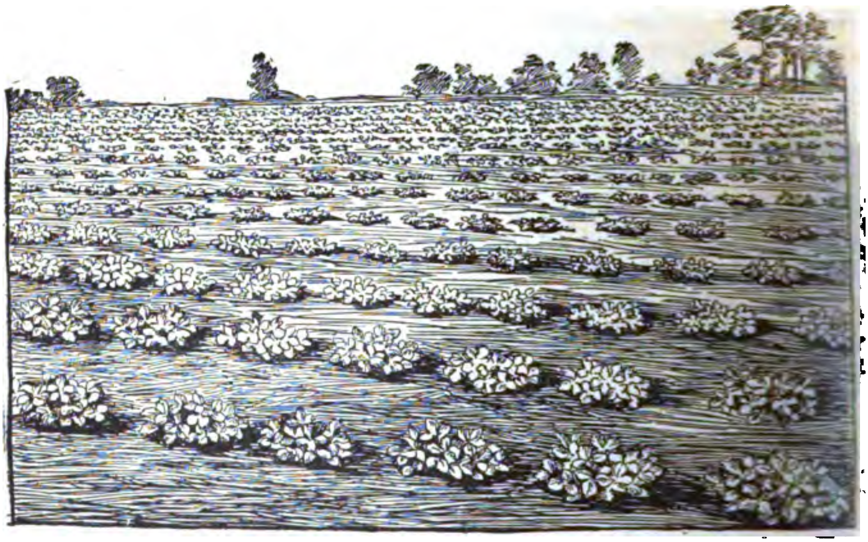


FIG. 8.—Hill system of cultivation.

spread out so as to have a larger percentage of their surface actually in contact with the soil than when set with a round dibble.

DEPTH TO SET THE PLANTS.

No plant which the gardener has to handle is more exacting in regard to depth of planting than the strawberry. As the plant is practically stemless, the base of the leaves and the roots being so close together, care is required to avoid setting the plant so deep that the terminal bud will be covered or so shallow that the upper portion of the roots will be exposed, either being a disadvantage which frequently results in the death of the plant.

SYSTEM OF PLANTING.

[There are two general systems of planting strawberries: One con-
[te]mplates the maintenance of the plants in hills with the possibility of
[cul]tivating them in both directions; the other allows more freedom
[and] the plants spread and form a broad belt or row called a "matted
[ro]w."

Planting in hills.—The system of cultivation predetermines the system of planting. For the hill system of culture (fig. 8) plants are set singly either 3 by 3 feet apart, or with the rows 4 feet apart and the plants 2 feet apart in the row, depending upon the character of the soil and the length of time the plantation is to be maintained. In Florida a common practice is to lay the land off in broad beds 8 to 12

FIG. 9.—Matted row cultivation.

feet wide, the rows of plants to run lengthwise of the beds, the rows 24 inches apart, with the plants 18 inches apart in the rows. Such beds afford sufficient drainage and hold the mulch better than narrow beds or raised rows, and the space between the plants admits light to all sides of the plant—an advantage in coloring the fruits which can not be secured by the matted row system early in the season in the climate of Florida. The hill system raises the plant somewhat and admits of more intensive cultivation than does the matted row, an important consideration in combating crab-grass. On very light dry soils it is considered best to practice flat or level culture rather than bedding.

Planting in matted rows.—In order to maintain a belt of plants 12 to 18 inches wide, as shown in figure 9, and still have space between the belts for cultivation and the other operations necessary to the successful management of a plantation, the rows at planting time should be much farther apart than is necessary with the hill system. A common practice is to set the plants in single rows 4 feet apart, with the plants 12 inches apart in the row. The runners which develop from the plants are then allowed to take possession of the area for 6 to 9 inches on either side of the original plants, thus making a matted row 12 to 18 inches wide; this leaves 30 inches between the rows, which allows ample space for cultivation and gathering the fruit. This space can be reduced from 30 inches to as little as 18 inches where land is valuable and it is necessary to secure maximum returns; on thin soil, however, the greater distance is most satisfactory. There is one advantage in the narrow cultivated space. After the second crop has been harvested the runners can be allowed to take possession of the cultivated middles and when the young plants become thoroughly established the original rows can be broken up with a narrow turning plow or a sharp cultivator. In this way a patch can be very satisfactorily and cheaply renewed, and by a liberal use of suitable fertilizers the rotation can be kept up on the same soil for several years. Some planters prefer to set the plants for the matted row in a double row at planting time. The practice is to establish two rows 12 inches apart, 6 inches on each side of the center of the matted belt, setting the plants 2 feet apart in each row and alternating the plants in the row, so that the plants actually stand a little over a foot apart, as shown in the accompanying diagram:

  *   *   *   *   *   *   *

*   *   *   *   *   *   *   *

CULTIVATION.

Clean and shallow culture are the watchwords of successful cultivators. Growers have come to realize that cultivation means more than the destruction of weeds. Ridding the soil of weeds, thus removing the competition between these interlopers and the plants it is desired to foster, is an important part of the work, but not all. Cultivation has a beneficial influence upon the soil by loosening it and making it more easily penetrated by moisture in the form of rain or dew. By keeping a blanket of loose soil 3 inches thick over the area not actually occupied by plants, the evaporation of soil moisture is reduced; more moisture is, therefore, retained for the use of the plants in the rows. By conserving moisture, cultivation tends to counterbalance the evil effect of drought. A better stand of plants can be maintained during a dry period on well-tilled ground than upon ground that is poorly cultivated. The mechanical effect of grinding the soil upon itself during cultivation reduces it to smaller particles, thus exposing more surface to the action of soil moisture, and, as a result creasing the available plant food of the soil. The old saying that tillage is manure," if interpreted in terms of crop yield, is true, ιough, since tillage adds no plant food to the soil, the statement is ɔt literally true. The benefit from preserving a soil mulch, with its ɒnsequent economy in the use of soil moisture, is sufficiently important ι justify thorough tillage.

MULCHING.

Covering the surface of the soil with dead or decaying vegetable ıatter is the meaning of the term mulching as here used.

Objects of mulching.—Mulching in strawberry culture serves different urposes, depending upon the locality in which the plants are grown. . mulch acts as a protection from cold, prevents freezing and thawing ıd the consequent lifting of the plants ("heaving out"); it retards rowth in cold regions by shading the crowns and maintaining a low ɔil temperature longer than in soil not mulched; it acts as a con- ɜrver of moisture, discourages weed growth by smothering the young ɜedling, and finally protects the fruit from contact with the soil.

Materials for mulch.—The materials which can be used in mulching re various, but their value depends largely upon their freedom from reed seeds and their fitness to protect the plants without smothering hem. Whole or cut straw free from grains, strawy manure from the orse stable, and pine straw from the forest are among the more com- ıon mulching materials. In certain sections marsh hay, either from resh or salt water marshes, is a common and very satisfactory mulching ıaterial.

When to apply the mulch.—At the North where the soil is likely to reeze and thaw several times in the course of the winter, it is the prac- ice to put on the mulch as soon as the ground is sufficiently frozen to .llow driving upon it with a loaded cart or wagon. Where the freez- ng of the soil is only superficial or only temporary, if at all, the mulch erves the purpose of a protection from wind more than from frost, .nd in such sections the mulch is put on as soon as active growth eases, usually early in December, and is allowed to remain until after he crop is harvested.

Some growers remove the mulch early and give the plants thorough ultivation before the fruits are half grown; then if it seems desirable o protect the fruits from the earth the mulch is replaced for this ɔurpose.

In other localities where heavy snows are of annual occurrence, and where they remain throughout the winter, thus affording protection rom repeated freezing and thawing, as well as preventing deep freez- ing of the soil, mulching is not generally practiced; if practiced at all a light mulch only can be used, as a heavy covering is likely to cause loss by smothering the plants.

HARVESTING AND SHIPPING.

The time of gathering the fruit, as well as the manner of handling is governed by the use to which it is to be put. If for a local market, much riper fruits can be handled than when they are to be shipped long distances.

The most progressive growers of strawberries for local markets not only give particular attention to the ripeness of the fruit, but to assorting and grading as well, only large perfect berries being placed in the first grade, and all small or soiled fruits in the second.

Shipment to distant markets.—For a distant market the fruits must be gathered as soon as fully grown and colored. When the fruits are removed from the plants they should go either into cooled shipping cases or into a cool storeroom where the temperature can be maintained at about 50° F. If this is impracticable, they should be placed in the shade in as cool a situation as possible. Fruits to be shipped in refrigerator boxes (fig. 11), such as are used by the southern growers (Florida growers in particular), can be placed in the chilled carriers as soon as they have stood in the shade for a half hour. Such hardening off or chilling has much the same effect on soft fruits of this nature as it has upon flowers; it checks the ripening process and, while it does not entirely stop it, the effect is to deliver the fruits at the end of their journey in much better condition than when not so chilled. In this, as in all work of like nature, careful judgment is necessary. Too much cold is as bad as too little; in any case the chilling and icing should be considered merely as a means to an end. Experience has demonstrated that it is not advisable to attempt to hold soft fruits for any length of time in cold storage. The icing or shipping in refrigerator carriers allows the grower to bring his fruits to a higher state of perfection on the vines than when he is obliged to ship long distances without such appliances. For that reason alone this method of handling should be encouraged, as it gives the consumer a higher grade product. The great expense connected with this system of shipment means high prices to the consumer. Under present conditions it costs from 10 to 13 cents per quart to ship strawberries in refrigerator carriers from central Florida to the New York market. Add to this the commission for selling, and the fruit must sell for at least 25 cents per quart, in order that the grower may get a fair price

FIG. 10.—Fruiting plants in matted row.

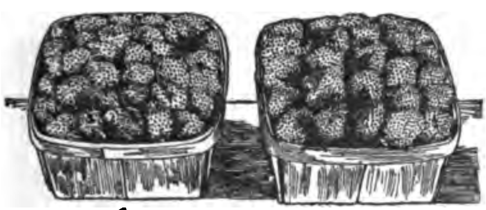
or his product. With the existing express rates, 6 to 8 cents f. o. b. ars at shipping point is a better remuneration for the grower than 15 cents wholesale in New York City.

Receptacles.—Whether it is to be shipped in crates or refrigerator arriers or to be carried to the local market, for best results the fruit hould not be rehandled after it is picked. The pickers should be rained to do the necessary assorting and grading as they pick the

Fig. 11.—Refrigerator shipping case.

ruit in the receptacles in which it is to be marketed. In some localiies, where the fruits become greatly soiled from mud splashing over hem during heavy rains, growers find it advisable to assort and pack he fruits in the manner shown in figure 12, and also to rinse them in water before assorting and packing them. This is the system used by nany of the most extensive and successful Florida growers.

The light splint-wood basket, holding 1 quart (fig. 12), is the most popular and most universally used. Many different forms of box or



1 2

Fig. 12.—Ungraded and selected fruit in splint-wood baskets: 1, Not graded or arranged; 2, selected and arranged.

basket have been designed, and various materials other than wood have been used in their construction, but up to the present none has met with general adoption.

As above stated, the refrigerator carrier is almost universally used for long-distance shipment. For shorter hauls, not more than a night's ride, the ordinary slat crate (fig. 13), holding 24 to 36 quart boxes, is very popular; it is also the package in general use for local marketing.

Picking.—In the commercial production of strawberries considerable numbers of persons have to be employed in picking the fruit and as this work is usually paid for by the quart it becomes necessary to have some system of keeping account of the work done by each individual. Different growers employ different schemes. Some issue a check or card for each quart of berries harvested, and when a certain number have been obtained by the picker these are exchanged for one of larger denomination. This has the advantage of reducing the number of quart checks necessary. The one objection to this plan is the liability to loss on the part of the pickers. Other growers use a tag similar to a shipping tag, which is fastened to the clothing of the picker, and as the fruit is delivered to the inspector credit for as many quarts as have been picked is punched out of the tag. Others use only a system of bookkeeping, the picker delivering his fruit to the inspector and depending upon the accuracy of the tallyman for the count. The system of recording the work of each picker will largely depend upon the character of the help employed and the extent of the work to be done. The plan that suits the circumstances of one may not be that which will meet the requirements of another. Each grower must study this problem for himself, and decide upon the plan best adapted to his conditions.

FIG. 13.—A slat shipping crate.

A convenience which is almost a necessity is a picking stand carrying from 4 to 6 boxes. A good type is shown in figure 14. The short legs hold the tray off the ground and prevent injury to the fruit, while the number of baskets (4 or 6) allows the picker to grade the berries as gathered.

Fig. 14.—A picking stand.

FORCING FOR WINTER FRUIT.

3ecause of the supply of southern-grown berries which reach the rkets from February on, the forcing of strawberries has little to ·ourage it, except for special purposes, such as to supply the tables those who can disregard the cost of the product and those who wish use the plants for decorative purposes. There are, however, some ›ple who will wish to grow a few pots of strawberries out of season, l for their information a brief description of the methods used is ·e given.

?lants to use.—The plants for forcing purposes should be the earliest mers from well-established plants. These runners should be rooted 2 or 3 inch pots, plunged in the soil at a convenient distance from : parent plant to allow the runner to be placed over the pot and ld in position by a small weight (stone) placed upon the extension the runner to hold it and to discourage its growth beyond the pot. soon as the young plant has filled the small pot with roots, it ›uld be cut loose from its parent and immediately shifted to a 6-inch t filled with soil composed of three parts of well rotted turf and one rt of sharp sand. To this should be added about one quart of finely ound bone or dissolved rock for each two bushels of the compost. soon as the plants have been placed in the 6-inch pots, these should plunged in coal ashes or tan bark, either in cold frame or in a sition where they can be sheltered from driving rains. The cold ıme is the most convenient and satisfactory arrangement. The ınts from this time on should be kept in a growing condition. ›out the middle of September or the first of October the pots will found filled with roots and the drying-off process should then gin. This will cause the plants to store up food in the crowns for e work which they will be called upon to do. The plants should kept rather dry, and be allowed to remain in the cold frame until eezing weather begins, or until about eight weeks before the berries e desired.

The forcing period.—Upon taking the plants from the cold frame, l dead or diseased leaves should be removed, the pots generally eaned, and the crowns of the plants sprayed with Bordeaux mixture. ıey should then be placed in a house with a night temperature of out 35° and a few degrees warmer during the day, and the same rangements in regard to plunging the pots as were maintained in the ld frame should be observed in the forcing house. After about six eight days, the temperature of the house should be raised at least degrees at night with a corresponding rise during the day. These gher temperatures should be maintained throughout the whole forcg period.

Pollination.—As soon as the blossoms appear, it will be necessary hand-pollinate them, in order to cause the fruits to set, and to accomplish this it is necessary to have the house dry and compa- tively warm during the middle of the day, which is usually the m convenient and satisfactory time for pollinating. A camel's-h brush can be used to transfer the pollen from stamen to pistil and fr plant to plant.

Fertilizing.—As soon as the fruits begin to swell the plants sho be fed with a dilute liquid manure made preferably from well-rott cow manure or sheep manure. The first application should be qu dilute and should be applied soon after the berries set. This app cation should be followed in about one week's time by a second appl tion of somewhat stronger manure water, a third about three da later, and so on at the same interval until the berries begin to co when all stimulant should be withheld and pure water only used f wetting the plants.

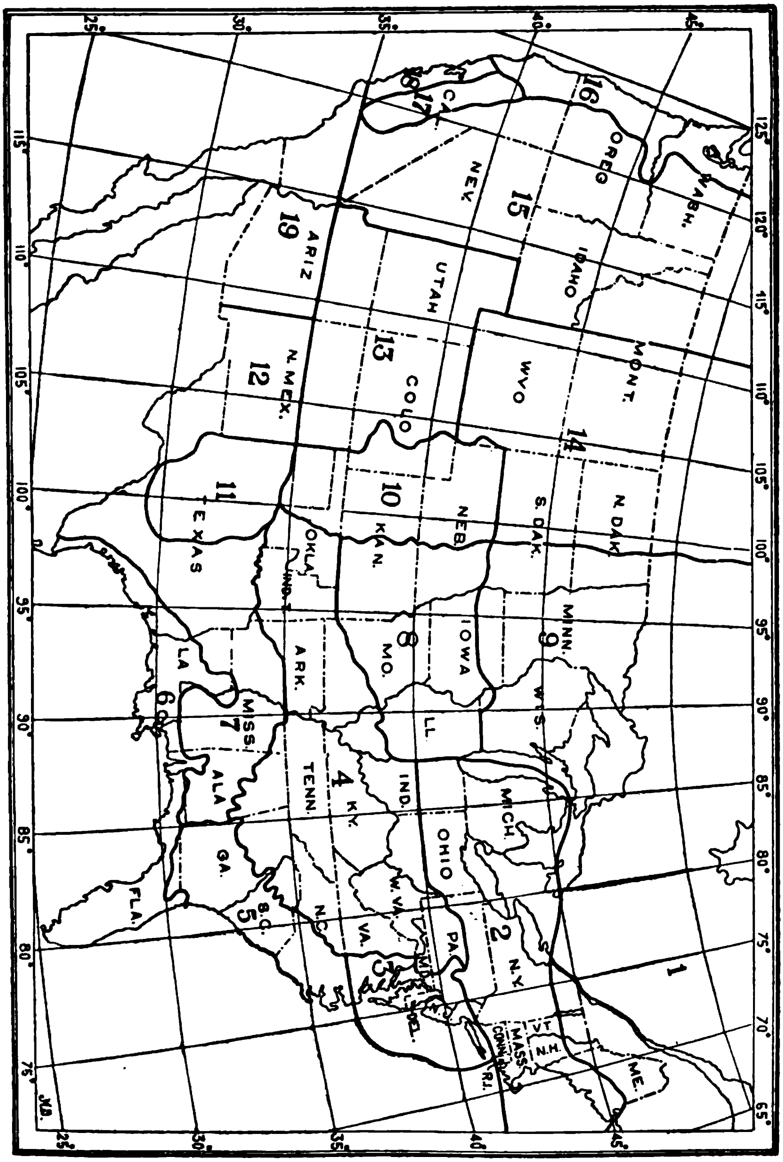
Thinning and protecting the fruits.—After the fruits have set, there are more than six or eight well formed berries upon a sing truss, it will be well to reduce the number to six or eight at mo for the strongest plants. As these increase in size, in order to prev them from becoming distorted and ill shaped, a support must be s plied. Experience has proved that a most convenient arrangem of this kind can be provided by using a small square of fine-me window-screen wire, cut so that it will fit the top of the pot somewh closely and still project sufficiently to support the berries.

Plants grown in this way make very satisfactory objects for deco tive purposes and form a very attractive feature in a forcing hou although the yield of berries is not sufficient to make them of gr great economic value unless the price obtainable is at least $1 pe quart. Varieties with large symmetrically formed fruits and perfe flowers should be selected for this work.

VARIETIES.

The popularity of one sort soon gives place to that of a mo promising new rival. This is perhaps more strikingly true of variet of strawberries than of any other cultivated fruit. Varieties are local adaptation, however, and a new sort must pass an examinatio each locality before its fitness can be determined. In some localiti sorts remain in general use for many years, but in most sections th follow one another in quick succession. Exceptions to this rule a some of the strawberry-growing sections of the Pacific coast. The areas seem to require peculiar qualities in the varieties adapted them and as a result only sorts of local origin find favor there. S varieties of this character have been able to hold the first place amo cultivated sorts of the region for a quarter of a century or more spite of repeated introductions of new varieties from other sectio This serves to emphasize the statement that varieties are local in th

ıptation. Perhaps no fruit is more cosmopolitan than the straw-
·ry, yet this is only made possible by the great variation in sorts
ıpting it to all the varied conditions of soil and climate which it has
encounter.



The question of the adaptability of varieties has been very carefully
ırked out by the American Pomological Society. The map (fig. 15)
ows the various fruit-sections of the United States, which for con-
nience are designated by numbers. Experience has demonstrated

that certain varieties are well adapted to each of these divisions. A few of the sorts which can be planted in each division with reasonable assurance of success are enumerated in the following list under each division, as indicated by its number.

The reader should consult the map to determine the division in which he is located and the following list for suitable varieties to plant in his section:

Division 1: Bederwood, Bubach No. 5, Carrie, Clyde, Crescent, Haverland, Saunders, Warfield, Wilson.

Division 2: Brandywine, Bubach No. 5, Clyde, Crescent, Gandy, Greenville, Haverland, Lovett, Michel Early, Parker Earle, Saunders, Sharpless, Warfield, Wilson.

Division 3: Bederwood, William Belt, Bismarck, Brandywine, Bubach No. 5, Enormous, Gandy, Greenville, Haverland, Manchester, Seaford, Tennessee Prolific, Lady Thompson, Warfield.

Division 4: Bederwood, Bubach No. 5, Crescent, Gandy, Greenville, Haverland, Michel Early, Lady Thompson, Warfield, Wilson.

Division 5: Brandywine, Gandy, Hoffman, Michel Early, Lady Thompson.

Division 6: Hoffman, Michel Early, Miner, Neunan, Lady Thompson.

Division 7: Brandywine, Bubach No. 5, Captain Jack, Cloud, Crescent, Downing, Gandy, Glen Mary, Michel Early, Miner, Neunan, Lady Thompson.

Division 8: Bederwood, Bubach No. 5, Crescent, Cumberland, Downing, Gandy, Haverland, Michel Early, Miner, Parker Earle, Sharpless, Warfield, Wilson.

Division 9: Bederwood, Crescent, Parker Earle, Warfield, Woolverton.

Division 10: Champion, Crescent, Downing, Gandy, Haverland, Monarch, Parker Earle, Warfield, Wilson.

Division 11: Hoffman and Michel Early are the only sorts mentioned as having proved themselves adapted to this region in the list prepared by the American Pomological Society.

Division 12: Arizona Everbearing, Australian Crimson, Dollar, Sharpless, and Lady Thompson where irrigation can be provided.

Division 13: Bederwood, Crescent, Cumberland, Haverland, Jessie, Manchester, Monarch, Sharpless, Woolverton.

Division 14: Crescent, Wilson, Bubach No. 5, Downing, Enhance, Gandy, Haverland, Jessie.

Division 15: Hood River, Jessie, Parker Earle, Sharpless, Saunders, Downing, Clyde-ford.

Division 16: Hood River, Magoon, Sharpless, Wilson.

Division 17: Sharpless.

Division 18: Dollar, Jessie, Monarch, Sharpless. These sorts are only fairly adapted to the region.

Division 19: Arizona Everbearing, Monarch, Australian Crimson, Dollar, Sharpless, Lady Thompson.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 203.

CANNED FRUIT, PRESERVES, AND JELLIES:

HOUSEHOLD METHODS OF PREPARATION.

[CORRECTED MARCH 25, 1905.]

BY

MARIA PARLOA.

PREPARED UNDER THE SUPERVISION OF THE OFFICE OF EXPERIMENT STATIONS,
A. C. TRUE, DIRECTOR.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1905.

203

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., June 27, 1904.

Sir: I have the honor to transmit herewith an article on household methods of canning and preserving fruit, prepared by Miss Maria Parloa, and to recommend it for publication as a Farmers' Bulletin, believing that it is a useful summary of available information. From time to time this Department has published popular bulletins summarizing data on the nutritive value of different foods and related topics. The present bulletin is similar in purpose to those previously issued, and its preparation was suggested by the numerous requests addressed to the Department for information on the questions discussed. Miss Parloa has made an extensive study of the subject and is thoroughly familiar with both the theoretical conditions and the practical details, and the summary which she has prepared embodies the results of much original work. Acknowledgment should be made to Prof. H. W. Conn, of Wesleyan University, for his kindness in furnishing data regarding micro-organisms and their relation to the process of canning and preserving.

In the present bulletin no attempt has been made to discuss methods of canning and preserving tropical fruits.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

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ILLUSTRATIONS.

CANNING AND PRESERVING FRUIT.

INTRODUCTION.

The common fruits, because of their low nutritive value, are not, s a rule, estimated at their real worth as food. Fruit has great ietetic value and should be used generously and wisely, both fresh nd cooked. Fruits supply a variety of flavors, sugar, acids, and a ecessary waste or bulky material for aiding in intestinal movement. 'hey are generally rich in potash and soda salts and other minerals. lost fresh fruits are cooling and refreshing. The vegetable acids ave a solvent power on the nutrients and are an aid to digestion hen not taken in excess.

Fruit and fruit juices keep the blood in a healthy condition when he supply of fresh meat, fish, and vegetables is limited and salt or moked meats constitute the chief elements of diet. Fresh fruit is genrally more appetizing and refreshing than cooked. For this reason it s often eaten in too large quantities, and frequently when underripe r overripe; but when of good quality and eaten in moderate quantiies it promotes healthy intestinal action and rarely hurts anyone.

If eaten immoderately, uncooked fruit is apt to induce intestinal listurbances. If eaten unripe, it often causes stomach and intestinal rritation; overripe, it has a tendency to ferment in the alimentary anal. Cooking changes the character and flavor of fruit, and while he product is not so cooling and refreshing as in the raw state, it can, s a rule, be eaten with less danger of causing stomach or intestinal rouble. If sugar be added to the cooked fruit, the nutritive value vill be increased. A large quantity of sugar spoils the flavor of the ruit and is likely to make it less easily digested.

Nowhere is there greater need of a generous supply of fruit than n the farm, where the diet is apt to be restricted in variety because f the distance from markets. Every farmer should raise a generous upply of the kinds of fruit that can be grown in his locality. Wives nd daughters on the farms should find pleasure in serving these fruits n the most healthful and tempting form. There are a large numer of simple, dainty desserts that can be prepared with fruit and without much labor. Such desserts should leave the pie as an occasional luxury instead of allowing it to be considered a daily necessity.

In the season when each kind of fruit is plentiful and at its best a generous supply should be canned for the season when both fruit and fresh vegetables are scarce. A great deal of the fruit should be canned with little or no sugar, that it may be as nearly as possible in the condition of fresh fruit. This is the best condition for cooking purposes. A supply of glass jars does cost something, but that item of expense should be charged to future years, as with proper care the breaking of a jar need be a rare occurrence. If there be an abundance of grapes and small, juicy fruits, plenty of juice should be canned or bottled for refreshing drinks throughout the year. Remember that the fruit and juice are not luxuries, but an addition to the dietary that will mean better health for the members of the family and greater economy in the cost of the table.

FRESH AND PRESERVED FRUIT FOR THE MARKET.

If the supply of fruit is greater than the family needs, it may be made a source of income by sending the fresh fruit to the market, if there is one near enough, or by preserving, canning, and making jelly for sale. To make such an enterprise a success the fruit and work must be first class. There is magic in the word "Homemade," when the product appeals to the eye and the palate; but many careless and incompetent people have found to their sorrow that this word has not magic enough to float inferior goods on the market. As a rule large canning and preserving establishments are clean and have the best appliances, and they employ chemists and skilled labor. The home product must be very good to compete with the attractive goods that are sent out from such establishments. Yet for first-class homemade products there is a market in all large cities. All first-class grocers have customers who purchase such goods.

To secure a market get the names of several first-class grocers in some of the large towns. Write to them asking if they would be willing to try a sample of your goods. If the answer is favorable, send samples of the articles you wish to sell. In the box with the fruit inclose a list of the articles sent and the price. Write your name and address clearly. Mail a note and a duplicate list at the time you send the box.

Fixing the price of the goods is important. Make it high enough to cover all expenses and give you a fair return for your labor. The expenses will be the fruit, sugar, fuel, jars, glasses, boxes, packing material, wear and tear of utensils, etc., transportation, and commission. The commission will probably be 20 per cent of the selling price. It may be that a merchant will find that your prices are too high or too low for his trade, or he may wish to purchase the goods outright. In ıy case it is essential that you estimate the full cost of the product ıd the value that you place on your labor. You will then be in a ›sition to decide if the prices offered will compensate you for the bor and expense. Do not be tempted, for the sake of a little money, › deprive your family of the fruit necessary to health and pleasure.

PACKING AND SHIPPING.

Each jar or jelly glass must be wrapped in several thicknesses of ›ft paper (newspapers will answer). Make pads of excelsior or hay y spreading a thick layer between the folds of newspapers. Line the ›ttom and sides of the box with these pads. Pack the fruit in the ıdded box. Fill all the spaces between the jars with the packing aterial. If the box is deep and a second layer of fruit is to go in, ut thick pasteboard or thin boards over the first layer and set the rapped jars on this. Fill all the spaces and cover the top with the acking material. Nail on the cover and mark clearly: GLASS. HIS SIDE UP.

The great secret in packing is to fill every particle of space so that othing can move.

PRINCIPLES OF CANNING AND PRESERVING.

In the preservation of foods by canning, preserving, etc., the most ssential things in the processes are the sterilization of the food and ll the utensils and the sealing of the sterilized food to exclude all erms.

BACTERIA, YEASTS, AND FERMENTATION.

Over one hundred years ago François Appert was the first to make ›ractical application of the method of preserving food by putting it n cans or bottles, which he hermetically sealed. He then put the ull bottles or cans in water and boiled them for more or less time, epending upon the kinds of food.

In Appert's time and, indeed, until recent years it was generally hought that the oxygen of the air caused the decomposition of food. ppert's theory was that the things essential to the preservation of ood in this manner were the exclusion of air and the application of entle heat, as in the water bath, which caused a fusion of the prin-ipal constituents and ferments in such a manner that the power of he ferments was destroyed.

The investigations of scientists, particularly of Pasteur, have shown hat it is not the oxygen of the air which causes fermentation and utrefaction, but bacteria and other microscopic organisms.

Appert's theory as to the cause of the spoiling of food was incorrect but his method of preserving it by sealing and cooking was corr-. and the world owes him a debt of gratitude.

In their investigations scientists have found that if food is perfectl sterilized and the opening of the jar or bottle plugged with steril- cotton, food will not ferment, for the bacteria and yeasts to whi such changes are due can not pass through the cotton. This meth can not be conveniently followed with large jars.

Bacteria and yeasts exist in the air, in the soil, and on all vegeta and animal substances, and even in the living body, but although such universal occurrence, the true knowledge of their nature economic importance has only been gained during the last forty ye.

There are a great many kinds of these micro-organisms. Some great harm, but it is thought that the greater part of them are ben- ficial rather than injurious.

Bacteria are one-celled and so small they can only be seen by of a microscope. The process of reproduction is simple and rap. The bacterium becomes constricted, divides, and finally there are cells instead of one. Under favorable conditions each cell divid and so rapid is the work that it has been estimated that one bacter may give rise, within twenty-four hours, to seventeen million similar organisms. The favorable conditions for growth are moistur warmth, and proper food.

Yeasts, which are also one-celled organisms, grow less rapidly. bud develops, breaks off, and forms a new yeast plant. Some yeas and some kinds of bacteria produce spores. Spores, like the dr seeds of plants, may retain their vitality for a long time, even w exposed to conditions which kill the parent organism.

Yeasts and nearly all bacteria require oxygen, but there are spe of the latter that seem to grow equally well without it, so that t exclusion of air, which, of course, contains oxygen, is not always protection, if one of the anaerobic bacteria, as the kinds are call which do not require oxygen, is sealed in the can.

Spoiling of food is caused by the development of bacteria or yeas Certain chemical changes are produced as shown by gases, odors, a flavors.

Bacteria grow luxuriantly in foods containing a good deal of nitr genous material, if warmth and moisture are present. Among fo rich in nitrogenous substances are all kinds of meat, fish, eggs, pe beans, lentils, milk, etc. These foods are difficult to preserve account of the omnipresent bacteria. This is seen in warm, mug weather, when fresh meat, fish, soups, milk, etc., spoil quickly. Ba teria do not develop in substances containing a large percentage sugar, but they grow rapidly in a suitable wet substance which co ins a small percentage of sugar. Yeasts grow very readily in dilute lutions containing sugars in addition to some nitrogenous and minal matters. Fruits are usually slightly acid and in general do not pport bacterial growth, and so it comes about that canned fruits are ore commonly fermented by yeasts than by bacteria.

Some vegetable foods have so much acid and so little nitrogenous bstance that very few bacteria or yeasts attack them. Lemons, anberries, and rhubarb belong to this class.

Temperature is an important factor in the growth of bacteria and easts. There are many kinds of these organisms, and each kind grows st at a certain temperature, some at a very low one and others at ıe as high as 125° F., or more. However, most kinds of bacteria are estroyed if exposed for ten or fifteen minutes to the temperature of oiling water (212° F.); but, if the bacteria are spore producers, cookg must be continued for an hour or more to insure their complete estruction. Generally speaking, in order to kill the spores the temerature must be higher than that of boiling water, or the article to e preserved must be cooked for about two hours at a temperature of 12° F., or a shorter time at a higher temperature under pressure. easts and their spores are, however, more easily destroyed by heat ıan bacteria spores. Hence, fruits containing little nitrogenous aterial are more easily protected from fermentation than nitrogeous foods in which in general fermentation is caused by bacteria. Of ourse, it is not possible to know what kinds of organisms are in the ood one is about to can or bottle; but we do know that most fruits re not favorable to the growth of bacteria, and, as a rule, the yeasts hich grow in fruits and fruit juice can be destroyed by cooking ten r fifteen minutes at a temperature of 212° F. If no living organisms re left, and the sterilization of all appliances has been thorough, there s no reason why the fruit, if properly sealed, should not keep, with ut slight change of texture or flavor, for a year or longer, although anned fruits undergo gradual change and deterioration even under he most favorable conditions.

When fruit is preserved with a large amount of sugar (a pound of ugar to a pound of fruit) it does not need to be hermetically sealed o protect it from bacteria and yeasts, because the thick, sugary sirup ormed is not favorable to their growth. However, the self-sealing ars are much better than keeping such fruit in large receptacles, from which it is taken as needed, because molds grow freely on moist, ugary substances exposed to the air.

MOLDS AND MOLDING.

Every housekeeper is familiar with molds which, under favorable conditions of warmth and moisture, grow upon almost any kind of organic material. This is seen in damp, warm weather, when molds form in a short time on all sorts of starchy foods, such as boiled potatoes, bread, mush, etc., as well as fresh, canned, and preserved fruits.

Molds develop from spores which are always floating about in the air. When a spore falls upon a substance containing moisture and suitable food it sends out a fine thread, which branches and works its way over and into the attacked substance. In a short time spores are produced and the work of reproduction goes on.

In the first stages molds are white or light gray and hardly noticeable; but when spores develop the growth gradually becomes colored. In fact, the conditions of advanced growth might be likened to those of a flower garden. The threads—mycelium—might be likened to the roots of plants and the spores to the flower and seeds.

Mold spores are very light and are blown about by the wind. They are a little heavier than air, and drop on shelves, tables, and floor. and are easily set in motion again by the movement of a brush, duster. etc. If one of these spores drops on a jar of preserves or a tumbler of jelly, it will germinate if there be warmth and moisture enough in the storeroom. Molds do not ordinarily cause fermentation of canned foods, although they are the common cause of the decay of raw fruit. They are not as injurious to canned goods as are bacteria and yeasts. They do not penetrate deeply into preserves or jellies, or into liquids or semiliquids, but if given time they will, at ordinary room temperature, work all through suitable solid substances which contain moisture. Nearly every housekeeper has seen this in the molding of a loaf of bread or cake.

In the work of canning, preserving, and jelly making it is important that the food shall be protected from the growth of molds as well as the growth of yeasts and bacteria.

To kill mold spores food must be exposed to a temperature of from 150° F. to 212° F. After this it should be kept in a cool, dry place and covered carefully that no floating spore can find lodgment on its surface.

STERILIZATION.

To sterilize a substance or thing is to destroy all life and sources of life in and about it. In following the brief outline of the structure and work of bacteria, yeasts, and molds, it has been seen that damage to foods comes through the growth of these organisms on or in the food; also that if such organisms are exposed to a temperature of 212° F., life will be destroyed, but that spores and a few resisting bacteria are not destroyed at a temperature of 212° F., unless exposed to it for two or more hours.

Bacteria and yeasts, which are intimately mixed with food, are and s easily destroyed as are those on smooth surfaces, such as the utenils and jars employed in the preparation of the food.

Since air and water, as well as the foods, contain bacteria and yeasts, nd may contain mold spores, all utensils used in the process of preerving foods are liable to be contaminated with these organisms. 'or this reason all appliances, as well as the food, must be sterilized.

Stewpans, spoons, strainers, etc., may be put on the fire in cold or oiling water and boiled ten or fifteen minutes. Tumblers, bottles, lass jars, and covers should be put in cold water and heated gradually o the boiling point, and then boiled for ten or fifteen minutes. The ars must be taken one at a time from the boiling water at the moment hey are to be filled with the boiling food. The work should be done n a well swept and dusted room, and the clothing of the workers and he towels used should be clean. The food to be sterilized should be erfectly sound and clean.

As in this bulletin we have only to do with fruits, it will not be necssary to say anything more about long cooking at a high temperature.

In canning fruits it is well to remember that the product is more atisfactory if heated gradually to the boiling point and then cooked he given time.

UTENSILS NEEDED FOR CANNING AND PRESERVING.

In preserving, canning, and jelly making iron or tin utensils should ever be used. The fruit acids attack these metals and so give a bad olor and metallic taste to the products. The preserving kettles should e porcelain lined, enameled, or of a metal that will not form troubleome chemical combinations with fruit juices. The kettles should be road rather than deep, as the fruit should not be cooked in deep ayers. Nearly all the necessary utensils may be found in some ware ot subject to chemical action. A list of the most essential articles ollows:

Two preserving kettles, 1 colander, 1 fine strainer, 1 skimmer, 1 adle, 1 large-mouthed funnel, 1 wire frying basket, 1 wire sieve, 4 longandled wooden spoons, 1 wooden masher, a few large pans, knives or paring fruit (plated if possible), flat-bottomed clothes boiler, vooden or willow rack to put in the bottom of the boiler, iron tripod r ring, squares of cheese cloth. In addition, it would be well to ave a flannel straining bag, a frame on which to hang the bag, a irup gauge and a glass cylinder, a fruit pricker, and plenty of clean owels.

The regular kitchen pans will answer for holding and washing the ruit. Mixing bowls and stone crocks can be used for holding the ruit juice and pared fruit. When fruit is to be plunged into boiling water for a few minutes before paring, the ordinary stewpans may be employed for this purpose.

Scales are a desirable article in every kitchen, as weighing is much more accurate than the ordinary measuring. But, knowing that a large percentage of the housekeepers do not possess scales, it has seemed wise to give all the rules in measure rather than weight.

FIG. 1.—Wire basket.

If canning is done by the oven process, a large sheet of asbestos, for the bottom of the oven, will prevent the crackng of jars.

The wooden rack, on which the bottles rest in the washboiler, is made in this manner: Have two strips of wood measuring 1 inch high, 1 inch wide, and 2 inches shorter than the length of the boiler. On these pieces of wood tack thin strips of wood that are 1½ inches shorter than the width of the boiler. These cross-strips should be about 1 inch wide, and there should be an inch between two strips. This rack will support the jars and will admit the free circulation of boiling water about them. Young willow branches, woven into a mat, also make a good bed for bottles and jars.

FIG. 2.—Wire sieve.

The wire basket is a saver of time and strength (fig. 1). The fruit to be peeled is put into the basket, which is lowered into a deep kettle partially filled with boiling water. After a few minutes the basket is lifted from the boiling water, plunged for a moment into cold water, and the fruit is ready to have the skin drawn off.

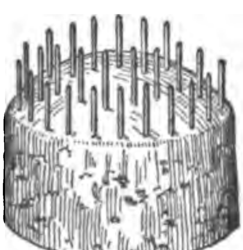

FIG. 3.—Fruit pricker.

A strong wire sieve is a necessity when purées of fruit are to be made (fig. 2). These sieves are known as purée sieves. They are made of strong wire and in addition have supports of still stronger wire.

A fruit pricker is easily made and saves time (fig. 3). Cut a piece half an inch deep from a broad cork; press through this a dozen or more coarse darning needles; tack the cork on a piece of board. Strike the ruit on the bed of needles, and you have a dozen holes at once. Vhen the work is finished, remove the cork from the board, wash and ry thoroughly. A little oil on the needles will preent rusting. With needles of the size suggested there s little danger of the points breaking, but it is worth emembering that the use of pricking machines was bandoned in curing prunes on a commercial scale n California because the steel needles broke and emained in the fruit.

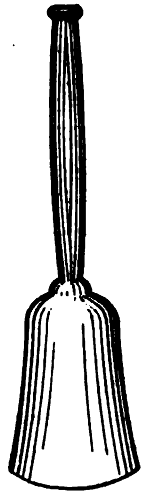

FIG. 4.—Wooden vegetable masher.

A wooden vegetable masher is indispensable when naking jellies and purées (fig. 4).

A sirup gauge and glass cylinder (fig. 5 A and B) re not essential to preserving, canning, and jelly naking, but they are valuable aids in getting the ight proportion of sugar for fruit or jelly. The irup gauge costs about 50 cents and the cylinder bout 25 cents. A lipped cylinder that holds a little ver a gill is the best size.

Small iron rings, such as sometimes come off the hub of cart wheels, may be used instead of a tripod for slightly raising the preserving kettles from the hot stove or range.

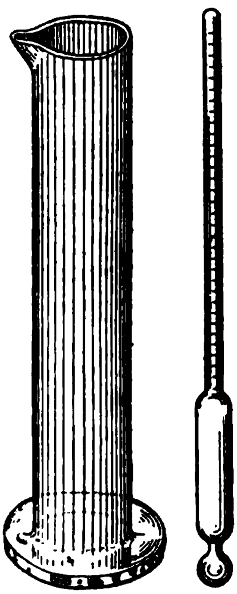

FIG. 5.—Glass cylinder (A) and sirup gauge (B).

To make a flannel straining bag, take a square piece of flannel (27 by 27 inches is a good size), fold it to make a three-cornered bag, stitch one of the sides, cut the top square across, bind the opening with strong, broad tape, stitch on this binding four tapes with which to tie the bag to a frame.

To use this bag, tie it to a strong frame or to the backs of two kitchen chairs. If the chairs are used, place some heavy articles in them; or the bag may hang on a pole (a broom handle) which rests on the backs of the chairs. A high stool turned upside down makes a good support for the bag. Put a bowl on the floor under the bag, then pour in the fruit juice, which will pass through comparatively clear.

Before it is used the bag should be washed and boiled in clear water.

SELECTION AND PREPARATION OF THE FRUIT.

The selection of fruit is one of the first steps in obtaining successful results. The flavor of fruit is not developed until it is fully ripe, but the time at which the fruit is at its best for canning, jelly making, etc., is just before it is perfectly ripe. In all soft fruits the fermentative stage follows closely upon the perfectly ripe stage; therefore it is better to use underripe rather than overripe fruit. This is especially important in jelly making for another reason also: In overripe fruit the pectin begins to lose its jelly-making quality.

All fruits should, if possible, be freshly picked for preserving, canning, and jelly making. No imperfect fruit should be canned or preserved. Gnarly fruit may be used for jellies or marmalades by cutting out defective portions. Bruised spots should be cut out of peaches and pears. In selecting small-seeded fruits, like berries, for canning, those having a small proportion of seed to pulp should be chosen. In dry seasons berries have a larger proportion of seeds to pulp than in a wet or normal season, and it is not wise to can or preserve such fruit unless the seeds are removed. The fruit should be rubbed through a sieve that is fine enough to keep back the seeds. The strained pulp can be preserved as a purée or marmalade.

When fruit is brought into the house put it where it will keep cool and crisp until you are ready to use it.

The preparation of fruit for the various processes of preserving is the second important step. System will do much to lighten the work.

Begin by having the kitchen swept and dusted thoroughly, that there need not be a large number of mold spores floating about. Dust with a damp cloth. Have plenty of hot water and pans in which jars and utensils may be sterilized. Have at hand all necessary utensils, towels, sugar, etc.

Prepare only as much fruit as can be cooked while it still retains its color and crispness. Before beginning to pare fruit have some sirup ready, if that is to be used, or if sugar is to be added to the fruit have it weighed or measured.

Decide upon the amount of fruit you will cook at one time, then have two bowls—one for the sugar and one for the fruit—that will hold just the quantity of each. As the fruit is pared or hulled, as the case may be, drop it into its measuring bowl. When the measure is full put the fruit and sugar in the preserving kettle. While this is cooking another measure may be prepared and put in the second preserving kettle. In this way the fruit is cooked quickly and put in the jars and sealed at once, leaving the pans ready to sterilize another set of jars.

If the fruit is to be preserved or canned with sirup, it may be put into the jars as fast as it is prepared. As soon as a jar is full, pour in enough sirup to cover it.

If several people are helping and large kettles are being used for the preserving, or where fruit (like quinces and hard pears) must be first boiled in clear water, the pared fruit should be dropped into a bowl of cold water made slightly acid with lemon juice (one tablespoonful of lemon juice to a quart of water). This will keep the fruit white.

All large, hard fruit must be washed before paring. Quinces should be rubbed with a coarse towel before they are washed.

If berries must be washed, do the work before stemming or hulling them. The best way to wash berries is to put a small quantity into a colander and pour cold water over them; then turn them on a sieve to drain. All this work must be done quickly that the fruit may not absorb much water.

Do not use the fingers for hulling strawberries. A simple huller can be bought for five cents.

If practicable pare fruit with a silver knife, so as not to stain or darken the product. The quickest and easiest way to peel peaches is to drop them into boiling water for a few minutes. Have a deep kettle a little more than half full of boiling water; fill a wire basket with peaches; put a long-handled spoon under the handle of the basket and lower into the boiling water. At the end of three minutes lift the basket out by slipping the spoon under the handle. Plunge the basket for a moment into a pan of cold water. Let the peaches drain a minute, then peel. Plums and tomatoes may be peeled in the same manner.

If the peaches are to be canned in sirup, put them at once into the sterilized jars. They may be canned whole or in halves. If in halves, remove nearly all the stones or pits. For the sake of the flavor, a few stones should be put in each jar.

When preparing cherries, plums, or crab apples for canning or preserving, the stem or a part of it may be left on the fruit.

When preparing to make jelly have ready the cheese-cloth strainer, enameled colander, wooden spoons, vegetable masher, measures, tumblers, preserving kettles, and sugar.

If currant jelly is to be made, free the fruit from leaves and large stems. If the jelly is to be made from any of the other small fruits, the stems and hulls must be removed.

When the jelly is to be made from any of the large fruits the important part of the preparation is to have the fruit washed clean, then to remove the stem and the blossom end. Nearly all the large fruits are better for having the skin left on. Apples and pears need not be cored. There is so much gummy substance in the cores of quinces that it is best not to use this portion in making fine jelly.

MAKING SIRUP FOR USE IN CANNING AND PRESERVING.

Such sirups as are used in canning and preserving are made with varying proportions of water and sugar. When the proportion of sugar is large and that of the water small the sirup is said to be heavy. When the water predominates the sirup is light.

There are several methods of measuring the proportion of sugar in a sirup. The most scientific and accurate is with the sirup gauge. Careful measurement or weighing is, however, quite satisfactory for all ordinary work if the sirup need not be boiled a long time. In boiling the water evaporates and the sirup grows thicker and richer. The amount of evaporation depends upon the surface exposed and the pressure of the atmosphere. For example, if a large quantity of sirup is boiled in a deep kettle the evaporation will not be rapid. If the same quantity of sirup were boiled the same length of time in a broad, shallow kettle the water would evaporate more rapidly and the sirup would be thicker and heavier. If a given quantity of sirup were boiled the same length of time in a high altitude, Colorado for example, and at the sea level, it would be found that the sirup boiled at the sea level would be thicker and less in volume than that boiled in Colorado. From this it will be seen that it is difficult to say what proportion of sugar a sirup will contain after it has been boiling ten or more minutes. Of course by the use of the sirup gauge the proportion of sugar in a sirup may be ascertained at any stage of the boiling. After all, however, it is possible to measure sugar and water so that you can know the percentage of sugar when the sirup begins to boil. The following statement gives the percentage of sugar at the time when the sirup has been boiling one minute and also what kind of sirup is suitable for the various kinds of fruit:

One pint sugar and 1 gill of water gives sirup of 40° density: Use for preserved strawberries and cherries.

One pint sugar and one-half pint water gives sirup of 32° density.

One pint sugar and 3 gills water gives sirup of 28° density: Use either this or the preceding for preserved peaches, plums, quinces, currants, etc.

One pint sugar and 1 pint water gives sirup of 24° density: Use for canned and fruits.

One pint sugar and 1½ pints water gives sirup of 17° density.

One pint sugar and 2 pints water gives sirup of 14° density: Use either of these two light sirups for canned pears, peaches, sweet plums, and cherries, raspberries, blueberries, and blackberries.

The lightest sirups may be used for filling up the jars after they are taken from the oven or boiler. The process of making a sirup is very simple, but there are a few points that must be observed if sirup and fruit are to be perfect. Put the sugar and water in the saucepan and stir on the stove until all the sugar is dissolved. Heat slowly to the boiling point and boil gently without stirring. The length of time that the sirup should boil will depend upon how rich it is to be. All sirups are better for boiling from ten to thirty minutes. If rich sirups are boiled hard, jarred, or stirred they are apt to crystallize. The sirup may be made a day or two in advance of canning time. The light sirups will not keep long unless sealed, but the heavy sirups keep well if covered well.

USE OF THE SIRUP GAUGE.

The sirup gauge is a graduated glass tube, with a weighted bulb, that registers from 0° to 50°, and that is employed to determine the quantity of sugar contained in a sirup.

If this gauge is placed in pure water the bulb will rest on the bottom of the cylinder or other container. If sugar be dissolved in the water the gauge will begin to float. The more sugar there is dissolved in the water the higher the gauge will rise. In making tests it is essential that the sirup should be deep enough to reach the zero point of the gauge. If a glass cylinder holding about half a gill is filled to about two-thirds its height, and the gauge is then placed in the cylinder, the quantity of sugar in the sirup will be registered on the gauge.

Experiments have demonstrated that when sugar is dissolved and heated in fruit juice, if the sirup gauge registers 25°, the proportion of sugar is exactly right for combining with the pectin bodies to make jelly. The sirup gauge and the glass cylinder must both be heated gradually that the hot sirup may not break them. If the gauge registers more than 25°, add a little more fruit juice. If, on the other hand, it registers less than 25°, add more sugar. In making sirups for canning and preserving fruits, the exact amount of sugar in a sirup may be ascertained at any stage of boiling, and the sirup be made heavier by adding sugar, or lighter by adding water, as the case demands.

CANNING FRUIT.

This method of preserving fruit for home use is from all points the most desirable. It is the easiest and commonly considered the most economical and the best, because the fruit is kept in a soft and juicy condition in which it is believed to be easily digested. The wise housekeeper will can her principal fruit supply, making only enough rich preserves to serve for variety and for special occasions.

The success of canning depends upon absolute sterilization. If the proper care is exercised there need be no failure, except in rare cases, when a spore has developed in the can. There are several methods of canning; and while the principle is the same in all methods, the conditions under which the housekeeper must do her work may, in her case, make one method more convenient than another. For this reason three will be given which are considered the best and easiest. These are: Cooking the fruit in the jars in an oven; cooking the fruit in the jars in boiling water; and stewing the fruit before it is put in the jars. The quantity of sugar may be increased if the fruit is liked sweet.

It is most important that the jars, covers, and rubber rings be in perfect condition. Examine each jar and cover to see that there is no defect in it. Use only fresh rubber rings, for if the rubber is not soft and elastic the sealing will not be perfect. Each year numbers of jars of fruit are lost because of the false economy in using an old ring that has lost its softness and elasticity. Having the jars, covers, and rings in perfect condition, the next thing is to wash and sterilize them.

Have two pans partially filled with cold water. Put some jars in one, laying them on their sides, and some covers in the other. Place the pans on the stove where the water will heat to the boiling point. The water should boil at least ten or fifteen minutes. Have on the stove a shallow milk pan in which there is about 2 inches of boiling water. Sterilize the cups, spoons, and funnel, if you use one, by immersing in boiling water for a few minutes. When ready to put the prepared fruit in the jars slip a broad skimmer under a jar and lift it and drain free of water. Set the jar in the shallow milk pan and fill to overflowing with the boiling fruit. Slip a silver-plated knife or the handle of a spoon around the inside of the jar, that the fruit and juice may be packed solidly. Wipe the rim of the jar, dip the rubber ring in boiling water and put it smoothly on the jar, then put on the cover and fasten. Place the jar on a board and out of a draft of cold air. The work of filling and sealing must be done rapidly, and the fruit must be boiling hot when it is put into the jars. If screw covers are used, it will be necessary to tighten them after the glass has cooled and contracted. When the fruit is cold wipe the jars with a wet cloth. Paste on the labels, if any, and put the jars on shelves in a cool, dark closet.

In canning, any proportion of sugar may be used, or fruit may be canned without the addition of any sugar. However, that which is designed to be served as a sauce should have the sugar cooked with it. Fruit intended for cooking purposes need not have the sugar added to it.

Juicy fruits, such as berries and cherries, require little or no water. Strawberries are better not to have water added to them. The only exception to this is when they are cooked in a heavy sirup.

RASPBERRIES.

12 quarts of raspberries.
2 quarts of sugar.

Put 2 quarts of the fruit in the preserving kettle; heat slowly on the stove; crush with a wooden vegetable masher; spread a square of ıeese cloth over a bowl, and turn the crushed berries and juice into . Press out the juice, which turn into the preserving kettle. Add ıe sugar and put on the stove; stir until the sugar is dissolved. When ıe sirup begins to boil, add the remaining 10 quarts of berries. Let ıem heat slowly. Boil ten minutes, counting from the time they egin to bubble. Skim well while boiling. Put in cans and seal as irected.

RASPBERRIES AND CURRANTS.

10 quarts of raspberries.
3 quarts of currants.
2½ quarts of sugar.

Heat, crush, and press the juice from the currants and proceed as irected for raspberries.

BLACKBERRIES.

The same as for raspberries.

CURRANTS.

12 quarts of currants.
4 quarts of sugar.

Treat the same as for raspberries.

GOOSEBERRIES.

6 quarts of berries.
1½ quarts of sugar.
1 pint of water.

For green gooseberries dissolve the sugar in the water, then add the ruit and cook fifteen minutes. Ripe gooseberries are to be treated he same as the green fruit, but use only half as much water. ìreen gooseberries may also be canned the same as rhubarb (see ı. 22).

BLUEBERRIES.

12 quarts of berries.
1 quart of sugar.
1 pint of water.

Put water, berries, and sugar in the preserving kettle; heat slowly. ǝoil fifteen minutes, counting from the time the contents of the kettle ıegin to bubble.

CHERRIES.

6 quarts of cherries.
1½ quarts of sugar.
½ pint of water.

Measure the cherries after the stems have been removed. Stone hem or not, as you please. If you stone them be careful to save all he juice. Put the sugar and water in the preserving kettle and stir over the fire until the sugar is dissolved. Put in the cherries and heat slowly to the boiling point. Boil ten minutes, skimming carefully.

GRAPES.

6 quarts of grapes.
1 quart of sugar.
1 gill of water.

Squeeze the pulp of the grapes out of the skins. Cook the pulp five minutes and then rub through a sieve that is fine enough to hold back the seeds. Put the water, skins, and pulp into the preserving kettle and heat slowly to the boiling point. Skim the fruit and then add the sugar. Boil fifteen minutes.

Sweet grapes may be canned with less sugar; very sour ones may have more.

RHUBARB.

Cut the rhubarb when it is young and tender. Wash it thoroughly and then pare; cut into pieces about 2 inches long. Pack in sterilized jars. Fill the jars to overflowing with cold water and let them stand ten minutes. Drain off the water and fill again to overflowing with fresh cold water. Seal with sterilized rings and covers. When required for use, treat the same as fresh rhubarb.

Green gooseberries may be canned in the same manner. Rhubarb may be cooked and canned with sugar in the same manner as gooseberries.

PEACHES.

8 quarts of peaches.
1 quart of sugar.
3 quarts of water.

Put the sugar and water together and stir over the fire until the sugar is dissolved. When the sirup boils skim it. Draw the kettle back where the sirup will keep hot but not boil.

Pare the peaches, cut in halves, and remove the stones, unless you prefer to can the fruit whole.

Put a layer of the prepared fruit into the preserving kettle and cover with some of the hot sirup. When the fruit begins to boil skim carefully. Boil gently for ten minutes, then put in the jars and seal. If the fruit is not fully ripe it may require a little longer time to cook. It should be so tender that it may be pierced easily with a silver fork. It is best to put only one layer of fruit in the preserving kettle. While this is cooking the fruit for the next batch may be prepared.

PEARS.

If the fruit is ripe it may be treated exactly the same as peaches. If, on the other hand, it is rather hard it must be cooked until so tender that a silver fork will pierce it readily.

QUINCES.

4 quarts of pared, cored, and quartered quinces.
1½ quarts of sugar.
2 quarts of water.

Rub the fruit hard with a coarse, crash towel, then wash and drain. are, quarter, and core; drop the pieces into cold water (see p. 17). ut the fruit in the preserving kettle with cold water to cover it gen-rously. Heat slowly and simmer gently until tender. The pieces ill not all require the same time to cook. Take each piece up as on as it is so tender that a silver fork will pierce it readily. Drain a platter. Strain the water in which the fruit was cooked through eese cloth. Put two quarts of the strained liquid and the sugar into e preserving kettle; stir over the fire until the sugar is dissolved. hen it boils skim well and put in the cooked fruit. Boil gently for out twenty minutes.

CRAB APPLES.

6 quarts of apples.
1½ quarts of sugar.
2 quarts of water.

Put the sugar and water into the preserving kettle. Stir over the re until the sugar is dissolved. When the sirup boils skim it.

Wash the fruit, rubbing the blossom end well. Put it in the boil-g sirup, and cook gently until tender. It will take from twenty to fty minutes, depending upon the kind of crab apples.

PLUMS.

8 quarts of plums.
2 quarts of sugar.
1 pint of water.

Nearly all kinds of plums can be cooked with the skins on. If it is esired to remove the skin of any variety, plunge them in boiling ater for a few minutes. When the skins are left on, prick them oroughly to prevent bursting. (See fruit pricker, p. 14.)

Put the sugar and water into the preserving kettle and stir over the re until the sugar is dissolved. Wash and drain the plums. Put me of the fruit in the boiling sirup. Do not crowd it. Cook five inutes; fill and seal the jars. Put more fruit in the sirup. Continue this manner until all the fruit is done. It may be that there will ot be sufficient sirup toward the latter part of the work; for this eason it is well to have a little extra sirup on the back of the stove.

STEWED TOMATOES.

Wash the tomatoes and plunge into boiling water for five minutes. are and slice, and then put into the preserving kettle; set the kettle on an iron ring. Heat the tomatoes slowly, stirring frequently from the bottom. Boil for thirty minutes, counting from the time the vegetable begins actually to boil. Put in sterilized jars and seal.

WHOLE TOMATOES.

8 quarts of medium-sized tomatoes.
4 quarts of sliced tomatoes.

Put the pared and sliced tomatoes into a stewpan and cook as directed for stewed tomatoes. When they have been boiling twenty minutes take from the fire and rub through a strainer. Return to the fire.

While the sliced tomatoes are cooking, pare the whole tomatoes and put them in sterilized jars. Pour into the jars enough of the stewed and strained tomato to fill all the interstices. Put the uncovered jars in a moderate oven, placing them on a pad of asbestos or in shallow pans of hot water. Let the vegetable cook in the oven for half an hour. Take from the oven and fill to overflowing with boiling hot strained tomato, then seal. If there is any of the strained tomato left, can it for sauces.

CANNED FRUIT COOKED IN THE OVEN.

This method of canning fruit, in the opinion of the writer, is the one to be preferred. The work is easily and quickly done, and the fruit retains its shape, color, and flavor better than when cooked in the preserving kettle.

Cover the bottom of the oven with a sheet of asbestos, the kind plumbers employ in covering pipes. It is very cheap and may usually be found at plumbers' shops. If the asbestos is not available, put into the oven shallow pans in which there are about two inches of boiling water.

Sterilize the jars and utensils. Make the sirup; prepare the fruit the same as for cooking in the preserving kettle. Fill the hot jars with it, and pour in enough sirup to fill the jar solidly. Run the blade of a silver-plated knife around the inside of the jar. Place the jars in the oven, either on the asbestos or in the pan of water. The oven should be moderately hot. Cook the fruit ten minutes; remove from the oven and fill the jar with boiling sirup. Wipe and seal. Place the jars on a board and out of a draft of air. If the screw covers are used tighten them after the glass has cooled.

Large fruits, such as peaches, pears, quinces, crab apples, etc., will require about a pint of sirup to each quart jar of fruit. The small fruits will require a little over half a pint of sirup.

The amount of sugar in each quart of sirup should be regulated to suit the fruit with which it is to be used. The data on page 18 will be a guide. The quantities given will not make the fruit very sweet. The quantity of sugar may be increased or diminished to suit the taste.

CANNED FRUIT COOKED IN A WATER BATH.

Prepare the fruit and sirup as for cooking in the oven.

Fill the sterilized jars and put the covers on loosely. Have a wooden ck in the bottom of a wash boiler (see p. 14). Put in enough warm ater to come to about 4 inches above the rack. Place the filled jars the boiler, but do not let them touch one another. Pack clean white tton rags, or perhaps better, cotton rope, between and around the rs to prevent them from striking one another when the water begins boil. Cover the boiler and let the fruit cook ten minutes from the ne the water surrounding it begins to boil.

Draw the boiler back and take off the cover. When the steam asses off take out one jar at a time and place in a pan of boiling ater beside the boiler, fill up with boiling sirup, and seal. Put the rs on a board and do not let cold air blow upon them. If screw overs are used tighten them when the glass has cooled and contracted.

PRESERVING FRUIT.

In the case of most fruits, canning with a little sugar is to be prerred to preserving with a large quantity of sugar. There are, hower, some fruits that are only good when preserved with a good deal f sugar. Of course, such preparations of fruit are only desirable for ccasional use. The fruits best adapted for preserving are strawberies, sour cherries, sour plums, and quinces. Such rich preparations hould be put up in small jars or tumblers.

STRAWBERRIES.

Use equal weights of sugar and strawberries. Put the strawberries the preserving kettle in layers, sprinkling sugar over each layer. he fruit and sugar should not be more than 4 inches deep. Place e kettle on the stove and heat the fruit and sugar slowly to the boilg point. When it begins to boil skim carefully. Boil ten minutes, ounting from the time the fruit begins to bubble. Pour the cooked ruit into platters, having it about 2 or 3 inches deep. Place the latters in a sunny window, in an unused room, for three or four ays. In that time the fruit will grow plump and firm, and the sirup ill thicken almost to a jelly. Put this preserve, cold, into jars or umblers.

WHITE CURRANTS.

Select large, firm fruit, remove the stems, and proceed as for strawerries.

CHERRIES.

The sour cherries, such as Early Richmond and Montmorency, are est for this preserve. Remove the stems and stones from the cherries nd proceed as for strawberry preserve.

CHERRIES PRESERVED WITH CURRANT JUICE.

12 quarts of cherries.
3 quarts of currants.
2 quarts of sugar.

Put the currants in the preserving kettle and on the fire. When they boil up crush them and strain through cheese cloth, pressing out all the juice.

Stem and stone the cherries, being careful to save all the juice. Put the cherries, fruit juice, and sugar in the preserving kettle. Heat to the boiling point and skim carefully. Boil for twenty minutes. Put in sterilized jars or tumblers. This gives an acid preserve. The sugar may be doubled if richer preserves are desired.

PLUM PRESERVE.

4 quarts of green gages.
2 quarts of sugar.
1 pint of water.

Prick the fruit and put it in a preserving kettle. Cover generously with cold water. Heat to the boiling point and boil gently for five minutes. Drain well.

Put the sugar and water in a preserving kettle and stir over the fire until the sugar is dissolved. Boil five minutes, skimming well. Put the drained green gages in this sirup and cook gently for twenty minutes. Put in sterilized jars.

Other plums may be preserved in the same manner. The skin should be removed from white plums.

QUINCES.

4 quarts of pared, quartered, and cored quinces.
2 quarts of sugar.
1 quart of water.

Boil the fruit in clear water until it is tender, then skim out and drain.

Put the 2 quarts of sugar and 1 quart of water in the preserving kettle; stir until the sugar is dissolved. Let it heat slowly to the boiling point. Skim well and boil for twenty minutes. Pour one-half of the sirup into a second kettle. Put one-half of the cooked and drained fruit into each kettle. Simmer gently for half an hour, then put in sterilized jars. The water in which the fruit was boiled can be used with the parings, cores, and gnarly fruit to make jelly.

FRUIT PURÉES.

Purées of fruit are in the nature of marmalades, but they are not cooked so long, and so retain more of the natural flavor of the fruit.

ꞁhis is a particularly nice way to preserve the small, seedy fruits, hich are to be used in puddings, cake, and frozen desserts.

Free the fruit from leaves, stems, and decayed portions. Peaches ıd plums should have the skins and stones removed. Rub the fruit rough a purée sieve. To each quart of the strained fruit add a pint sugar. Pack in sterilized jars. Put the covers loosely on the jars. lace the jars on the rack in the boiler. Pour in enough cold water come half way up the sides of the jars. Heat gradually to the boil-g point and boil thirty minutes, counting from the time when the ater begins to bubble.

Have some boiling sirup ready. As each jar is taken from the ›iler put it in a pan of hot water and fill up with the hot sirup. Seal once.

MARMALADES.

Marmalades require great care while cooking because no moisture added to the fruit and sugar. If the marmalade is made from ber-es the fruit should be rubbed through a sieve to remove the seeds. large fruit is used have it washed, pared, cored, and quartered.

Measure the fruit and sugar, allowing one pint of sugar to each ıart of fruit.

Rinse the preserving kettle with cold water that there may be a ight coat of moisture on the sides and bottom. Put alternate layers f fruit and sugar in the kettle, having the first layer fruit. Heat owly, stirring frequently. While stirring, break up the fruit as ıuch as possible. Cook about two hours, then put in small sterilized ırs.

FRUIT PRESERVED IN GRAPE JUICE.

Any kind of fruit can be preserved by this method, but it is particu-ırly good for apples, pears, and sweet plums. No sugar need be used ı this process.

Boil 6 quarts of grape juice in an open preserving kettle, until it is ›duced to 4 quarts. Have the fruit washed and pared, and, if apples r pears, quartered and cored. Put the prepared fruit in a preserv-ıg kettle and cover generously with the boiled grape juice. Boil ently until the fruit is clear and tender, then put in sterilized jars.

BOILED CIDER.

When the apple crop is abundant and a large quantity of cider is ıade, the housekeeper will find it to her advantage to put up a gener-us supply of boiled cider. Such cider greatly improves mince-meat, nd can be used at any time of the year to make cider apple sauce. t is also a good selling article.

The cider for boiling must be perfectly fresh and sweet. Put it in large, open preserving kettle and boil until it is reduced one-half.

Skim frequently while boiling. Do not have the kettle more than two-thirds full.

Put in bottles or stone jugs.

CIDER APPLE SAUCE.

5 quarts of boiled cider.
8 quarts of pared, quartered, and cored sweet apples.

Put the fruit in a large preserving kettle and cover with the boiled cider. Cook slowly until the apples are clear and tender. To prevent burning, place the kettle on an iron tripod or ring. It will require from two to three hours to cook the apples. If you find it necessary to stir the sauce be careful to break the apples as little as possible. When the sauce is cooked, put in sterilized jars.

In the late spring, when cooking apples have lost much of their flavor and acidity, an appetizing sauce may be made by stewing them with diluted boiled cider, using 1 cupful of cider to 3 of water.

CIDER PEAR SAUCE.

Cooking pears may be preserved in boiled cider the same as sweet apples. If one prefers the sauce less sour, 1 pint of sugar may be added to each quart of boiled cider.

METHODS OF MAKING JELLY.

In no department of preserving does the housekeeper feel less sure of the result than in jelly making. The rule that works perfectly one time fails another time. Why this is so the average housekeeper does not know; so there is nearly always an element of uncertainty as to the result of the work. These two questions are being constantly asked: "Why does not my jelly harden?" "What causes my jelly to candy?"

It is an easy matter to say that there is something in the condition of the fruit, or that the fruit juice and sugar were cooked too short or too long a time. These explanations are often true; but they do not help the inquirer, since at other times just that proportion of sugar and time of cooking have given perfect jelly. In the following pages an attempt is made to give a clear explanation of the principles underlying the process of jelly making. It is believed that the women who study this carefully will find the key to unvarying success in this branch of preserving.

PECTIN, PECTOSE, PECTASE.

In all fruits, when ripe or nearly so, there is found pectin, a carbohydrate somewhat similar in its properties to starch. It is because of this substance in the fruit juice that we are able to make jelly. When equal quantities of sugar and fruit juice are combined and the mixture heated to the boiling point for a short time, the pectin in the fruit latinizes the mass.

It is important that the jelly maker should understand when this latinizing agent is at its best. Pectose and pectase always exist in e unripe fruit. As the fruit ripens the pectase acts upon the pectose, iich is insoluble in water, converting it into pectin, which is soluble. ctin is at its best when the fruit is just ripe or a little before. If e juice ferments, or the cooking of the jelly is continued too long, e pectin undergoes a change and loses its power of gelatinizing. is, therefore, of the greatest importance that the fruit should be esh, just ripe or a little underripe, and that the boiling of the sugar d juice should not be continued too long.

Fruits vary as to the quantities of sugar, acid, pectin, and gums in eir composition. Some of the sour fruits contain more sugar than some of the milder-flavored fruits. Currants, for example, often ntain four or five times as much sugar as the peach. The peach es not contain so much free acid and it does contain a great deal of ctin bodies, which mask the acid; hence, the comparative sweetness the ripe fruit.

SELECTION AND HANDLING OF FRUIT FOR JELLY MAKING.

An acid fruit is the most suitable for jelly making, though in some the acid fruits, the strawberry, for example, the quantity of the lly-making pectin is so small that it is difficult to make jelly with is fruit. If, however, some currant juice be added to the strawrry juice, a pleasant jelly will be the result; yet, of course, the vor of the strawberry will be modified. Here is a list of the most sirable fruits for jelly making. The very best are given first: Curnt, crab apple, apple, quince, grape, blackberry, raspberry, peach.

Apples make a very mild jelly, and it may be flavored with fruits, wers, or spices. If the apples are acid it is not advisable to use any vor.

Juicy fruits, such as currants, raspberries, etc., should not be thered after a rain, for they will have absorbed so much water as to ake it difficult, without excessive boiling, to get the juice to jelly.

If berries are sandy or dusty it will be necessary to wash them, but e work should be done very quickly so that the fruit may not absorb uch water. (See washing fruit, p. 17.)

Large fruits, such as apples, peaches, and pears, must be boiled in ater until soft. The strained liquid will contain the flavoring matter d pectin.

It requires more work and skill to make jellies from the fruits to hich water must be added than from the juicy fruits. If the juicy uits are gathered at the proper time one may be nearly sure that ey contain the right proportion of water. If gathered after a rain the fruit must be boiled a little longer that the superfluous water may pass off in steam.

In the case of the large fruits a fair estimate is 3 quarts of strained juice from 8 quarts of fruit and about 4 quarts of water. If the quantity of juice is greater than this it should be boiled down to 3 quarts.

Apples will always require 4 quarts of water to 8 quarts of fruit but juicy peaches and plums will require only 3 or 3½ quarts.

The jelly will be clearer and finer if the fruit is simmered gently and not stirred during the cooking.

It is always best to strain the juice first through cheese cloth and without pressure. If the cloth is double the juice will be quite clear. When a very clear jelly is desired the strained juice should pass through a flannel or felt bag. The juice may be pressed from the fruit left in the strainer and used in marmalade or for a second-quality jelly.

To make jelly that will not crystallize (candy) the right proportion of sugar must be added to the fruit juice. If the fruit contains a high percentage of sugar, the quantity of added sugar should be a little less than the quantity of fruit juice. That is to say, in a season when there has been a great deal of heat and sunshine there will be more sugar in the fruit than in a cold, wet season; consequently, 1 pint of currant juice will require but three-quarters of a pint of sugar. But in a cold, wet season the pint of sugar for the pint of juice must be measured generously.

Another cause of the jelly crystallizing is hard boiling. When the sirup boils so rapidly that particles of it are thrown on the upper part of the sides of the preserving kettle they often form crystals. If these crystals are stirred into the sirup they are apt to cause the mass to crytallize in time.

The use of the sirup gauge and care not to boil the sirup too violently would do away with all uncertainty in jelly making. The sirup gauge should register 25°, no matter what kind of fruit is used. (See p.19.)

Jellies should be covered closely and kept in a cool, dry, dark place.

CURRANT JELLY.

The simplest method of making currant jelly is perhaps the following: Free the currants from leaves and large stems. Put them in the preserving kettle; crush a few with a wooden vegetable masher or spoon; heat slowly, stirring frequently.

When the currants are hot, crush them with the vegetable masher. Put a hair sieve or strainer over a large bowl; over this spread a double square of cheese cloth. Turn the crushed fruit and juice into the cheese cloth, and let it drain as long as it drips, but do not use pressure. To hasten the process take the corners of the strainer ıth firmly in the hands and lift from the sieve; move the contents raising one side of the cloth and then the other. After this put ɜ cloth over another bowl. Twist the ends together and press out much juice as possible. This juice may be used to make a second ality of jelly.

The clear juice may be made into jelly at once, or it may be strained rough a flannel bag. In any case, the method of making the jelly is ː same.

Measure the juice, and put it in a clean preserving kettle. For ery pint of juice add a pint of granulated sugar.

Stir until the sugar is dissolved, then place over the fire; watch ısely, and when it boils up draw it back and skim; put over the fire ain, and boil and skim once more; boil and skim a third time; then ur into hot glasses taken from the pan of water on the stove and ; on a board. Place the board near a sunny window in a room where ere is no dust. It is a great protection and advantage to have sheets glass to lay on top of the tumblers. As soon as the jelly is set cover one of the three methods given. (See p. 29.)

To make very transparent currant jelly, heat, crush, and strain the rrants as directed in the simplest process. Put the strained juice in e flannel bag and let it drain through. Measure the juice and sugar, nt for pint, and finish as directed above.

To make currant jelly by the cold process follow the first rule for lly as far as dissolving the sugar in the strained juice. Fill warm, ɜrilized glasses with this. Place the glasses on a board and put the ard by a sunny window. Cover with sheets of glass and keep by e window until the jelly is set. The jelly will be more transparent the juice is strained through the flannel bag. Jelly made by the ld process is more delicate than that made by boiling, but it does ıt keep quite so well.

RASPBERRY AND CURRANT JELLY.

Make the same as currant jelly, using half currants and half rasp-ɜrries.

RASPBERRY JELLY.

Make the same as currant jelly.

BLACKBERRY JELLY.

Make the same as currant jelly.

STRAWBERRY JELLY.

To 10 quarts of strawberries add 2 quarts of currants and proceed for currant jelly, but boil fifteen minutes.

RIPE-GRAPE JELLY.

An acid grape is best for this jelly. The sweet, ripe grapes contain too much sugar. Half-ripe fruit, or equal portions of nearly ripe and green grapes, will also be found satisfactory. Wild grapes make delicious jelly. Make the same as currant jelly.

GREEN-GRAPE JELLY.

Make the same as apple jelly.

PLUM JELLY.

Use an underripe acid plum. Wash the fruit and remove the stems. Put into the preserving kettle with 1 quart of water for each peck of fruit. Cook gently until the plums are boiled to pieces. Strain the juice and proceed the same as for currant jelly.

APPLE JELLY.

Wash, stem, and wipe the apples, being careful to clean the blossom end thoroughly. Cut into quarters and put into the preserving kettle. Barely cover with cold water (about 4 quarts of water to 8 of apples) and cook gently until the apples are soft and clear. Strain the juice and proceed as for currant jelly. There should be but 3 quarts of juice from 8 quarts of apples and 4 of water.

Apples vary in the percentage of sugar and acid they contain. A fine-flavored acid apple should be employed when possible. Apple jelly may be made at any time of the year, but winter apples are best and should be used when in their prime, i. e., from the fall to December or January. When it is found necessary to make apple jelly in the spring, add the juice of one lemon to every pint of apple juice.

CIDER APPLE JELLY.

Make the same as plain apple jelly, but covering the apples with cider instead of water. The cider must be fresh from the press.

CRAB-APPLE JELLY.

Make the same as plain apple jelly.

QUINCE JELLY.

Rub the quinces with a coarse crash towel; cut out the blossom end. Wash the fruit and pare it and cut in quarters. Cut out the cores, putting them in a dish by themselves. Have a large bowl half full of water; drop the perfect pieces of fruit into this bowl. Put the parings and imperfect parts, cut very fine, into the preserving kettle. Add a quart of water to every 2 quarts of fruit and parings. Put on the fire and cook gently for two hours. Strain and finish the same as apple jelly. The perfect fruit may be preserved or canned.

'o make quince jelly of a second quality, when the parings and it are put on to cook put the cores into another kettle and cover m generously with water and cook two hours. After all the juice been drained from the parings and fruit, put what remains into preserving kettle with the cores. Mix well and turn into the aining cloth. Press all the juice possible from this mixture. Put juice in the preserving kettle with a pint of sugar to a pint of :e; boil ten minutes.

WILD FRUITS FOR JELLIES.

Vild raspberries, blackberries, barberries, grapes, and beach plums make delicious jellies. The frequent failures in making barberry y come from the fruit not being fresh or from being overripe.

PREPARATION OF THE GLASSES FOR JELLY.

iterilize the glasses; take from the boiling water and set them in a llow baking pan in which there is about 2 inches of boiling water.

COVERING JELLIES.

ellies are so rich in sugar that they are protected from bacteria yeasts, but they must be covered carefully to protect them from ld spores and evaporation. The following methods of covering ies are all good:

lave disks of thick white paper the size of the top of the glass. ien the jelly is set, brush the top over with brandy or alcohol. a disk of paper in the spirits and put it on the jelly. If the sses have covers, put them on. If there are no covers, cut disks paper about half an inch in diameter larger than the top of the ss. Beat together the white of one egg and a tablespoonful of d water. Wet the paper covers with this mixture and put over the ss, pressing down the sides well to make them stick to the glass; or covers may be dipped in olive oil and be tied on the glasses, but y must be cut a little larger than when the white of egg is used.

A thick coating of paraffin makes a good cover, but not quite so safe the paper dipped in brandy or alcohol, because the spirits destroy mold spores that may happen to rest on the jelly. If such spores covered with the paraffin they may develop under it. However, paper wet with spirits could be put on first and the paraffin poured er it.

f paraffin is used, break it into pieces and put in a cup. Set the in a pan of warm water on the back of the stove. In a few ments it will be melted enough to cover the jelly. Have the coat- about a fourth of an inch thick. In cooling the paraffin contracts, l if the layer is very thin it will crack and leave a portion of the y exposed.

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By

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BUREAU OF ENTOMOLOGY,
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SIR: I have the honor to transmit herewith the manuscript of an account of The Cotton Bollworm, based upon investigations conducted during the year 1904, prepared by A. L. Quaintance and F. C. Bishopp, of this Bureau, and to recommend the immediate publication of the same as a Farmers' Bulletin. The investigations are in continuation of those reported for the year 1903 and published as Farmers' Bulletin No. 191, which this bulletin is designed to supersede.

Very respectfully,

L. O. HOWARD,
Entomologist.

Hon. JAMES WILSON,
Secretary of Agriculture.

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THE COTTON BOLLWORM.[a]

INTRODUCTION.

The cotton bollworm became known as an enemy of cotton early in the history of the cultivation of this crop in the United States. As the industry has grown, the losses from this insect have assumed greater proportions, especially in the absence of the employment of any remedial measures, and more particularly in the Southwestern States of the cotton belt, where farming conditions and practices have been least calculated to interfere with its successful development.

From long familiarity, planters have become more or less accustomed to its ravages, and the disposition has been to regard these as necessarily incident to cotton culture. The fact that serious injury has been of irregular occurrence has contributed to the disposition to neglect the adoption of remedial measures long known to be of value. Probably the most difficult feature of the whole question of lessening the present serious ravages of the bollworm consists in securing the adoption by cotton growers of methods generally admitted to be of value. This difficulty is not peculiar to cotton farmers suffering from bollworm ravages, but finds parallel among the growers of agricultural and horticultural crops generally. Often a pest of long standing will be tolerated, and no effort made to prevent injury from it, whereas the ravages of a recently introduced species become the subject of much complaint; of which facts the cotton boll weevil and the cotton bollworm furnish an excellent illustration. Curiously enough, the crisis in cotton culture in Texas, brought about by the former species, will, it appears, be the means of securing the adoption, in that State at least, of methods of farming best calculated to reduce injury from the cotton bollworm. Certain facts in the life history of the latter species render effective those cultural methods which are of value in avoiding weevil injury. It now appears certain that both of these serious enemies of the cotton plant will be best controlled by identically the same methods of improved farm practice.

[a] *Heliothis obsoleta* Fab., formerly known as *H. armiger* Hübner.

SUMMARY OF LIFE HISTORY AND HABITS.

The bollworm has four distinct stages in its development—namely, the egg, larva, pupa, and adult or moth.

The eggs are most easily found on the silks of corn, and may be readily seen with the unaided eye. They are oval in shape, whitish or yellowish in color, and average in diameter about 0.45 to 0.50 mm. The number of eggs deposited by a single moth varies from about [illegible] to 3,000 with an average of about 1,100. The eggs are laid, beginning usually about twilight, on the several food plants of the larva, which are preferably corn, cotton, tomatoes, etc., in about the order named. Eggs on corn are placed almost promiscuously over the plant, but there is shown a preference for silks when these are present. On cotton, eggs are placed more largely on the leaves and squares, but there is a considerable scattering of them over the entire plant. Eggs hatch in from two and one-half to ten days, depending on the season.

In the larval stage, the insect is variously designated as bollworm, bud-worm, corn ear-worm, tomato-fruit worm, etc., depending on the particular plant and part of the plant infested. It is during this stage only that injury is inflicted. Newly hatched bollworms are very small and are usually overlooked by planters until they are of sufficient size to attract attention by their injury. The bollworm is a voracious feeder, and during the summer may complete its growth in from twelve to fifteen days. During the cool weather of spring and fall the rate of growth is much slower. A full-grown bollworm measures from 1¼ to 1½ inches in length. Larvæ vary much in color and markings, ranging, in different individuals, from pale greenish to rose-colored, dark brown, and almost black.

When full grown the bollworm leaves its food plant and burrows in the soil to a depth, usually, of from 2 to 5 inches, and, after constructing a cell extending upward nearly to the surface of the soil, enters the pupal stage. This stage, during summer, lasts from ten days to two weeks, and longer in the spring and fall. The insect hibernates in the pupal condition.

The bollworm moth, like its larva, varies much in color, ranging from a dull olive green to a pale yellow. The wings expand about [illegible] inches, and the body is about ⅞ of an inch in length. During the day the moths hide in grass or weeds around the margins of fields or among the foliage of plants infested by the larvæ. Toward dusk they leave their retreats and feed on the nectar of various flowers. In cotton fields their principal food is the nectar secreted on the squares and flowers of the cotton plants. After feeding oviposition begins, this process may alternate with feeding. Eggs are deposited almost promiscuously over the plants. This habit of promiscuous oviposition, especially on the cotton plant, renders it possible, during periods of severe bollworm injury, to employ arsenical poisons for the destruction of young larvæ before they are of sufficient size to attack squares and bolls.

The number of generations annually produced by the bollworm in the cotton belt varies from about 4 to 7, depending on the latitude, with an average of about 5. In the latitude of Paris, Tex., there appear to be but 4; at Victoria, Tex., there are apparently 6. The irregularity in time of appearance of moths in the spring and other causes soon produce a confusion of generations, so that these are rarely well marked.

In general, moths issue from hibernating pupæ in the spring, in any locality in the cotton belt, at a time when most of the field corn is from 10 to 20 inches high. By far the larger part of the eggs of these moths is placed on young field corn. A small part is placed on other plants, as garden vegetables, roses, etc. The larvæ resulting from eggs laid on field corn attack the tender central roll of leaves, soon riddling it, and are on this account termed bud-worms. In the latitude of Paris, Tex., moths of the second generation appear as field corn is coming into tassel and silk. These portions of the plant are freely oviposited on, and the second generation of bollworms largely infests the same parts, especially of roasting ears, in which infestation may reach as high as 90 to 100 per cent of the ears. By the time the moths of the next generation are out, field corn has begun to yellow and ripen and is no longer attractive to the moths for oviposition purposes; hence these go to cotton, from which they secure nectar as food and on which most of their eggs are deposited. Cotton is not attacked in force by bollworms until the corn of the locality has begun to ripen, which time will average about the first of August. The third generation of bollworms is the one most destructive to cotton. The fourth generation, also, infests cotton during September, but owing to the attack of parasites, and frequently to unfavorable weather conditions, injury is rarely of serious proportions.

Larvæ of this generation, on completing their growth, enter the soil and transform to pupæ, in which condition the majority remain during the winter. A few may develop moths, and there are thus some bollworms to be found on cotton quite up to frost.

FARM PRACTICE IN RELATION TO BOLLWORM INJURY.

At the present time in the United States injury to cotton from the bollworm assumes its greatest importance in Texas, Louisiana, Mississippi, Indian Territory, Oklahoma, and Arkansas. The rapid increase in cotton acreage during the past ten or twenty years in the more western part of the cotton belt has contributed largely to th more serious depredations of the bollworm in this territory, as compared with its injuries in the Carolinas, Georgia, and Florida. Those who have followed the development of cotton culture west of the Mississippi during recent years need not be informed how extensive this development has been. Quoting from the Twelfth Census:

Of the entire crop 34.5 per cent was grown west of the Mississippi River in 18 38.44 per cent in 1889, and 43.80 per cent in 1899. Of the total increase of 4,0 acres in the decade, 1890 to 1900, 3,637,398 acres or 88.7 per cent was contribut Texas, Indian Territory, and Oklahoma. The increase in Texas was 3,025,824 acres in Indian Territory, 371,987 acres; in Oklahoma 239,569 acres. This leave increase of onl 462,433 acres for all the other States, which was nearly reache the increase of 440,970 acres in Alabama.

The tide of emigration, which about 1850 began to move westwa from the more eastern cotton States, peopled this newer countr largely with cotton farmers, and cotton has been the crop rais largely to the exclusion of everything else. Until recently but littl attention has been given to diversified farming, corn and cotton bein the principal crops grown. As transportation facilities have impro the tendency has been, perhaps, to depend more and more on th North and West for the food supply and to increase the farm acreag in cotton. This extension of the cotton area and neglect of cr diversification has resulted partly from the belief that climate and s were not adapted to the cultivation of those crops grown successful farther north, but more largely on account of labor and econom considerations. Landowners have for the most part come to conside cotton as the only crop which may be grown on a large scale w reasonable convenience and safety to themselves, and there has th been developed a condition of finances which has necessitated t planting of cotton by tenants and small landowners in need of credi as collateral for the amounts advanced.

Plantations and farms of large size are the rule, and the tenan system, therefore, finds its maximum development in the area und consideration. This fact, in connection with the large areas in cott as compared with other crops, and the natural fertility of the s which produces a rank succulent plant growth, have been import factors in bringing about the present importance of bollworm ravag

The cotton crop requires the occupancy of the ground from ea in the spring until late in the fall, the growth of the plant bei checked only by frost. If the fall be unfavorable, picking may greatly delayed, often extending through the winter and well into following spring. Under such circumstances a thorough plowing the ground in the fall or winter, with its consequent benefi influence in destroying hibernating pupæ, is not possible, and la nay be planted to cotton several years in succession without a thorough breaking up. By reason of the tenant system of farming, cultivation has, on the whole, been insufficient, and the plant has thus been least able to put on an excess of early fruit, so as to insure a crop in spite of insect attack.

The situation is aggravated by the use of seed which has not been selected for early fruiting or other desirable qualities, often from public ginneries and of absolutely unknown variety.

The principal crops grown, namely cotton and corn, are the two preferred food plants of the bollworm. As a general rule the agricultural practices of the States and Territories mentioned result in conditions theoretically most favorable for the development of this insect. The serious ravages of the bollworm which this territory, and to a less extent other portions of the cotton belt, have suffered, have their explanation in prevalent methods of farm practice. The movement for diversification of crops, now well under way in Texas, and other improvements in farming must gradually bring about that condition of relative immunity from injury enjoyed by the older, more eastern cotton-belt States.

DESTRUCTIVENESS OF THE BOLLWORM.

Bollworm injury varies much from year to year, depending on the relative earliness of the cotton crop, the character of the weather, and

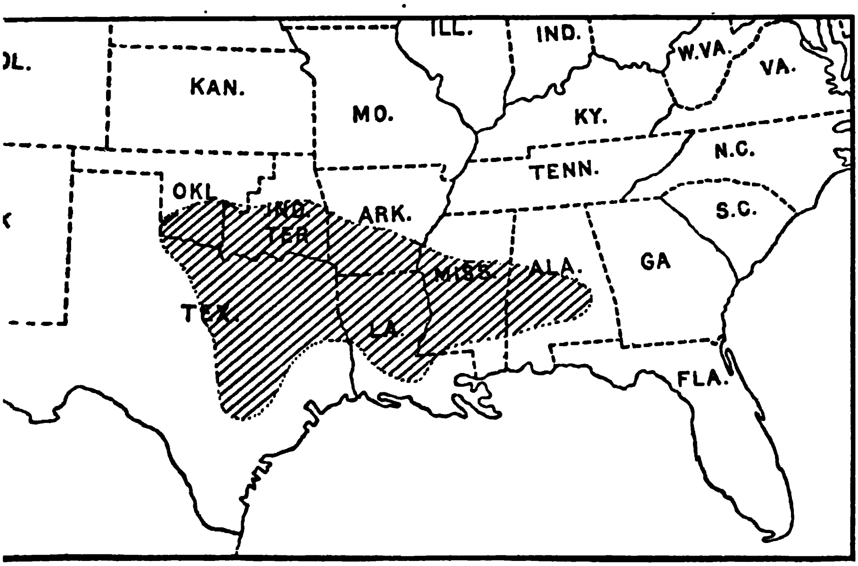

FIG. 1.—Map showing approximately the area of bollworm injury in 1904.

other factors. Not for many years have its depredations been more widespread and serious than during 1903. The heavy and general rains during the winter of 1902–1903 practically prohibited winter plowing, and from the same cause planting in the spring was everywhere delayed from four to six weeks. Subsequent weather conditions, especially in late July and early August, were such as a: held to be most favorable to bollworm development. The general lateness of the cotton crop resulted in there being but little fr: sufficiently matured to be exempt from attack upon the migration of the insects to cotton in early August. The capabilities of the insect for injury under such conditions are very great. In the territory infested by the boll weevil the combined attack of these two species often left but little to be gathered. A yield of 1 bale from 15 to 25 acres was frequently reported, and in some fields cotton whatever was gathered.

The following estimates of bollworm injury in 1903 in certain counties in Texas are made up from data from various sources and from personal observation, and are given to indicate the capabilities for injury of this species under such conditions as prevailed during the year:

Estimates of bollworm injury to the cotton crop in certain counties in Texas in 1903.

	Per cent.		Per cent.
Navarro	20 to 25	Lamar	40 t[illegible]
Henderson	15 to 20	Delta	50 t[illegible]
Limestone	20 to 25	Hunt	30 t[illegible]
Falls	8 to 10	Hopkins	25 t[illegible]
Bell	8 to 10	Kaufman	25 [illegible]
Robertson	15 to 20	Van Zandt	2[illegible]
Fannin	50 to 60		

In pleasing contrast were the much less serious ravages of the insect in 1904, when it was only more or less locally that severe injury occurred. The favorable weather of the fall of 1903 and the following winter and spring permitted very general breaking up of land during this period, and many pupæ were undoubtedly thus destroyed. The moths were noticeably much less numerous in young fields during the spring, and they were subsequently much less abundant as evidenced by the number of eggs on the silks of early and late corn.

The cotton crop was, on the whole, planted at or before the normal date, and in most fields a fair crop of bolls had so matured by early August as to be exempt from bollworm attack in the presence of abundance of more tender bolls and squares. While complaint of injury came from a considerable range of territory, it was not, on the whole, of serious extent, except on late cotton on bottom lands.

In the accompanying map (fig. 1) the shaded area marks approximately the territory infested in 1904. The average annual injury to the cotton crop of the South, mostly confined to the western part of the cotton belt, is probably not less than $11,500,000.

PLAN AND SCOPE OF INVESTIGATION.

The present bollworm investigation has been conducted largely in exas, in view of the seriousness of the depredations of the pest in ıat State. The work was begun in the spring of 1903 and has conıued to the end of the year 1904. The investigation has been proseıted both in the laboratory and in the field. During 1903 headquarters ere established at Victoria, Tex., where office and other facilities ere available in the building occupied by the force engaged in cotton oll weevil investigations. Experiment farms were established at alvert, Wills Point, and Hetty, Tex., covering in all 140 acres. Only ıe entomologist was engaged in the work. The more important sults of the work of 1903 have been given in Farmers' Bulletin No.)1 of this Department. In 1904, by reason of an increased appropriion, the work was considerably enlarged. Headquarters were estabshed at Paris, Tex., where a laboratory was equipped for the study all points likely to throw light on methods of control. Four ıtomologists were continuously engaged in the investigation, and a th during the summer and fall months.

In the field, experiments were conducted largely along the lines llowed in 1903, as follows: (1) To determine the possibility of makg a crop of cotton before the period of greatest bollworm injury, by e early planting of early-maturing varieties of cotton, aided by ferlizers and by thorough cultivation; (2) to determine the value in ollworm control of spraying or dusting cotton with arsenical poisons;) to determine the value of corn as a trap crop in protecting cotton om bollworm injury.

In the prosecution of this work it has been necessary for the Departent to have control of numerous tracts of land, along with labor and rm equipment. These have been secured by means of contracts with anters whereby the planter has been guaranteed a satisfactory yield cotton in return for the obligation assumed to carry out the epartment's instructions as to the growing and handling of the crop. the course of the investigation, experiment and demonstration rms have been established as follows:

Experiment farms used in work with the bollworm, 1904.

Location.	Plantation of—	Number of acres.
Paris, Tex	L. J. Bankhead	40
Ladonia, Tex	C. T. Jackson	100
Hetty, Tex	Capt. B. D. Wilson	30
Sulphur Springs, Tex	Hon. J. T. Hargrove	50
Pittsburg, Tex	J. F. Harrison	40
Wills Point, Tex	Capt. A. N. Alford	50
Do	O. L. Johnson	40
Shreveport, La	Hon. W. L. Foster	10
Mound, La	Capt. F. L. Maxwell	55
Quinlan, Tex	Joe Smith	30
Terrell, Tex	Demonstration farm of E. H. R. Green.	15

In addition to the 490 acres represented above, numerous smaller areas have been utilized in cooperation with planters, increasing the aggregate to about 600 acres.

On these farms tests have been made of every expedient likely to be of value in circumventing bollworm injury. The scheme as to cultural methods has included the comparison of early-maturing varieties of cotton from the more northern States with local varieties, and of early with late planting; a study of the effect of fertilizers in increasing the crop and in hastening maturity; and a comparison of average cultivation with thorough cultivation under all of the above conditions. Such work, as will at once appear, bears directly on the bollworm question in its relation to the production of an early crop.

The accompanying diagram of a 48-acre field will serve to illustrate the method followed in the solution of the several questions involved. The methods of treatment enumerated have thus been brought into comparison under the uniform conditions as to soil, etc., which are necessary in experimental work of this kind.

Experimental cotton plats of the Department of Agriculture at Ladonia, Tex., 1

Plat 1. Early planted. Early variety. Thorough cultivation. Fertilized.	Plat 2. Early planted. Early variety. Thorough cultivation. No fertilizer.	Plat 3. Early planted. Native seed. Thorough cultivation. No fertilizer.
Plat 4. Early planted. Early variety. Average cultivation. Fertilized.	Plat 5. Early planted. Early variety. Average cultivation. No fertilizer.	Plat 6. Early planted. Native seed. Average cultivation. No fertilizer.
Plat 7. Late planted. Early variety. Thorough cultivation. Fertilized.	Plat 8. Late planted. Early variety. Thorough cultivation. No fertilizer.	Plat 9. Late planted. Native seed. Thorough cultivation. No fertilizer.
Plat 10. Late planted. Early variety. Average cultivation. Fertilized.	Plat 11. Late planted. Early variety. Average cultivation. No fertilizer.	Plat 12. Late planted. Native seed. Average cultivation. No fertilizer.

Experiments designed more particularly to test the effect of several classes of fertilizers were conducted on the principal types of soil in north Texas, and the plan and results of this work on two of them al soils are detailed on a later page. Owing to complications which ould result from the presence of the weevil, these experimental farms ere as much as possible located in sections comparatively free from is pest in Texas.

One feature of the work has been the comparison of varieties of tton with especial reference to their earliness, prolificness, and ality of staple. In all, 75 supposed varieties of cotton have been mpared during the past year.

In the case of insects attacking staple crops, the margin of profit in eir cultivation does not often permit of the employment of remedial asures other than those involving changes or improvements in farm actice. However, the readiness with which cotton may be poisoned th Paris green or other arsenicals, particularly in a dry form, by eans of poison blowers or the primitive but effective method of bags spended from poles, has placed this operation among those which ay reasonably be employed. Considerable attention has been given the matter of testing poisons in bollworm control, both in 1903 and 04. In all cases the plan has been to measure off, say, 20 acres of iform cotton, 10 of which would be poisoned and 10 left as a check. e efficacy of the treatment has been measured by the yield from the spective areas.

No rational plan may be formulated for the control of an insect cept as based on a thorough knowledge of its life and habits. The portance of life-history studies is therefore evident. The labora-y investigations of the past two years have covered all important tures of the biology of the bollworm, confirming many points eady known and enlarging our knowledge of the species. The ermination of the number of generations was effected by the use of arge breeding cage in which corn and cotton were grown exactly in the fields. These observations were checked by rearing experi-nts in the laboratory. The destructive capacity of individual boll-rms was determined repeatedly by confining a larva on a cotton nt under a wire cage. The efficacy of poisons was determined in a all way by the same plan. The effect of the destruction of pupal ls, as would be accomplished by plowing, was determined both for and high temperatures. The length of life cycle and the number stages has been determined for a large series of individuals cover- the entire season. The effect of food on the life and egg laying of moth, the number of eggs deposited by a single female, conditions ich affect their vitality, and many other points have been investigated.

Especial attention has been given to the study of the parasites and daceous enemies of the bollworm, especially as to their value in ping this pest in subjection. It has always been a pleasing propo-on to import from foreign countries the enemies of a pest and ar- se against it in the hope of lessening its destructiveness. Ear the present investigation many foreign entomologists were corresponded with in countries where this species was known to occur in the hope that important enemies of the bollworm might be discovered and imported to this country. No important enemies, however, have been discovered.

SOME RESULTS OF FIELD WORK.

Attention has elsewhere been called to the principal lines of field work. Of first importance is the so-called cultural method, which consists of the employment of all such means as will contribute to the production of an early crop of cotton. This involves especially, (1) the use of seed of early-fruiting varieties; (2) early planting in the spring; (3) early and thorough cultivation; (4) the use of fertilizers to hasten and increase the growth of the plant and the development of fruit.

As has been stated, the cotton crops of Texas and adjacent States have, until recently, been largely produced from native-grown seed often secured from public ginneries and of unknown variety and origin. The accumulated effect of the climate has been to make the crop later and later in maturing, especially in the absence of selection of seed for earliness and other qualities. During years of severe bollworm injury, the insects, upon their migration from ripening corn to cotton in early August, have found but few fields in which the bolls were sufficiently matured and hardened to be unsuitable for food and practically all of the fruit has been subject to attack. The importance of early planting to avoid bollworm injury has long been recognized by planters, but sufficient attention has not been given the matter of using improved varieties of seed and to the adoption of improved farm practices. Many observers have noted that relatively less injury was done by the bollworm and other cotton pests, especially the leaf-worm, to early-planted than to late-planted cotton. Thus Riley, as early as 1885, says:

> Our knowledge of the natural history of Aletia [*Alabama argillacea*] and the ever occurring experiences with its ravages, teach us that the principal and most effective means of prevention is to hasten the maturity of the plant so that a portion of the crop shall be beyond the reach of harm from the more destructive July and August broods of the worm. * * *
>
> Improving the cotton seed in the direction just mentioned can be accomplished principally by careful selection of early varieties of cotton or possibly by introducing seeds from more northern regions. Early planting is to be strongly urged in this connection, although of course it has its drawbacks in the risks of exceptionally late frosts.

Professor Mally, in discussing certain statistics of the comparative injury by the bollworm to early and late cotton in Texas in 1892, says:

> The late cotton, therefore, shows a loss of 50.6 per cent, while the early cotton shows no real loss. This may be taken as an extreme case, but the general principle remains that late cotton receives by far the greater portion of bollworm attack, virtually protecting the cotton fields about it.

bolls, is shown in the following tables, as is also the comparative injury to early and late-planted cotton:

Table I.—*Showing bollworm injury to early-planted and late-planted cotton.*

BOLLWORM INJURY TO EARLY-PLANTED COTTON.

Date of observation.	Locality.	Number of plants examined.	Total injured.							Total uninjured.							Total fruit on plant.	Average percent of injury.	Date of planting.	Variety of seed and kind of soil.
			Squares.	Very small bolls.	One-fourth-grown bolls.	One-half-grown bolls.	Three-fourths-grown bolls.	Full-grown bolls.	Total.	Squares.	Very small bolls.	One-fourth-grown bolls.	One-half-grown bolls.	Three-fourths-grown bolls.	Full-grown bolls.	Total.				
Aug. 9	Ladonia	10	81	56	27	17	2	5	138	65	181	106	53	32	59	446	584	23.6	Apr. 1	King. Black-waxy, wooded.
Aug. 11	Ben Franklin	10	13	16	2	4	0	0	35	308	79	88	51	40	23	584	619	5.6	Mar. 29	Hall. Black-waxy, wooded.
Aug. 12	Quinlan	10	0	5	3	1	2	4	15	9	65	2	3	13	165	257	272	5.5	Apr. 1	King. Post-oak.
Aug. 15	Wills Point	20	15	39	9	0	0	0	63	165	340	141	86	82	397	1,211	1,274	4.9	....do....	King. Gray, prairie.
Aug. 22	Paris	5	3	22	9	10	1	0	45	11	48	13	16	21	79	183	228	19.7	Mar. 30	Big Boll. Black, prairie.
Aug. 31	Almont	10	4	27	8	3	3	0	45	57	123	26	64	153	330	753	798	5.6	Mar. 23	King. Red River bottom.
	Total	65	66	165	58	35	8	9	341	610	781	376	273	341	1,053	3,434	3,775	......		
	Average per cent of injury	......	9.7	19.5	13.3	11.3	2.3	.8	......	......	......	......	......	......	......	......	......	......		

INJURY TO LATE-PLANTED COTTON.

Date of observation.	Locality.	Number of plants examined.	Injured: Squares.	Very small bolls.	One-fourth-grown bolls.	One-half-grown bolls.	Three-fourths-grown bolls.	Full-grown bolls.	Total.	Uninjured: Squares.	Very small bolls.	One-fourth-grown bolls.	One-half-grown bolls.	Three-fourths-grown bolls.	Full-grown bolls.	Total.	Total fruit on plant.	Average percent of injury.	Date of planting.	Variety of seed and kind of soil.
Aug. 9	Ladonia	10	75	76	43	20	2	0	216	221	41	73	52	7	1	395	611	35.3	May 2	King. Black-waxy, wooded.
Aug. 11	Ben Franklin	10	56	55	14	5	1	1	132	221	71	60	82	29	17	430	562	23.5	Apr. 15	Hall. Black-waxy, wooded.
Aug. 12	Quinlan	10	4	29	8	10	4	0	55	88	186	45	74	53	46	492	547	10.0	Apr. 25	Big Boll. Post-oak.
Aug. 15	Wills Point	20	18	54	21	8	6	1	108	291	259	82	70	81	188	969	1,077	10.0	May 2	Rowden. Gray, prairie.
Aug. 22	Paris	5	56	67	13	11	7	3	157	210	53	20	84	50	10	377	534	29.6	May 1	Peterkin. Black, prairie.
Aug. 31	Almont	10	149	81	28	8	1	0	267	602	137	62	38	36	31	906	1,173	23.6	June 2	Fleming. Red River bottom.
	Total	65	358	362	127	62	21	5	935	1,633	747	342	300	256	291	3,569	4,504	......		
	Average per cent of injury	......	17.9	32.6	29.7	15.9	6.7	1.7	......	......	......	......	......	......	......	......	......	......		

TABLE II.—*Comparative injury by bollworm to early-planted and late-planted c...*

Locality.	Early-planted.			Late-planted.			Per cent in favor of early planting.	Kind ...
	Date of planting.	Seed used.	Per cent of injury.	Date of planting.	Seed used.	Per cent of injury.		
Ladonia, Tex	Apr. 1	King	23.6	May 2	King	35.3	11.7	Black-waxy ...ed.
Ben Franklin, Tex.	Mar. 19	Hall	5.6	Apr. 15	Hall	23.5	17.9	Do.
Quinlan, Tex	Apr. 1	King	5.5	Apr. 25	Gin	10.0	4.5	Post-oak.
Wills Point, Tex	Mar. 30	...do	4.9	May 2	Rowden	10.0	4.1	Gray, prair...
Paris, Tex	...do	Gin	19.7	May 1	Gin	29.6	9.9	Black prair...
Almont, Tex	Mar. 23	King	5.6	June 2	Fleming	23.6	18.0	Red River ...
Average of all observations.			9.3			20.7	11.4	

It will be noted that in determining the percentages of inj... observations were made on early and late cotton in the same loc... and on the same date as shown in Table I, so that the comparison... quite fair. The average total injury to early cotton was 9.3 per c... as compared with an average total injury of 20.7 per cent to l... cotton. This difference is undoubtedly less than would be the c... during seasons of more severe injury than occurred in 1904. T... decided preference of the bollworm for squares and young boll... shown in the figures of average percentages of injury given in t... tables. Thus the sum of the percentages of injury, as shown in... tables, to squares and bolls one-half grown or less is 149.7, whil... bolls from three-fourths to full-grown the percentages of injury ... aggregate 11.5.

Many detailed observations have been made during the cour... the present investigation bearing out the above statements, and ... as to the comparative freedom of early cotton from bollworm in... have been gathered. This fact has been the basis of one of the p... cipal lines of experimental work.

For the completeness of experiments, the presence in injur... numbers of the bollworm has been necessary. Unfortunately, f... an experimental point of view, the injuries of this species during ... on the several experiment farms were not sufficiently marked to ... made the tests as thorough as could be desired. However, the co... erable amount of data collected throughout the season on the ef... of the several methods of treatment, and the final results, as show... the weights of cotton produced, are none the less valuable as indi... ing the relation of such work to the production of an early crop

WILLS POINT FARM.

The experimental farm at Wills Point, Tex., on the plantation of ... O. L. Johnson, was located on a typical gray prairie soil of that ı. The land had been in cotton for the three preceding years, and productiveness was considered to be one-third of a bale per acre. : accompanying plan illustrates the arrangement and treatment of eight 5-acre plats of this experimental farm, together with the yield.

Experimental cotton plats of Department of Agriculture at Wills Point, Tex., 1904.

Plat I. Five acres. Planted March 30, King seed. Fertilized, C. B. G.[a], 400 pounds per acre. Cultivated 8 times. Hoed 4 times. ield, pounds seed cotton per acre, 986.6.	Plat V. Five acres. Planted April 1, King seed. Unfertilized. Cultivated 8 times. Hoed 4 times. Yield, pounds seed cotton per acre, 765.
Plat II. Five acres. Planted March 30, King seed. 'ertilized, R. A. P.[b], 300 pounds per acre. Cultivated 8 times. Hoed 4 times. ield, pounds seed cotton per acre, 995.6.	Plat VI. Five acres. Planted April 1, King seed. Fertilized, R. A. P.[b], 300 pounds per acre, plus dressing of nitrate of soda, 100 pounds per acre, when plants had 4 to 6 leaves. Cultivated 8 times. Hoed 4 times. Yield, pounds seed cotton per acre, 852.4.
Plat III. Five acres. Planted March 30, King seed. Unfertilized. Cultivated 8 times. Hoed 4 times. ield, pounds seed cotton per acre, 736.4.	Plat VII. Five acres. Planted April 1, King seed. Fertilized, A. P. & P. M.[c], 300 pounds per acre. Cultivated 8 times. Hoed 4 times. Yield, pounds seed cotton per acre, 831.4.
Plat IV. Five acres. Planted March 30, King seed. rtilized, A. P. & P. M.[c], 400 pounds per acre. Cultivated 8 times. Hoed 4 times. ield, pounds seed cotton per acre, 974.	Plat VIII. Five acres. Planted May 2, Rowden seed. Unfertilized. Cultivated 4 times. Hoed 2 times. Yield, pounds seed cotton per acre, 675.4.

. B. G.—A commercial cotton boll guano; analysis—available phosphoric acid, 8 per cent; potash, cent; nitrogen, 2 per cent.

. A. P.—A commercial acid phosphate; analysis—available phosphoric acid, 14 per cent.

. P. & P. M.—An acid phosphate and potash mixture; analysis—available phosphoric acid, 13.79 cent; potash, 4.65 per cent.

More detailed figures are given in the following table:

TABLE III.—*Showing treatment of and results from plats on bollworm experiment of Department of Agriculture at Wills Point, Tex., 1904.*

Plat number.	Variety of cotton.	Fertilizer and quantity used per acre.	Date of planting.	Number of times cultivated.	Number of times hoed.	Yield per acre in pounds of seed cotton.	Increase per acre in pounds of seed cotton as compared with Plat VIII.	Value of increase per acre at 3.[illegible] cents per pound seed cotton as compared with Plat VIII.	Cost of fertilizer per acre.
I	N. C. King..	C. B. G., 400 pounds.	Mar. 30	8	4	986.6	311.2	$11.47	[illegible]
II	.....do......	R. A. P., 300 pounds.	....do...	8	4	995.6	320.2	11.81	[illegible]
III	.....do......	Unfertilized.........	....do...	8	4	736.4	61.0	2.24	..
IV	.....do......	A. P. and P. M., 400 pounds.	....do...	8	4	974.0	298.6	11.01	[illegible]
V	.....do......	Unfertilized.........	Apr. 1	8	4	765.0	89.6	3.30	...
VI	.....do......	R. A. P., 300 pounds; sodium nitrate, 100 pounds.	....do...	8	4	852.4	177.0	6.53	[illegible]
VII	.....do......	A. P. and P. M., 300 pounds.	....do...	8	4	831.4	156.0	5.75	[illegible]
VIII	Rowden....	Unfertilized.........	May 2	4	2	675.4	....	....	...

Aside from the yields of cotton, the influence of the several t[illegible] ments on the fruiting of the plant was determined by actual c[illegible] of all the fruit on 20 plants for each plat, on several different d[illegible] during the season.

Vigorous, well-branched plants were selected in various part[illegible] each plat. These plants were not marked, and consequently a di[illegible] ent set of plants was used each time the counts were made. The [illegible] age was determined in this way five times during the summer, at i[illegible] vals of about sixteen days. The first count was made on Ju[illegible] square production having just begun; the last on August 15, [illegible] the bolls were beginning to open.

The prime object in making these records was to determine th[illegible] ative earliness of fruit production, (1) with King seed, early pla[illegible] fertilizers, and thorough cultivation; (2) with King seed, early [illegible] ing, no fertilizer, and thorough cultivation, and (3) with Ro[illegible] (native) seed, late planting, no fertilizer, and ordinary culti[illegible] The records made on plants grown under the conditions named [illegible] last group are used as a basis of comparison.

BLE IV.—*Showing rate of fruiting on respective plats of bollworm experiment farm of Department of Agriculture at Wills Point, Tex., 1904.*

'lat nber.	Date of exami-nation.	Aver-age num-ber of squares per plant.	Average number of bolls per plant.				Average increase per plant in number of—				
			One-fourth grown.	One-half to three-fourths grown.	Full-grown.	Open.	Squares as com-pared with plat 8.	One-fourth-grown bolls as com-pared with plat 8.	One-half to three-fourths grown bolls as com-pared with plat 8.	Full-grown bolls as com-pared with plat 8.	Open bolls as com-pared with plat 8.
I	June 9	6 3/20	....	....	....	....	5 13/20	....	....	....	....
II	....do...	5 12/20	....	....	....	....	5 3/20	....	....	....	....
III	....do...	2 5/20	....	....	....	....	1 12/20	....	....	....	....
IV	....do...	6 4/20	....	....	....	....	5 12/20	....	....	....	....
V	....do...	3 15/20	....	....	....	....	3 3/20	....	....	....	....
VI	....do...	5 3/20	....	....	....	....	4 18/20	....	....	....	....
VII	....do...	6 1/20	....	....	....	....	5 9/20	....	....	....	....
VIII	....do...	12/20	....	....	....	....	....	....	....	....	....
I	June 23	37 15/20	8/20	1/20	....	....	30 18/20	8/20	1/20	....	....
II	....do...	34 9/20	7/20	1/20	....	....	27 4/20	6/20	1/20	....	....
III	....do...	20 1/20	1/20	....	....	....	12 18/20	1/20	....	....	....
IV	....do...	32 9/20	3/20	....	....	....	25 4/20	3/20	....	....	....
V	....do...	20 17/20	2/20	....	....	....	13 12/20	2/20	....	....	....
VI	....do...	31 6/20	4/20	....	....	....	24 1/20	4/20	....	....	....
VII	....do...	32 7/20	6/20	1/20	....	....	25 2/20	6/20	1/20	....	....
VIII	....do...	7 5/20	....	....	....	....	....	....	....	....	....
I	July 9	100 9/20	5 4/20	2 14/20	2/20	....	65 2/20	3 18/20	2 14/20	2/20	....
II	....do...	73 9/20	3 14/20	1 4/20	....	....	38 2/20	2 8/20	1 4/20	....	....
III	....do...	51 7/20	2 13/20	6/20	....	....	16	1 7/20	6/20	....	....
IV	....do...	89 14/20	5 8/20	18/20	....	....	51 7/20	4 2/20	18/20	....	....
V	....do...	44 17/20	2 15/20	1/20	....	....	9 10/20	1 12/20	1/20	....	....
VI	....do...	74	4 15/20	1/20	....	....	38 13/20	3 9/20	1/20	....	....
VII	....do...	84 11/20	8 7/20	1 1/20	2/20	....	49 4/20	7 1/20	1 1/20	2/20	....
VIII	....do...	35 7/20	1 6/20	....	....	....	....	....	....	....	....
I	July 25	64 9/20	21 1/20	18 4/20	9 17/20	....	2 5/20	12 18/20	15 2/20	9 8/20	....
II	....do...	67	18 9/20	12 2/20	9 3/20	....	4 18/20	2 4/20	9	8 14/20	....
III	....do...	76 13/20	10 7/20	6 18/20	5 3/20	....	14 13/20	2 4/20	3 18/20	4 14/20	....
IV	....do...	99 11/20	17 15/20	9 18/20	8	....	37 19/20	9 13/20	6 18/20	7 11/20	....
V	....do...	59 6/20	12 9/20	5 15/20	4 11/20	....	−2 15/20	4 5/20	2 13/20	4 1/20	....
VI	....do...	82 8/20	19 13/20	9 13/20	7 2/20	....	20 4/20	11 13/20	6 11/20	6 13/20	....
VII	....do...	70 14/20	23 9/20	11 18/20	8	....	8 13/20	15 3/20	8 19/20	7 11/20	....
VIII	....do...	62 1/20	8 3/20	3 2/20	9/20	....	....	....	....	....	....
I	Aug. 15	4 4/20	3 12/20	8 4/20	12 8/20	6 11/20	−10 7/20	−7	11/20	4 7/20	5 9/20
II	....do...	10 14/20	10 14/20	8 7/20	16 5/20	3 7/20	−3 7/20	9/20	14/20	8 4/20	2 2/20
III	....do...	14 14/20	15 18/20	8 9/20	14 13/20	1 18/20	3/20	4 18/20	12/20	6 11/20	13/20
IV	....do...	6 10/20	12 13/20	8 9/20	16 5/20	4 11/20	−8 13/20	2 1/20	10/20	8 4/20	3 9/20
V	....do...	8 11/20	9 8/20	8 4/20	18 1/20	1 18/20	−5 17/20	−1 4/20	11/20	10	11/20
VI	....do...	12 1/20	10 15/20	9 1/20	15 14/20	3 12/20	−2 10/20	3/20	1 7/20	7 13/20	2 14/20
VII	....do...	2 18/20	9 3/20	8 10/20	13 4/20	3 12/20	−11 13/20	−1 9/20	17/20	5 3/20	2 7/20
VIII	....do...	14 11/20	10 13/20	7 13/20	8 1/20	1 5/20	....	....	....	....	....

he counts made on the several dates plainly show that the plats in first group, that is, Nos. I, II, IV, VI, and VII, had a decided intage over the others in earliness of fruit production; those in second group, that is, Nos. III and V, were about intermediate, le No. VIII fell far behind all the others. Plats of the first group hed their maximum square production about July 9; those in the nd group about two weeks later; and plat VIII about a week later the second.

he decided uniformity of the results of the counts on the several s is noteworthy; also their conformity with the earliness as shown by the first picking. The total weight of the cotton picked from the several plats bears out the results of the counts, for it is noticeable that the maximum square production on the unfertilized plats never reached as high as on those which were fertilized, and Plat VIII, which had ordinary treatment, was considerally below Plats III and V, unfertilized, but which were planted with King seed and thoroughly cultivated. The same effects are noticeable in the maximum boll production.

Bolls which are full grown by August 15, as shown by counts of injured and uninjured fruit, are practically safe from bollworm injury; hence the advantage of early-fruiting varieties, early planting, fertilizers, and thorough cultivation may be readily seen: for on the above date Plats I, II, IV, VI, and VII show an average of $19\frac{1}{5}$ bolls per plant, which would be practically out of danger of bollworm injury. Of these $19\frac{1}{5}$ bolls there was an average of $4\frac{9}{20}$ bolls per plant open on that date. Plats III and V show an average of $18\frac{3}{20}$ bolls per plant practically out of danger, an average of $1\frac{7}{20}$ of these being open. Plat VIII had $9\frac{3}{10}$ bolls per plant out of danger, or less than half the number which on the fertilized plats would be quite sure of escaping bollworm injury.

PITTSBURG FARM.

The experimental farm at Pittsburg, Tex., on the plantation of Mr. J. F. Harrison, was located on a typical sandy soil of that section. It was supposed that fertilizers would exert considerable influence on the production of cotton on a soil of this character, and this feature of the work was emphasized. The land used was said to have been in cultivation continuously for the past sixty years. In 1902 it was planted to corn and in 1903 to cotton. The productiveness of the land was considered to be one-fourth bale per acre.

The accompanying plan shows the treatment of, and the results from, the respective plats involved in this fertilizer experiment:

Experimental cotton plats of the Department of Agriculture at Pittsburg, Tex., 1904.

Plat I. Five acres. Hetty seed. Planted April 13. Fertilized, R. P. C.[a] 300 pounds per acre. Cultivated 8 times. Hoed 3 times. Yield, pounds seed cotton per acre, 1,403.8.	Plat III. Five acres. Hetty seed. Planted April 13. Fertilized, R. A. P.[c] 320 pounds per acre. Cultivated 8 times. Hoed 3 times. Yield, pounds seed cotton per acre, 1,202.8.
Plat II. Five acres. Hetty seed. Planted April 13. Fertilized, C. B. G.[b] 400 pounds per acre. Cultivated 8 times. Hoed 3 times. Yield, pounds seed cotton per acre, 997.8.	Plat IV. Five acres. Hetty seed. Planted April 13. Unfertilized. Culivated 8 times. Hoed 3 times. Yield, pounds seed cotton per acre, 694.

[a] R. P. C.—A commercial potash compound, analyzing—available phosphoric acid, 10 per cent; pot-ash, 2 per cent.

[b] C. B. G.—A commercial cotton boll guano, analyzing—available phosphoric acid, 8 per cent; potash, ...r cent; nitrogen, 2 per cent.

[c] R. A. P.—A commercial acid phosphate, analyzing—available phosphoric acid, 14 per cent.

The comparative earliness of the crop, the increase and value of the same, and the net gain by the use of fertilizers are shown more in detail for the respective plats in the table below:

TABLE V.—*Showing treatment of, and results from, plats in Department of Agr[illegible] bollworm experimental farm at Pittsburg, Tex., 1904.*

Plat number.	Variety of cotton.	Fertilizer and quantity used per acre.	Date of planting.	Times cultivated.	Times hoed.	Yield per acre in pounds of seed cotton.	Weights of seed cotton picked—August 29–30.	September 7–19.	September 23–October 3.	October 10–28.	November 23–26.	Increase per acre in pounds of seed cotton as compared with Plat IV.	Value of increase per acre at 3.814 cents per pound seed cotton.	Cost of fertilizer per acre.	Net gain.
I	Hetty.	300 pounds. R. P. C.	Apr. 13	8	3	1,403.8	148.6	358.8	397.4	375.6	123.4	709.8	$23.[illegible]	$3.[illegible]	[illegible]
II	...do..	400 pounds. C. B. G.	...do...	8	3	997.8	158.6	340.6	266.4	162.2	70.0	303.8	10.07	4.[illegible]	[illegible]
III	...do..	320 pounds. R. A. P.	...do...	8	3	1,202.8	232.0	499.0	307.2	125.8	38.8	508.8	16.86	[illegible]	[illegible]
IV	...do..	Unfertilized.	...do...	8	3	694.0	.....	377.0	.....	297.6	19.4	.....	.....	...	
Average price per pound lint cotton							11$\frac{1}{16}$	10$\frac{7}{16}$	10$\frac{3}{16}$	9$\frac{11}{16}$	9$\frac{3}{16}$	.....	.....	...	

Plats I and IV are compared graphically with respect to earliness and yield in figure 2.

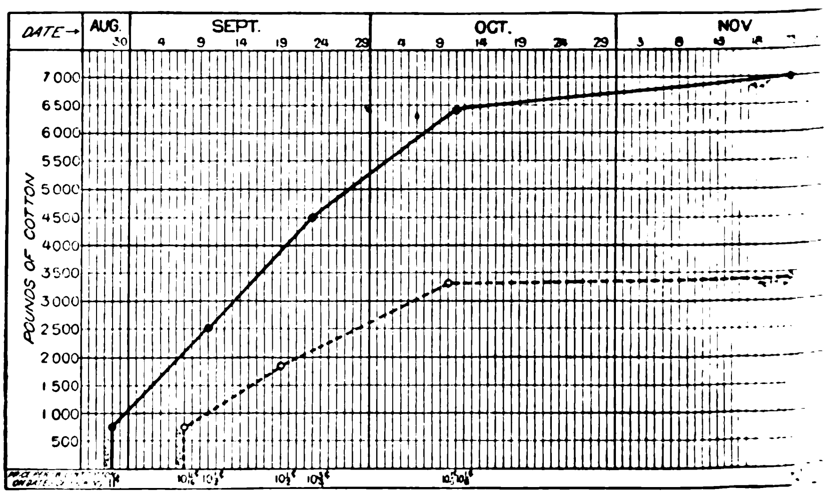

FIG. 2.—Diagram comparing Plats I and IV of the Pittsburg (Tex.) farm, fertilized and unfertilized respectively, with regard to earliness and yield of seed cotton.

In connection with the above results as to final yield should be considered certain data relative to the rate of fruit production during the season as determined by counts on different dates on 20 plants on each plat. The important results of these counts are indicated in the following table:

TABLE VI.—*Showing rate of fruiting on respective plats of Department of Agriculture's bollworm experimental farm at Pittsburg, Tex., 1904.*

Plat number.	Dates of examination.	Average number of squares per plant.	Average number of bolls per plant.				Average increase per plant in number of—				
			One-fourth-grown.	One-half to three-fourths-grown.	Full-grown.	Open.	Squares as compared with Plat IV.	One-fourth-grown bolls as compared with Plat IV.	One-half to three-fourths-grown bolls as compared with Plat IV.	Full-grown bolls as compared with Plat IV.	Open bolls as compared with Plat IV.
I	June 24	21 6/20	....	....	....	....	9 16/20	....	....	....	....
II	....do ...	19 9/20	....	....	....	....	7 18/20	....	....	....	....
III	....do ...	21 11/20	....	....	....	....	10 1/20	....	....	....	....
IV	....do ...	11 13/20	....	....	....	....	....	....	....	....	....
I	July 13	62 3/20	2 18/20	1 11/20	1/20	....	16 12/20	14/20	1	1/20	....
II	....do ...	73 6/20	4 4/20	1 13/20	3/20	....	27 14/20	2	1 2/20	3/20	....
III	....do ...	61 13/20	4 4/20	1 3/20	....	....	16 3/20	2	12/20	....	....
IV	....do ...	45 11/20	2 4/20	11/20	....	....	....	....	....	....	....
I	July 28	81 11/20	16 3/20	5 18/20	4 12/20	....	15 3/20	5 7/20	1 12/20	2 7/20	....
II	....do ...	90 18/20	14 11/20	5 15/20	5 9/20	....	24 2/20	3 16/20	1 9/20	3 5/20	....
III	....do ...	103 17/20	12 5/20	6 5/20	4 11/20	....	37 9/20	1 9/20	1 18/20	2 9/20	....
IV	....do ...	66 7/20	10 18/20	4 7/20	2 5/20	....	....	....	....	....	....
I	Aug. 18	25 18/20	16 3/20	15 5/20	9 5/20	18/20	−8 6/20	1 9/20	3 17/20	4 11/20	7/20
II	....do ...	31 9/20	20 11/20	13 14/20	10 18/20	4/20	−2 8/20	5 18/20	2 6/20	5 16/20	1/20
III	....do ...	36 12/20	17 3/20	13 18/20	5 19/20	19/20	3 3/20	2 7/20	2 10/20	16/20	13/20
IV	....do ...	33 18/20	14 15/20	11 8/20	4 14/20	3/20	....	....	....	....	....

UMMARY REMARKS CONCERNING THE EXPERIMENTS WITH CULTURAL METHODS.

In the case of field experiments involving questions of the character f those presented above, final conclusions may not be drawn as the esult of one or even several years' tests. Variations in seasons and ther conditions often produce results one year not verifiable the next; nd what appears desirable for one character of soil may not be useul on another. The writers would, therefore, be entirely unwarانted in making specific recommendations, especially as regards the se of certain fertilizer elements, on the data secured in the course of ıst year's investigation.

Certain general statements are, however, apparently warranted. At ıe Pittsburg, Wills Point, and other experimental farms the use of ertilizers resulted in a notably earlier and larger crop of cotton, as ompared with the unfertilized check plats.

On soils deficient in one or more of the three principal elements of lant food, namely, phosphoric acid, nitrogen, and potash, the appliation of the needed element or elements results in a more rapid and larger growth of the plant and a consequent earlier and greater production of squares. It would appear that herein lies the principal value of fertilizers, as related to the production of an early crop.

On the Pittsburg farm, attention is called to the larger and earlier yields obtained from the use of a fertilizer containing 10 per cent of phosphoric acid and 2 per cent of potash, and from the use of 14 per cent acid phosphate alone, as compared with a complete fertilizer analyzing, phosphoric acid 8 per cent, nitrogen 2 per cent, and potash 2 per cent. On the Wills Point farm the largest yield was obtained from the use of 14 per cent acid phosphate. Plats I, II, and IV, however, show approximately the same total yield. The comparative earliness may be indicated from the following weights of seed cotton picked by August 26: Plat I, 2,325 pounds; Plat II, 2,029 pounds; Plat IV, 2,554 pounds. This gives again a slight balance in favor of an acid phosphate and potash fertilizer as to earliness of crop. It may also be mentioned here that in the fertilizer experiments in 1904, on the plantation of Capt. B. D. Wilson, Hetty, Tex., on rich "bottom" soil, the use of 400 pounds per acre of a phosphoric acid and potash mixture gave a considerably larger early and total yield of cotton than did the use of 300 and 450 pounds per acre, respectively, of phosphoric acid. The first picking from phosphoric acid and potash mixture plats, September 3, was 499 pounds seed cotton per acre. From the plat treated with 300 pounds acid phosphate, 354⅔ pounds of seed cotton per acre were secured; and from the plat receiving 450 pounds of acid phosphate the yield was 355⅓ pounds of seed cotton per acre. The total yield of seed cotton per acre from the respective plats was 1,387⅔ pounds, 1,153 pounds, and 1,280⅔ pounds.

It is, however, only intended to point out the usefulness, in general, of employing fertilizers in a system of cotton culture designed to produce a crop ahead of bollworm injury. The exact character of the fertilizer and the quantity per acre to be used are matters of further experimentation. The previously tabulated data in regard to fertilizers should furnish planters with a basis for experimentation by which they will finally arrive at conclusions true for their respective soils.

Of equal importance in the production of early cotton is the use of varieties with an inherent tendency to begin fruiting early in the growth of the plant, or low on the plant, and on which the joints are short. Observant planters need not be told of the great difference in fruiting habit of different varieties of cotton. The long-limbed sorts are necessarily later in setting squares, and they are also less productive than those with shorter joints. The desirable qualities, as early fruiting, good staple, etc., may be perpetuated and improved by seed selection. Seasonal conditions, such as a shorter growing season, have led, in the northern part of the cotton belt, to the use of early-fruiting, prolific varieties in those sections. Seed of such varieties, especially the King s recently been extensively planted in Texas on account of these aracteristics, in both the bollworm and boll weevil infested regions. ie importance of the use of selected early-fruiting varieties, as compared with the native "run-down" gin seed, was well illustrated in e investigations during 1903. On the plantation of Capt. B. D. Wiln, at Hetty, Tex., under conditions of severe bollworm injury, early anted King seed produced an average of 1,348 pounds per acre of ed cotton, as against 187 pounds per acre of early-planted but lateituring gin seed. The advantage of early planting is emphasized results secured on various farms. On the Wilson farm in 1903 rly-planted King with thorough cultivation gave 1,348 pounds seed tton per acre, as compared with 360 pounds per acre from late-planted ng also with thorough cultivation.

Early and thorough cultivation is another important factor in the oduction of early cotton. Plants should be chopped out as early as acticable to admit of free branching and consequent square proction. The fertility of the soil, either native or introduced by ans of fertilizers, may be used by plants only in solution. Conseently, for the conservation of moisture and other reasons, timely d frequent cultivations are of the utmost importance.

TRAP CROPS.

Attention has been elsewhere called to the decided preference of llworms for corn as compared with other plants upon which it is own to feed. This preference permits of the use of corn in a way culated to protect cotton from injury.

The corn should be planted in belts through the cotton field at a ie that will result in its being in tassel and silk about the first of igust. By this time moths are developing from larvæ matured in roasting ears of neighboring corn which has now begun to ripen d is no longer attractive to the moths for egg-laying purposes. In natural course of events, the moths migrate to cotton fields, where y deposit the bulk of their eggs. Finding these belts of corn in sel and silk, however, they deposit on them the greater part of their gs, and correspondingly neglect the cotton plants. The September neration of larvæ is sometimes a source of considerable injury, ecially to very late cotton. Corn may easily be brought into silk as to attract moths of this generation by planting only a porn of the belts through the cotton fields at the time of first planting d then completing the work two or three weeks later. The same sults may be secured by planting patches of corn here and there over plantation, following crops of oats, wheat, or Irish potatoes. wpeas are very attractive to bollworm moths, owing to their fonds for the nectar profusely secreted by this plant. Thus the corn trap rows may be made more effective by planting rows of peas alternately with rows of corn. The peas should come into full bloom at the time the corn is silking. This will necessitate planting the peas about the time the corn appears above the ground. The advantage gained by the use of trap crops can not be expressed in pounds of seed cotton, as it is impossible to arrange a test so that the area left for comparison will be subjected to the same conditions without having it adjacent and consequently equally subject to protection by the corn. The worm moths fly freely, and are therefore attracted to fresh corn from a considerable distance, and the influence of the trap rows is thus quite general.

During 1903 tests of corn trap crops for protecting cotton against the more destructive August generation of bollworms were made at Calvert and Wills Point, Tex. Early in August the number of eggs upon 8 typical plants in the trap rows at Wills Point was found to be, on an average, 495 per plant, 804 eggs being the maximum number found on a single plant. No account was taken of eggs deposited on plants previous to or succeeding this time. From these figures some idea may be gained of the vast number of eggs which are thus diverted from cotton. In 1904 tests of corn as a trap crop were made at Sulphur Springs, Quinlan, and Hetty, Tex., and at Shreveport, La. The same general plan was carried out in all the above localities, protection from the August brood only being sought. Belts from 10 to 40 feet wide extending across the field were left unplanted at the time of planting cotton, and these were seeded to Mexican June corn by June 1 in rows from 5 to 6 feet apart. Ten days later cowpeas were planted between the rows of corn, thus leaving ample room for cultivation. The corn was planted in about the proportion of 10 rows to 40 rows of cotton, and the individual fields varied from 20 to 40 acres.

The following table, computed from counts made of the number of eggs on 20 typical plants in trap rows on the farm of Mr. J. T. Hargrove, Sulphur Springs, Tex., will give an idea of the number of eggs kept from the cotton by a few acres of trap corn. The figures show the average number of eggs for each plant and the average number on the various portions of the plants:

TABLE VII.—*Distribution and average number of bollworm eggs on corn.*

Date of examination.	Number of eggs on—					Condition of corn.
	Entire plant.	Leaves.	Sheaths.	Tassels.	Silks.	
July 28	338.4	88.85	55.55	64.93	129.1	Many plants not in silk.
August 16	52.55	12	7.85	10.8	21.9	Corn in roasting-ear, drying.

ing a year of greater bollworm abundance the number of eggs ould be deposited on corn would doubtless far exceed the numere given. The number of eggs occurring on an acre of trap t one time, as based on the above figures, is surprisingly great. the average number of eggs per plant on July 28, as given in le, the protection afforded by the plants on a single acre may be ted in a theoretical way. Assuming the corn rows to be 6 feet nd the plants 1½ feet apart in the row, there would be on an 40 plants. On the average of 338.4 eggs per plant, as found here would be 1,637,856 eggs distributed over the acre of corn. ies of observations it has been determined that a single bolleding freely on cotton will destroy on an average 8 squares, 1 nd 1¾ bolls during the course of its growth. Assuming that e fruit destroyed would have eventually matured, there would l destruction of 17,470,464 bolls. On an average of 70 bolls ound of seed cotton, this would mean a destruction of 249,578 of cotton in the seed, or at the rate of 1,500 pounds seed cotton le, 166 bales.

st be remembered, however, that in the above calculations it umed that from every egg a mature larva would develop. uld be far from the case in reality. In fact it has been l that on an average but one larva reaches maturity from eggs deposited on corn. It was further assumed that all of res and flowers injured would have otherwise reached maturity, fact would not be the case, as many squares and young bolls by the plants on account of unfavorable weather or other con- However, after making due allowance for all of these condie benefits to be derived from a proper use of corn as a trap seen to be very great.

ght appear at first sight that the practice of furnishing the n with an abundance of its preferred food would simply result eater increase and consequent destructiveness. This, however, result, for when the eggs are concentrated on the corn plants, e silks, they are very largely destroyed by a certain parasite redaceous enemies, and the larvæ hatching from these eggs are killed by the cannibalistic habits of the bollworms themselves. some 15 to 30 young larvæ which may usually be found in a silked ear of corn, but one or two bollworms will eventually aturity.

rous instances have come under the observation of the writers lanters, in attempting to make use of trap crops, have made ake of planting the corn at the usual time in the spring. The s been, that the cotton has suffered greater injury than would se have occurred. The success of the trap crop idea as here considered depends entirely on having the corn in tassel and silk on or about the first of August, and it must be planted considerably later than the normal time of planting corn in the spring. June corn planted the last of May or first of June, with good cultivation, will be silking and tasseling freely by August 1.

The greatest benefit will come from the use of corn as a trap crop in its general adoption by the planters of a neighborhood. In the case of large plantations it is quite possible to adopt a system of growing late corn, after oats, wheat, or other early-maturing crops, which will attract the bollworms from the plantation generally. An instance of this practice may be cited on the plantation of Mr. F. L. Maxwell, of Mound, La. It has been the practice of this gentleman to grow small areas of late corn after oats here and there over the plantation to the almost complete protection of his large cotton crop.

USE OF ARSENICAL POISONS.

The opinion prevails more or less generally among cotton planters that the bollworm may not be successfully poisoned, by reason of the fact that it bores to the interior of squares and bolls, and does not feed on the exterior parts of the plant to any extent. Such a belief is true only of the later stages of the larva. The average planter seldom has his attention attracted by so small a creature as a newly hatched bollworm, and it thus results that the habits of the insect during its early larval existence are practically unknown to him. This unobserved period in the development of the larva is the only time when poison may be expected to exert any considerable influence in bollworm control.

From extended studies of the egg-laying habits of the moth and the actions of the newly-hatched larvæ there is every reason to believe, on theoretical grounds, that, by the application of poison to cotton about the time the eggs of the large August generation begin to hatch, the injury from this insect may be greatly reduced. A series of observations made during the summer of 1903 on the distribution of eggs on cotton plants, as determined by watching the moths while ovipositing, showed that 73 per cent of the eggs were so placed that the resulting larvæ would be readily susceptible to poison. By carefully examining several plants, 65 per cent of the eggs were found to be on other parts than the squares, flowers, and bolls. During 1904 similar records were made by watching the moths ovipositing in cotton fields. The combined record of 25 moths is given below:

Distribution of bollworm eggs upon cotton plants.

	Eggs.
Leaves, upper surface	191
Leaves, lower surface	194
Squares	326
Flowers	110
Bolls	120
Growing tips	46
Stems	64
Petioles	29
Weeds	20
Objects on ground	21
Dead leaves	20

The total number of plants oviposited on by these 25 moths was 175. All larvæ hatching from eggs deposited elsewhere than on e squares and flowers may, for reasons to be given, be considered capable of destruction by poison. Therefore, of the 1,141 eggs posited, 705, or about 62 per cent, would fall in this class.

On account of the important bearing on the subject of poisoning, before mentioned, the habits of the newly hatched larvæ have been ite carefully studied. Immediately upon its escape from the egg e little larva devours its deserted egg-shell and soon afterwards gins a restless search for food. If it hatches from an egg placed on a square or flower, it may soon effect an entrance, but if situated ewhere, as on a leaf, it may wander about here and there, fre- ently tasting or rasping the epidermis of the leaf or other portion the plant where it may be, in its efforts to find suitable food.

This apparently aimless search is often continued for several hours. e same path is often crossed and recrossed many times with short ervals of surface feeding along the way. Many of these minute væ perish in their attempts to find suitable food; others succeed in ching some tender-growing portion of the plant, as the terminal d of unfolded leaves, which is soon penetrated. Although consid- ble traveling may be done later in the search for fresh food, but tle food is taken on the surface. Larvæ which hatch from eggs ced upon bolls may rasp the epidermis but are unable to enter except case of the smallest bolls. Therefore these, as well as larvæ from gs placed upon the leaves, petioles, stems, etc., are compelled to ek more tender portions. This period of what might be called ternal feeding varies greatly in different individuals, lasting, as a le, probably from a few hours to a day, or even more.

Considering the above facts, the necessity of applying poisons at e proper time is apparent. No arbitrary date may be given, owing the variability of the time at which the larvæ begin to hatch in structive numbers in different localities. However, the planter may termine this time approximately by careful observation. When moths are seen to be present in any considerable numbers in cotton fields, the poison should be applied immediately. The moths do not become abundant in the fields, as a rule, until the August generation appears, which is during the last few days of July or the first week of August. As has been stated, poisons should be applied when the eggs begin to hatch in numbers, about the first of August, and not when the larvæ have attained considerable size, as they have three weeks later. The first application should be made, as a rule, about the last of July, and should be repeated in about a week or ten days. In case of rain following an application, it should be repeated immediately. Sometimes a third treatment at a later date is desirable. When the dusting method is employed, the application should be made early in the morning or after a shower, as the moisture on the plants is important to retain the dust as it comes in contact with the foliage and other parts.

To illustrate the efficiency of poison when applied at the proper time in killing newly hatched larvæ, the following is of interest: The results were obtained by Mr. C. T. Brues in a small experiment conducted at the laboratory at Paris, Tex. On September 17, two plants which were squaring freely were covered with wire screen cages, one plant having previously been lightly dusted with paris green diluted with dry slaked lime. About 200 hundred eggs which were ready to hatch were placed upon each plant. Observations were made each day of the number of fruits injured until October 16, when all of the surviving larvæ had entered the soil to pupate. Only 1 square was injured during this period on the poisoned plant, while on the unpoisoned check plant 31 squares, 2 flowers, 12 small and large bolls were destroyed. Notwithstanding the fact that there were heavy rains during the nights of September 20 and 21, the destruction of the larvæ by one application was practically complete. In these instances the larvæ all hatched practically at the same time and shortly after the poison had been applied. Such uniformity in hatching would not be the case in the field, and therefore such complete extermination could not be expected.

As between the dusting and spraying methods of applying poisons the former seems more practicable. The main objection to the use of a spray is the difficulty usually found in securing water in proximity to fields, and the greater time required in the application of poison in liquid condition. Geared machinery may be secured for poisoning by either method, but the rather primitive way so largely used in combating the cotton caterpillar, by dusting the poison through bags tied to each end of a pole and carried by a man on horseback, has a decided advantage on account of cheapness of apparatus. By this means 20 to 25 acres may be poisoned during the few hours suitable for the work in the early morning and late evening. Where the poison usted over the plants, from 2 to 3 pounds of Paris green should ›ed per acre, and in spraying the poison should be used at the rate of pound to each 50 gallons of water. Fifty gallons of water will ›ray approximately 1 acre of cotton.

In purchasing poisons reliable brands should be insisted upon. 'here large dusting machines are used, it will be more economical to ix the Paris green with 3 or 4 times as much flour, or even more, · with sifted, dry, or air-slaked lime.

During the summer of 1903 very favorable results were obtained in ›ison experiments at Hetty and at Calvert, Tex., by reason of the ·eat abundance of bollworms at that time. At Hetty, Paris green as applied by means of bags on a pole. In this case a net gain of .79 per acre was realized. At Calvert, Paris green was applied ›th as a spray and in the dust form. By the former method a net in of $6.99 was secured, and by the latter a net gain of $4.44. lthough several experiments were conducted during the season of 04, no decided results were obtained owing to the more general sence of bollworms in destructive numbers.

In north Texas especially, there is a decided prejudice on the part cotton pickers against picking cotton from fields that have been isoned. Several reported instances of fatal poisoning, through cuts sores on the hands, are cited in support of these objections. The ·iters have investigated several of these reports of poisoning, and evidence has been found to warrant the conclusion that there is any nger to pickers from the proper use of poison in bollworm control. ırmony of action in poisoning on the part of planters would largely away with the present prejudice of pickers against this work.

INEFFECTIVE METHODS OF BOLLWORM CONTROL.

Attention has at various times been called to the inefficiency of cer- n methods often used by planters with a view to controlling the llworm. A common error is in the burning of lights to attract and ›troy the moths, and one less frequently employed is the use of isoned sweets placed in pans here and there in the cotton fields.

During the past two years, under varying conditions of weather, th of these procedures have been thoroughly tested. As a result · previously demonstrated futility of such work has been fully veri- l. Attention is called to the uselessness of such operations that the inter may avoid this needless expense.

RECOMMENDATIONS.

The work of the Bureau of Entomology during the past two years › shown that by the adoption of certain cultural expedients, desirable themselves, a satisfactory crop of cotton may be grown during ye- of severe bollworm injury. This requires, for best results, the ado- tion of all methods useful in the production of an early crop, and based on the fact that cotton is not attacked in force by bollw- until the corn in surrounding fields begins to harden, which in gen- is about the first of August.

In the cultural system, by which profitable crops of cotton may grown in spite of the presence of the bollworm, the following pro- ures are important: (1) Thorough plowing of the land during t fall or winter months to destroy as many as possible of the hibernat- pupæ in the soil; (2) the use of seed of early-fruiting varieti- cotton; (3) the use of fertilizers to hasten and increase the growth plants and the formation of fruit; (4) planting at the first practi- date in the spring; (5) early and frequent cultivation.

The use of corn as a trap crop is recommended. In planting cot- leave vacant strips across the fields every 200 or 300 feet suffici- wide for planting 10 or 12 rows of corn. The corn should be pla- so that it will be in prime silking condition about August 1. Un- favorable conditions of rainfall and with good cultivation, Mexi- June corn planted by June 1 will be in proper condition by Augu- Plant cowpeas in the corn belts so that the peas will be flowe- at the time the silks and tassels appear on the corn, thus furni- food for the moths and keeping them out of the cotton fields. M- the same benefits may be secured by planting patches of late corn different parts of the plantation, as after oats, wheat, etc. In all c- peas should be planted in the corn. The corn thus grown ma- harvested in the usual way. *The corn should not be planted for crop purposes in belts through the cotton field at the usual time of p- ing in the spring. To be of value in bollworm control it should in silk and tassel until about August 1.*

During seasons of severe bollworm injury, poisons may be profit- used on cotton. Poisons should be applied late in July and earl- August to secure the maximum destruction of young larvæ of generation. Two or three applications may be necessary at inter- of a week or ten days. After rains the application should be im- diately repeated. Paris green at the rate of from 2 to 3 pound- acre for each application will be satisfactory. It is best applied dry condition, either pure or mixed with cheap flour, and dusted the plants by the usual pole-and-bag method or by means of a spray machine.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 213.

RASPBERRIES.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., January 17, 1

Sir: I have the honor to transmit herewith a paper on raspberr prepared by Prof. L. C. Corbett, Horticulturist of this Bureau. recommend that it be published as a Farmers' Bulletin.

Respectfully,

B. T. Galloway,
Chief of Bur

Hon. James Wilson,
Secretary of Agriculture.

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RASPBERRIES.

INTRODUCTION.

Гhe origin of the raspberry, like that of many plants whose history edates that of existing civilized nations, is somewhat mystical.

Гhe European berry takes its name from its supposed place of gin, Mount Ida, the Latin terminology making it *idaeus;* and the ıeric name *Rubus* comes from its close relation to the rose. From botanist's point of view this relation is very complete, but from standpoint we can only see a general resemblance in the habits of two plants and particularly in their defensive armature.

ust what part these thorns play in the economy of nature is hard say, but certain it is that through cultivation they can be dispensed h, as is the case in our Davison Thornless raspberry and some of blackberries.

'he American raspberries, for there are two types of them—the red l the black—are both familiar to every lad who has passed along the hways of the older States. These berries are aborigines, and, like ny other native plants, were entirely neglected by the early settlers il they proved to their own satisfaction that the raspberry of the den of their native land could not be successfully grown in the new ntry. They then turned their attention to what Nature had placed ore them, and from the wild berries of the clearing have come the ıerican raspberries as we know them to-day.

'he name *raspberry*, as used in the United States to-day, embraces r distinct species of plants, three of which are of American origin, s placing to the credit of our native plants three important and lely cultivated culinary fruits. The two types of fruits represented these species are known popularly as red raspberries and black pberries or "blackcaps."

'he red-raspberry group, as represented in cultivation, includes not y the native red raspberry but the European red raspberry, or mble, and a type intermediate between the native red and black raspberry, which bears a purple fruit and is frequently spoken of as the "purple-cane" raspberry or as the "Schafer group." The red raspberry group, besides having varieties which produce the charac-teristic red fruits, has another set of varieties which produce amber or yellow fruit. These horticultural varieties are recognized and are con-sidered distinct sorts, but are not separated botanically into different species.

The black raspberry is distinct both in habit of growth and in the make-up of its fruit. It is recognized botanically as a species distinct from the three which enter into the red-raspberry group. The black raspberry is known to botanists as *Rubus occidentalis*. The habits of this plant and the quality of its berries are such that it has gained an important place in certain sections of this country as a commercial fruit.

The fact that the varieties of the red-berry type have to be marketed from the bushes as soon as ripe confines their cultivation to the vicinity of large centers of consumption, where climatic and soil conditions favor their development. The black-raspberry industry, however, can be profitably and successfully carried on in regions more remote from the centers of consumption, because of the fact that a large pro-portion of the fruits are evaporated and are sold in a dry state, there being ready sale for them when handled in this way.

RED RASPBERRIES.

As before mentioned, the red-raspberry group includes varieties which bear fruits of various shades of red, amber, yellow, and purple, the last-named division being a hybrid between the red and the bla[ck] types. The native red raspberry is known to botanists as *Rub[us] strigosus*. It is quite similar in many respects to the European rasp-berry, which is known as *Rubus idaeus*, but is distinguished from [it] by a more slender and open habit of growth, stiff prickles on the bear-ing, bristly canes, which are brown and somewhat glaucous. It al[so] has thinner leaves and the flower clusters are more open and spread-ing. The fruit of this plant is bright light red or rarely yellow o[r] whitish and is not produced continuously throughout the season, [b]ut having a distinct fruiting period. This type of berry is somewh[at] more hardy than the blackcap and pushes its northern limits consider-ably farther toward the Pole than does the black raspberry. One ty[pe] of this is found in the mountains of Arizona and northward to Alask[a].

The hybrid type of the red raspberry is known to botanists [as] *Rubus neglectus* and is commonly spoken of as the "purple ca[ne]" raspberry. This is a very variable group of plants which is the [off]-spring of a cross between *Rubus strigosus*, the red raspberry abo[ve] mentioned, and *Rubus occidentalis*, the common black raspberry.

ckcap. These hybrids occur both in nature and under cultivation, the plants have the characteristics of both the red and the black es in that they can be propagated either from root sprouts or layers.

nother type of red raspberry which is cultivated to a very limited ent in the United States, which is not native to our soil, is the com- n European raspberry known to botanists as *Rubus idaeus*. This nt is sparingly cultivated in the extreme northeastern portion of United States and again along the Pacific coast from Washington far south as central California. The most universally cultivated e of red raspberry belongs to the *strigosus* or native red raspberry up.

n habit of growth, the canes of the plants of all three species are ight and the bark is of a light-brown color, the canes themselves ng rather slender. The thorns, while numerous, are not formidable, n the case of the blackcap.

METHOD OF PROPAGATION.

he method of propagating the red raspberry is from root sprouts. drawback to the cultivation of this group of plants is their per- ent habit of throwing up root sprouts wherever a root is broken or overed, so that it is only a comparatively short time after planting re the whole area occupied by these plants is covered with young ots. Persistent cultivation is therefore necessary to hold them in bounds. For purposes of establishing new plantations, root outs which are one year old are best suited for making the new tings. Young succulent sprouts can, under very favorable condi- s, be successfully transplanted if a portion of the mother root is ied with the young plant. The safest method, however, is to use year-old plants rather than the young, succulent ones. The only of this group which is capable of perpetuating itself through rs of stolons is the purple cane raspberry, *Rubus neglectus*. It sufficient characteristics of the black raspberry to give it the power erpetuating itself by stolons.

SELECTION AND PREPARATION OF SOIL.

he nature of the soil upon which red raspberries thrive best is a ly or clay loam of a glacial drift formation. Naturally, they are d growing at high altitudes and in high latitudes, and are very uently found upon soils which are rocky and rough in character. use they naturally flourish upon such soils, it does not necessarily w that under cultivation they adapt themselves to such soils only. r thrive well upon moderately rich, deep soils and yield largest rns under these conditions.

The preparation of the soil for red raspberries should be the sa
as for any small fruit, preferably one or two seasons' preparatory til
age in a "hoe crop," which will to a very large extent rid the land of
weeds. Such crops as potatoes, beans, cowpeas, and plants of th
nature are good preparatory crops.

PLANTING.

The distance to plant will depend very largely upon the purpose for which the plantation is intended. If it is a commercial plantati upon soil which is not especially valuable the plants should be 3 fe apart in the row, and the rows should be not less than 6 feet apar This will allow of cultivation in both directions for two or three year and will permit the use of horsepower implements, and consequent much lessen the cost of tillage. On city lots or in a home fruit garde where it becomes desirable to combine in the same plantation rasp ries and other fruit-bearing plants, the distance can be somewhat sened, but even under these conditions the plants should not b closer than 2 feet apart in the row and the rows not less than 4 fe apart. Raspberries can be used as fillers between rows of ap pear, or peach trees, as suggested in Farmers' Bulletin No. 154, if is desirable to establish an intensive fruit garden.

The most economical way in which to handle the red raspberr commercial plantations is, after having thoroughly prepared the by plowing and harrowing, to lay off the rows with a turning pl which will make a furrow of sufficient depth to accommodate the yo plants. The plants can then be laid along the row at proper interv the roots spread out in fan-shape, and the earth hauled over them t slight extent with a hoe. The remainder of the filling can then be complished with a one-horse turning plow. In order to do this effectively, it is desirable that the roots be spread against the land of the furrow so that the loose dirt thrown out by the moldboar opening the planting furrow can be returned by the use of the horse turning plow.

In home fruit gardens, where it is not possible to resort to means, small holes can be opened with a spade, the plant roots sp in the ordinary fashion for planting larger plants, and the ea returned; but in all cases it should be the aim to firm the earth over the roots of the plants as they are set.

CULTIVATION.

Clean cultivation is necessary with the red raspberries becaus above stated, they are themselves of a weedy nature, and, in order hold them within bounds, implements which cut all the superflu ıoots and root sprouts from the cultivated area should be used. Durıg the early life of the plantation it will be found most economical › keep the plants in check rows so that cultivation by horsepower can e accomplished in two directions. Later, however, as the plantation rows older, it will be found advantageous, both in yield of fruit and or economy, to allow the plants to form a hedge or matted row, and › practice cultivation in one direction only. The space between the edges should be plowed at least once each year, and whether this shall e done in the spring or in the fall will depend upon the locality. In ıost instances, however, because of the high altitude and latitude in hich this plant thrives, spring plowing will be found to be most advanıgeous, as less injury to the roots will result from deep culture at this eason and the plants will be less liable to suffer from winterkilling. he remaining cultivation should be done with an implement which irs the surface of the soil only to the depth of 2 to 3 inches, so as not › interfere with the young feeding roots which spread through the soil osened by the plow.

FERTILIZERS.

Comparative tests with stable manure and complete commercial ferlizers have been conducted at the New Jersey experiment station ith three sorts of red raspberries, namely, Cuthbert, Marlboro, and urner. The results of these tests indicate that the liberal use of table manure (20 tons per acre) will produce large yields of fruit, ut when the question of economy enters, i. e., when the manure is urchased and charged against the gross return of the patch, the use f a complete fertilizer—containing nitrogen 4.5 per cent, phosphoric cid (available) 7.7 per cent, potash 13.3 per cent—at the rate of 500 ounds per acre gives a greater net profit at less outlay. The results f the New Jersey tests may be stated as follows: For each dollar ıvested in stable manure the crop returned $6.09, and for each dollar ıvested in a complete fertilizer, such as above described, there was a rop return of $27.15. But notwithstanding this great difference in ield, one would hardly be justified in throwing away stable manure nd purchasing a high-grade fertilizer. There are other crops, however, such as asparagus, cabbage, etc., to which the stable manure ıay be added with more profit than to the raspberries.

PRUNING.

Red raspberries require attention to direct their growth and fruit roduction at two seasons of the year—pruning in the summer, during ıe growing season, to regulate the height of the canes and induce he formation of fruiting wood for the following season, and pruning uring the winter or early spring for the purpose of eliminating the

canes which bore last season, so as to allow all the energy of the r
of the plant to be directed to the production of fruit and the for
tion of the next season's bearing wood.

The summer pruning, which is not generally practiced with
raspberries, consists in stopping the young shoots when they h
attained a height of from 18 to 20 inches. This induces the deve
ment of side shoots and the production of additional sprouts from
root. Both these types of growth are desirable in order to insur
large a growth of wood as the plants can carry to advantage. T
will have to be governed by the judgment of the grower and sh
be based on the variety, the character of the soil, and the kind
quantity of fertilizer used.

The winter pruning is a process of elimination. All canes wh
have served their purpose as fruit producers are removed, as are
dead or diseased canes, thus reducing the demands upon the root
the plant to the wood intended for fruit production.

The advantages of summer pruning are an increase in the area
bearing wood, and strong, low canes which require no artificial tr
or support.

HARVESTING THE FRUIT.

Because of the soft character of this fruit, it can only be success
harvested by hand picking. Small receptacles holding not more t
a pint and preferably those made of wood are best suited for handl
this crop. The reason for the use of small receptacles is that t
weight of the fruits themselves is sufficient to cause them to s
rapidly and to become mushy if too many are placed in a recepta
thus destroying their market value as well as appearance. Un
favorable conditions, the yield of the better sorts of red raspberri
particularly of the native red and purple cane types, is very large,
where they can be placed upon the market quickly after being pi
they are a very profitable crop.

EVAPORATION.

The red raspberry is to a very limited extent dried in an artifi
manner by the use of an evaporator in the same fashion as is t
blackcap. The demand for dried red raspberries, however, is very li
ited, and it is only within recent years that there has been a market
this product. The chief use at the present time of the dried red ra
berry is in the preparation of fruit juices and marmalades for use in
nection with soda fountains. The process employed in the handl
of the red raspberry is the same as that described for the black
except that the fruits must be hand-picked and handled much m
ently during the process of drying than is necessary with
ackcap.

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BLACK RASPBERRIES, OR BLACKCAPS.

CHARACTERISTICS.

The black raspberry, or blackcap, because it lends itself to several thods of harvesting and marketing, is capable of a wider range of nmercial cultivation than any of the types of the red raspberry. e black raspberry, under favorable conditions, is a strong, vigorous- owing plant, making canes armed with stiff prickers and bearing fruit upon shoots of one year's growth—that is, the shoots which

FIG. 1.—A cluster of black raspberries.

ow one year bear their fruit the succeeding spring. The fruit of e black raspberry is borne in dense terminal clusters, as shown in gure 1, and in most varieties is retained upon the plant even after it comes fully ripe. This characteristic is taken advantage of nowa- ys to gather the fruits in a very inexpensive fashion. Besides ving this character of holding the fruit, the black raspberry is as ell adapted for marketing from the vines as is the red raspberry— fact, it is not subject to the same criticism as is the red raspberry.

The fruits of the black raspberry are more rigid in character a
retain their form better. For this reason it is not necessary to
small-sized receptacles for placing them on the market, quart boxes or cups being usually employed, but, as with the red raspberries, the receptacles should be made of wood. The usual equipment of a picker for hand-picking black raspberries is shown in figure 2.

FIG. 2.—A berry picker and the customary equipment.

The black raspberry has another advantage over the red raspberry for commercial culture in that it is not so weedy in its habit of growth. It does not throw up root sprouts, as does the red raspberry, and for that reason it is more easily kept within bounds. It can also be more easily handled in check rows when desired, but in commercial plantations this is seldom done. Usually the plants are set comparatively close together in rows which are rather wide apart, and cultivation is carried on in one direction only.

FIG. 3.—Tip-layering raspberries.

METHOD OF PROPAGATION.

As already stated, the black raspberry does not throw up root sprouts, and is propagated only from stolons or layers, as shown ıre 3. In order to secure new plants the tips of the branches are ;htly covered with earth during the month of August, after which y take root readily. The rooted tips are usually left attached to parent stalk until the following spring, when the branch is cut r 8 inches above the surface of the ground, the roots being lifted, l in bunches, and stored for use or carried to the place where they to be replanted.

CHARACTER OF THE SOIL.

'he character of soil on which the black raspberry thrives best is a her rich clay loam. Sandy soils and those which are gravelly, ess well enriched, do not give sufficiently vigorous growth to make nmercial plantings profitable. Raspberries grow best on a soil ich is naturally well drained, rather than one which is moist. Under ural conditions they are found usually where the soil is somewhat ny in character and provided with good natural drainage.

PREPARATION OF THE SOIL.

The same general preparation of the soil as outlined for the red pberry is necessary for best results with the black raspberry. Pre- :atory treatment with cultivated crops in order to rid the land as ›roughly as possible of weeds is desirable. While the raspberry :upies the land for a considerable period of time, it has been demon- ated that instead of becoming unfitted for the production of cereal ›ps after the raspberries have been removed the soil is capable of :urning a good crop of wheat or rye. This is undoubtedly due to method of cultivation practiced rather than to the fact that the ›pberry adds any fertility to the soil.

PLANTING.

The distance at which black raspberries are usually set in commer- ıl plantations is 3 feet apart in rows which are 8 feet apart. The 'ong-growing, robust varieties will then make a very formidable dge of considerable width, as is shown in figure 4. The same method planting as described for red raspberries—that is, opening a furrow th the plow, placing the roots at the proper distances in the row, d covering with a turning plow—is very convenient and satisfactory.

CULTIVATION.

Clean cultivation is equally as desirable for the black raspberry as r the red raspberry, because weeds between the rows interfere with e later operations in the berry field. While cultivation should not carried on so late in the season as to interfere with the harvesting the fruit, it should be sufficiently thorough and continued late ıough to keep the ground free from weeds.

WINTER PROTECTION.

In some portions of the Northern States the raspberry can only be successfully fruited by giving it some form of protection during winter. One of the simplest methods of affording such protection is to bend the canes of the plant all in one direction along the line of the row and fasten them either by placing earth upon them or pegging them down. The roots are slightly loosened on one side of each plant and the canes are bent over the roots of its neighbor. After the tops have been

FIG. 4.—A general view in a 10-acre berry field.

properly placed a mound of earth is thrown over them. If after cold weather sets in the earth covering is deemed inadequate, additional protection may be provided by a layer of straw, strawy manure, or corn fodder.

FERTILIZERS.

Commercial growers of black raspberries have given little attention to the question of fertilizing their plantations. However, the extensive character of this industry and the small yields from some plantations indicate that this problem demands more attention than it has yet ived. While no careful experiments have been conducted which warrant a positive statement in this connection, it is safe to say the use of stable manure in moderate quantities, supplemented by rtilizer carrying 4 to 5 per cent of nitrogen, 10 to 12 per cent of sphoric acid, and from 6 to 8 per cent of potash, will prove beneficial. h a fertilizer, if applied at the rate of from 300 to 500 pounds per , should so increase the yield as to make its use profitable. Experi-ts which have been conducted with the red raspberry indicate that, n it is necessary to purchase manure at ordinary commercial rates, more economical to use a high-grade commercial fertilizer than to loy stable manure. Where the grower has home-produced barn-l manure it will undoubtedly be wiser for him to use it rather than to fertilize at all; but if the barnyard manure can be profitably loyed on truck or general crops and it is possible to purchase n-grade commercial fertilizers for the raspberries, the results will oubtedly justify the substitution of the commercial fertilizer for barnyard manure.

PRUNING.

Because of its manner of fruit bearing, the black raspberry requires e in its annual pruning; in fact, pruning must be done at two sons of the year in order to accomplish the best results. The young ots as they appear from the roots in the spring should be tipped or budded when they reach the height of 18 inches. It is better to go r the plantations frequently, making three or four trips in all, in ler to tip the canes when they are about the height mentioned, her than to delay the operation until some of them have reached a ght of 2 to 2½ feet. The early pinching or disbudding induces the elopment of more numerous lateral branches. Shoots which have n allowed to harden and to grow to 2 or 3 feet in height will form v lateral branches. If tipped when 18 inches high, a cane should duce four, five, or six lateral branches. If allowed to attain a ight of 3 feet and then cut back to 18 inches, it is probable that not re than two or three lateral branches will be formed; and, since se lateral branches form the fruit-bearing wood of the succeeding son, it is very desirable that the greatest possible number of branches secured to insure a heavy crop of fruit. It is evident, therefore, at summer pruning predetermines the crop for the succeeding year re than does any other single cultural factor.

The second pruning, which is also important, consists in removing e canes which bore the last crop of fruit. This work can be done any time after the crop has been harvested, but preferably during e spring following the crop. If the work is done in the spring the teral branches borne by the canes which developed from the roots of the mother plant should at the same time be shortened to ... to 12 inches in length, as shown in figure 5. From each bud ... short branches annual growth will be made which will termina... fruit cluster. Since it is not desirable to stake or trellis the ... raspberry in commercial plantations, the short canes have a ... advantage over the long ones in that they more easily suppo... fruit; in fact, canes wh... tipped when more than ... in height very freq... break down or fall over ... a heavy load of fruit. ... those that are kept at a h... of 18 inches usually stan... and hold their fruit of... ground. The early tipp... pinching of the shoots ha... advantages: It insures a gr... number of lateral branch... it also holds the fruit-b... canes more erect, thus pl... them in a more desira... sition for harvesting. An... advantage of early pinch... that it has a tendency to ... the mother root to thr... additional shoots. If the ... is allowed to throw up two or three strong shoots which are al... to attain 3 or 4 feet in height without check, there is no tende... the part of the mother root to start other dormant buds into gr... For very best commercial results it is desirable that each cr... mother root throw up from three to five or six shoots annuall... provide bearing wood for the next season. If, therefore, a syste... pruning can be followed which will increase the number of s... from the root there will be a gain in the succeeding crop.

FIG. 5.—Typical raspberry after pruning.

HARVESTING THE FRUIT.

Black raspberries are harvested in two ways. For consumpti... fresh fruit they are always hand picked. In fact, many of the ... mercial growers of blackcaps which are intended for evaporati... drying prefer to hand pick rather than to "bat" the fruit. There ... perhaps about as many advocates of hand picking as of "batting," ... a grower must decide for himself which, under his circumstances, ... most economical.

l **picking.**—The usual method of hand picking black raspberries ot be described further than to say that each picker is known by r and is furnished baskets or cups and a picking stand similar shown in figure , as the baskets led and deliv- o a receiving credit is given icker either in rm of checks or record by which norandum of the ity picked by is kept. The ods vary in differ- calities and with ent growers.

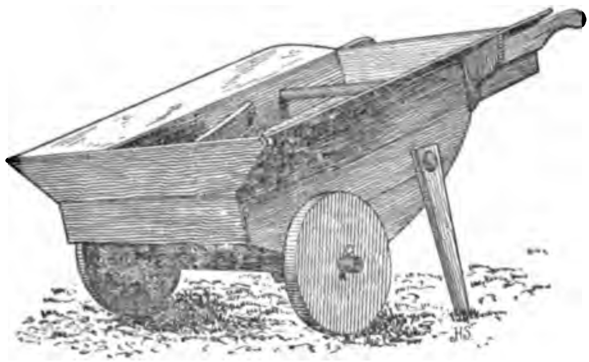


FIG. 6.—The original berry bat.

chanical harvesting, or "batting."—In the early nineties a mechan- levice for gathering raspberries was brought to the attention of berry growers as a cheap and comparatively satisfactory means of lessening the cost of gathering the crop. This device consisted of a tray mounted as shown in figures 6 and 7, and over the surface of the tray was spread a wire screen against which the berries were beaten by the use of a light paddle, the bushes being bent over the device so that the fruit would fall upon the screen as it was beaten from the plant. The idea was that the screen would allow the fruits pass through and fall into the tray, while leaves and portions of the e which might be beaten off would be retained by the screen, and, the een being hinged at the top, such refuse could be easily thrown off.

G. 7.—Details of the construction of the first berry harvester.

This device was too cumbersome to come into general use. it was modified, as shown in figures 8 and 9, to a light, n somewhat triangular covered with muslin frame is usually mad 6 inches wide at the b with sides slanting the top and tapered inches in width to ab 2½ inches in width. the narrow side a fastened, which ser handle for carrying vice, and along th end of the tray a lig

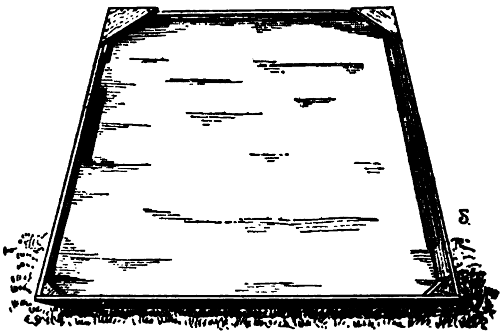


FIG. 8.—The berry bat or harvester as at present constructed.

is placed, which serves as a runner upon which to slide the along the surface of the ground. A narrow strip is also naile the back of the frame, as shown in figure 9, to act as a prote the muslin and as a support against which the knee of the o can be placed to force the picking tray under the plants. Af device, illustrated in figures 8 and 9, has been placed in posi shown in figure 10, the bushes are drawn over the canvas by wire hook and with a light, somewhat curved bat the well- fruits are knocked from the plants on to the muslin and roll to the lower end of the tray, where the wider portions of th form a receptacle.

With a device of this kind one man is capable of picking fro 8 bushels of fruit daily, while the most expert hand pickers c only about 100 quarts, or 3 bushels. It will thus be seen that this device is of considerable advantage, because it shortens the period of harvest and allows the employment of a class of labor which could not be employed for hand picking, as the latter is almost exclusively done by women and children, while the work of batting is almost entirely done by men. The drawback to the batting operation is that a sm centage of the berries is lost by bouncing out of the tray are forced against the muslin by the stroke of the paddle. Th

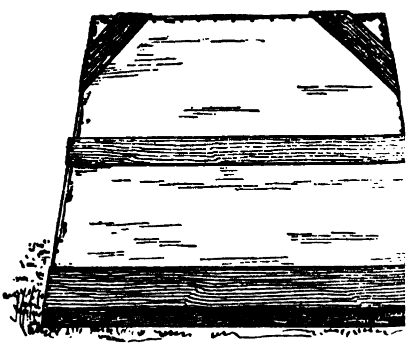


FIG. 9.—Detail of back of device shown in fi

›ver, is not very great, amounting, perhaps, to not more than one- of 1 per cent in extreme cases. Some loss also results from the that the fruits must be thoroughly ripened upon the plants before ›peration begins. This, however, is not great, and the saving the cost of hand picking will undoubtedly more than overbalance oss of fruit. The advocates of hand picking, however, contend there is not so much gain in the use of the bat as would at first ar, because it is necessary that the fruits which are batted be ed over a fan either before or after drying. Hence, some prefer method and some the other.

FIG. 10.—Berry harvesters at work.

It is necessary that the batted fruits, after being dried, be looked er carefully by hand, as are beans; otherwise, they will not be in fit ndition to go upon the market. These two operations, it is claimed, set the additional cost of hand picking, but, as before stated, each ower will have to determine for himself which method is most onomical under his particular conditions. It is obvious that the uits which are gathered by mechanical means will not be suitable for e as fresh fruits. The batting of raspberries is never practiced cept upon fruits which are to be evaporated.

Figures 11, 12, and 13 illustrate a modification of the device shown in figures 8 and 9, which is claimed by the inventor to posses advantages over the form. As all these de are homemade affairs, plans are presented der that both may b a test, which is the true way of determin their merits.

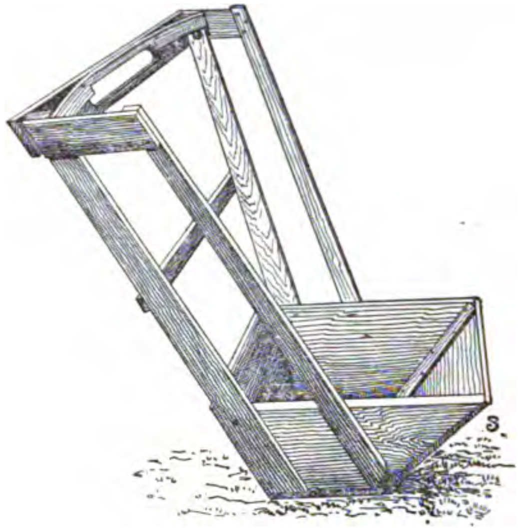


FIG. 11.—A modified form of the modern berry harvester.

CURING RASPBERRIE

EVAPORATION

The use of heat from the sun or from artificial source, for purpose of drying fruits has made the berry an important mercial product in sections of the U States. Regions which could not profitably engage in the growi this fruit were its sole use to be found as a fresh fruit upon the ma can now safely undertake its cultivation. While the sun drying of raspberries has been practiced as long as the raspberry has been used for culinary purposes, the art of drying it with artificial heat is a comparatively recent commercial development.

FIG. 12.—Front view of frame shown in figure 11.

The artificial process of drying under a high heat has an advantage over sun drying in that the product can be obtained m sooner and is of a more desirable quality. Evaporated fruit of t quality loses only a small percentage of its juices. The heat icient to sear the outside of the fruit by breaking down its r structure and giving it a dry, somewhat resistant surface, has a tendency to keep the interior portion much more moist ılatable than is possible under the slow operation of sun dry- With partially ripened fruits, such as peaches, apples, apricots, ı, etc., which are dried high heats, the proc- comes one of trans- ıg the starches into or, in other words, :kening of the ripen- ·ocess. This, to a cer- xtent, is accomplished the raspberry, but, as uits are usually thor- ıy matured when they › the evaporator, it is ; that there is much of a chemical change he raspberry than in ase of the apple. The roved quality of the uct from the evaporator not only adds to its commercial value increases the income of the producer, because there is less loss ›eight in evaporated than in sun-dried fruit. In other words, yield from a given area in evaporated fruit is somewhat greater ı the yield from the same area in sun-dried fruit. These features, ·ther with the rapidity with which the operation can be carried are considered of sufficient advantage to warrant growers of)berries in erecting evaporators at considerable expense.

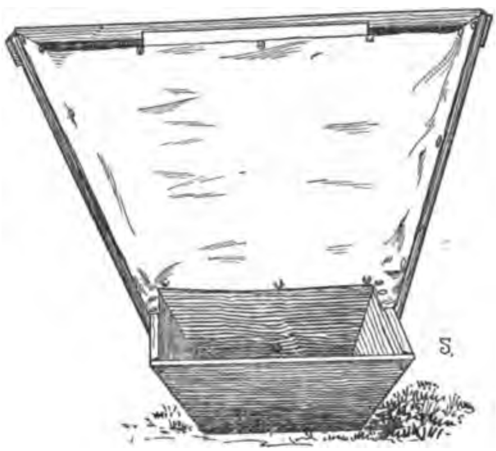


FIG. 13.—Completed harvester after the plan shown in figures 11 and 12.

TYPES OF EVAPORATORS.

'here are two distinct principles on which evaporators are con- ıcted—one using hot air as the means of drying the fruit, while the er uses the indirect means of producing an air current from heated ım pipes. In both instances the primary source is the same, but one the air is heated by being passed over a radiating surface like t of a hot stove, while in the other case the current of air is passed er heated steam pipes. There are also three important types of ıstruction, namely, the shaft or flue, the cabinet, and the hop kiln.

Shaft or flue evaporator.—The shaft or flue evaporator is sho figures 14 and 15. This device consists of a building which is] cally three stories in height. The basement story contains s rooms for fuel and gives space to the heating apparatus, wh usually a hot-air furnace or large stove. It is a common prac install a heating device for each shaft or flue, as illustrated in 15 (at the left), which shows a cross section of the building.

The furnace is provided either with a jacket of metal wh properly insulated, or with a brick wall which provides an o for the entrance of air from the outside, the wall usually being c up to th story. (of the wall the proper i structed. shaft is of dresse matched ber, an tends fro floor of second throug third s and out roof. A the roof drawn in to assum form o inverted These sh are usual or 4 feet sq inside m urement. are provided with a lifting device operated by a lever, or "bull wheel," which enables the operator to lift by mech means the entire charge in the shaft at one operation. necessity for this lifting device is that the screens which carr fresh fruits are placed in the flue, or shaft, at the bottom, 18 [illegible]ve the floor of the second story. The screens are u [illegible]uare, and are made of 1 by $1\frac{1}{4}$ or $1\frac{1}{2}$ inch

FIG. 14.—Exterior view of a flue evaporator, showing receiving platform.

›times in such fashion that they can be used either side up. The
a fruit is spread upon these screens to the depth of 1 or 1½ inches,
larger screens carrying about one bushel of fruit.
uring the drying process, when everything is working favorably,
reen carrying fresh fruit can be placed in the bottom of the shaft
·y fifteen to eighteen minutes, but after the shaft becomes filled,

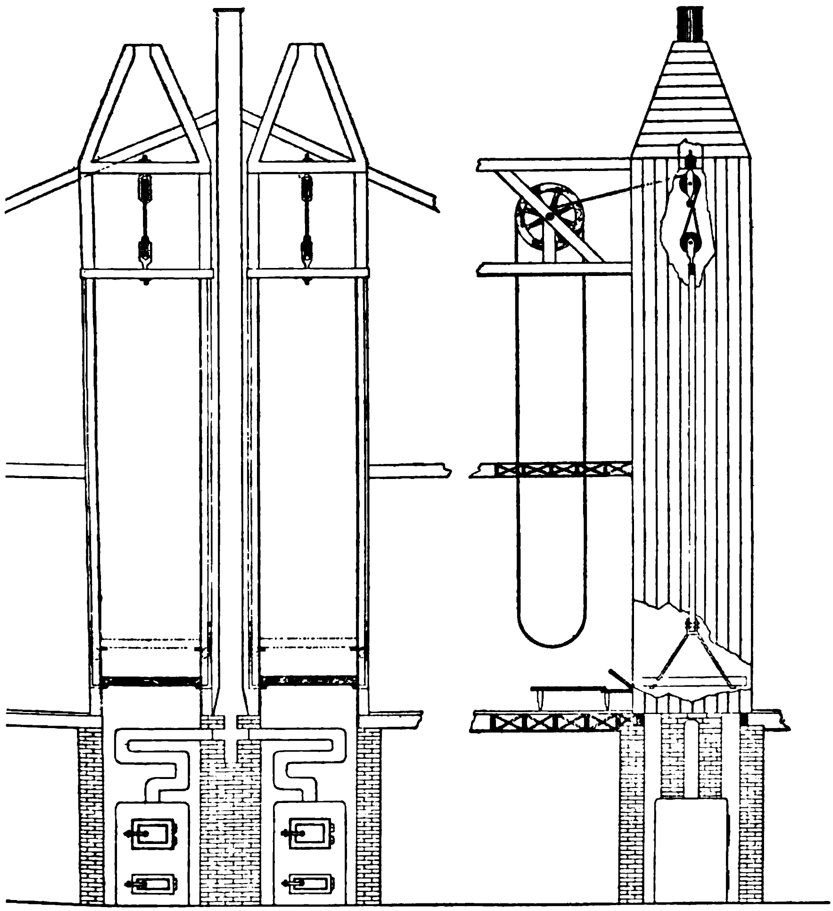


FIG. 15.—General construction of a twin flue evaporator.

› that when a new screen is added at the bottom one must be removed
t the top, the operation of manipulating two flues and spreading the
ruit is a sufficient task to keep a single individual occupied the entire
ime. It is necessary, as will be observed from the construction of
his device, to make a trip from the second to the third story each
ime a new screen is added, in order that one carrying dried fruit may
e removed at the top.

The opening from which the screens carrying the dried fruit removed is usually about 4 feet above the floor of the third story the stories are 10 feet high, this makes the distance between the p where the screens carrying the fresh fruits enter the shaft an point where the screens carrying the dried fruits are removed 12 feet.

The one drawback to this type of evaporator which has impressed itself upon the writer is that the steam and vapor fr fresh fruits which are placed in the bottom, which is also the intensely heated portion of the flue, all pass through the fruits are partially dried on the screens above. It is a more or less co complaint among operators that upon some days when atmosp conditions are of a certain character not easily described, the pr of evaporation, even under the best of management, can not be su fully carried on. The operators say the air is dead and that the will only come to a certain stage of dryness and remain in that tion without reaching the point where they can be removed fro shaft.

It has always been the conviction of the writer that the co principle for the construction of a shaft evaporator is one which in exactly the opposite direction from that now employed—that shaft which shall be arranged so that the fresh fruits go in at the where the heat is least intense and where the atmosphere is charged with moisture, and come out at the bottom, nearest th where the air is driest. While it is possible that the temperatu the top of the shaft would not be sufficient to break down the structure of the fruit and produce the desirable conditions whi now secured by placing it directly over the heat, experience wit cabinet evaporator described farther on proves that the princip correct. The chief reason why the shaft is now operated as it is lack of adequate means for lowering the frames. This can be ac plished by providing a spring clutch at the base of the lifting arm is forced into position under the second tray from the bottom lifting device is drawn upward. The lifting motion should then be tinued long enough to raise the column of trays in the shaft so release the one which rests at the bottom and immediately over fire. When this is withdrawn and the apparatus is allowed to itself, the weight of the trays carried by the lifting device will the spring clutch in position until the tray or screen to which engaged comes in contact with the ways at the bottom of the As soon as the weight of the trays is taken off the lifting device clutch will be released so that it will engage the second tray when the operation of lifting is gone through with again. It red that this method of operating the shaft will overcome the ılty experienced when the atmospheric conditions are not favor- to the use of the present method. It is also believed that this ruction will enable the operator to carry the fruit more quickly ıgh the process of drying.

binet evaporator.—For want of a better name, the writer has used erm "cabinet evaporator" to describe a style of evaporator which

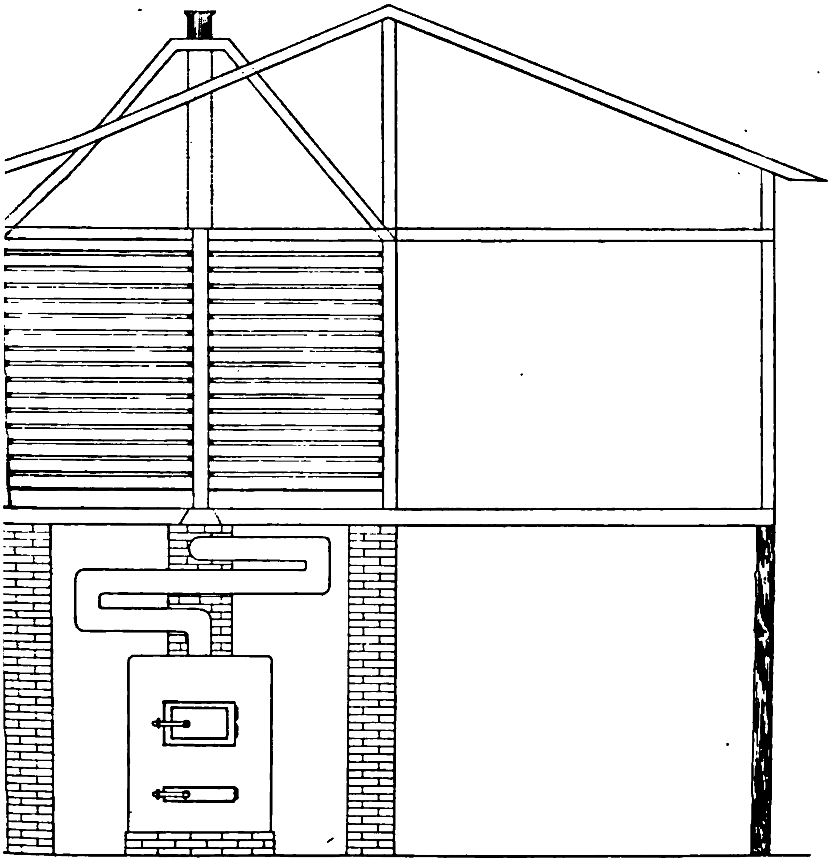


FIG. 16.—The simplest type of cabinet evaporator.

used by a number of small growers. This evaporator is constructed, shown in figure 16, of a series of loose drawers (the screens) upon hich the fruit is spread prior to the beginning of the operation of ying. The mechanism of the evaporator is very simple, consisting, shown in the illustration, of a stove or hot-air furnace placed in the ısement room, with the top of the furnace 3 feet or more below the west screen in the cabinet; the pipe from the furnace is arranged in a sort of spiral, being carried around the space below the drying area as many times as the distance between the lowest screen and the top of the furnace will permit, so as to throw off and utilize as nearly as possible all the heat coming from the fuel used in the furnace. The drying portion proper (the cabinet) consists usually of two compartments separated by a ⅞-inch partition, each compartment being provided with ways for carrying the fruit-laden screens.

The interior space of each one of these compartments is generally made 4 feet wide and 8 feet deep from front to back, so that upon each of the guides or ways, which are provided to carry the screens, there are two screens, one in front of the other. The perpendicular distance between the screens in the cabinet is usually about 4 inches. The screens themselves are 3½ or 4 feet square over all. Screens are also made so that they can be used either side up; the frames are constructed of material about 1¼ inches square, so that when 8 pieces are used and properly lapped at the corners they make a double frame. As the wire is placed between the two sets of strips, the screens can be used either side up.

The doors for the cabinets are usually hinged at the bottom, so that when opened they fall across supports which form a counter or rest upon which to place the loaded screens; and the bottom screen when placed upon the door will exactly slide into its proper groove.

The method of operating this cabinet evaporator is as follows: The screens, carrying freshly gathered fruit, are placed in at the top of the cabinet, and as those which are driest and which are immediately over the furnace are removed, those screens in the groove next above are taken out and placed on the one immediately below, each pair of screens in succession being lowered one space. This leaves the top space open and ready to receive two newly spread screens. These compartments are usually made so that they carry about 11 or 12 screens, one above another; that is, the distance from the bottom of the screen immediately over the furnace to the bottom of the uppermost screen is about 44 or 48 inches. This is a convenient height for handling the screens. If they are too high the operator has of necessity to stand upon a stool or to do the work in a very awkward position. When it is necessary to raise the arms above one's head in lifting the heavy screens it becomes very hard work. Convenience of operation, therefore, limits the height of the cabinet.

Another form of cabinet evaporator is illustrated in figure 17, the ground plan of which is shown in figure 18. This cabinet can be opened at both front and back instead of at the front only. The screens pass in at the top, as in the above-described arrangement, but the ways are much longer, so that there are from 6 to 10 screens upon ngle plane. The partition in this cabinet runs in a horizontal tion rather than in a perpendicular one, as is the case with partition in the cabinet arrangement illustrated in figure 16. ›r the topmost tier has been filled, the first screen having been

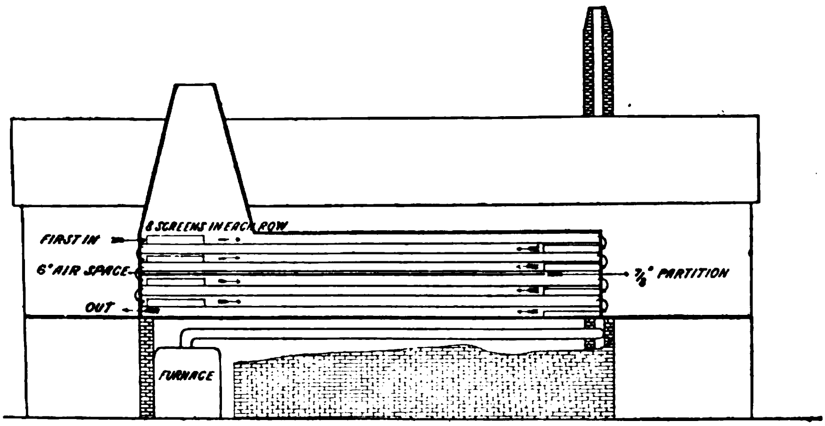


FIG. 17.—Horizontal form of the cabinet evaporator.

›hed farther and farther back as others were put in, the operator ›es it out at the rear and immediately places it in the next lower ›ove, where it is gradually pushed forward, and each screen in turn lows the same course. The cabinet is gradually filled in this way

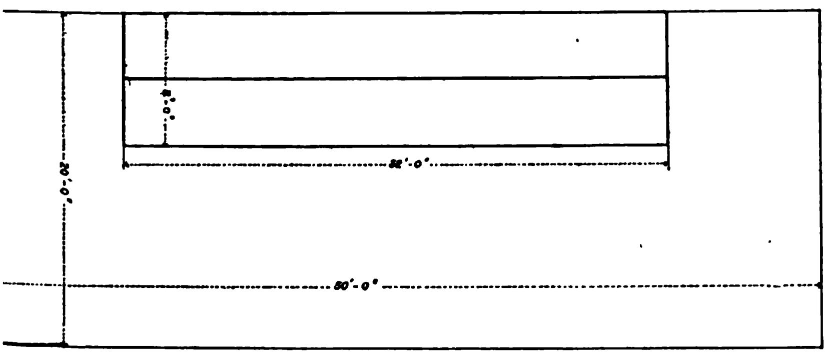


FIG. 18.—Floor plan of figure 17.

the process of evaporation goes on, and the dried fruits are taken t at the bottom immediately over the fire. The newly spread uits go into the evaporator at the point farthest away from the fire, iderneath the shaft through which the hot air passes out of the binet.

This plan of operation, as will be noticed, provides for drivir a portion of the moisture from the newly spread fruits immed under the hot-air exhaust shaft, while in the case of the shaft e rators, which raise the screens automatically, the plan of operat in an exactly opposite direction. Figure 17 of the horizonta inet evaporator is sufficiently self-explanatory to need no fi description.

HOP-KILN DRIER.

The hop-kiln drier consists of a large furnace room, in the cen which is placed either a large coal stove, a wood stove, or a h

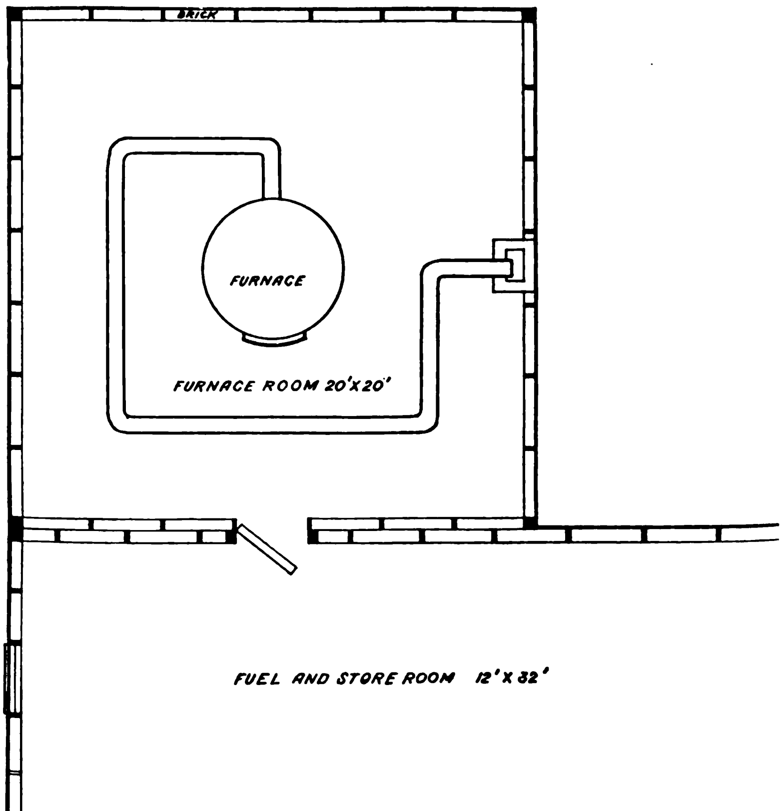


FIG. 19.—First floor plan of hop-kiln type of evaporator.

furnace without a jacket, as shown in figure 19. The pipe fron heater is then carried around the room so as to make at least one plete circuit. The furnace room is usually constructed as fol om is made exactly the same size as the drying kiln, which is to structed on the second floor. A common practice is to place studding 2 feet apart on either a brick or stone foundation, to the outside of the building with weatherboarding, and to fill ace between the studs with brick so as to form a 4-inch wall.

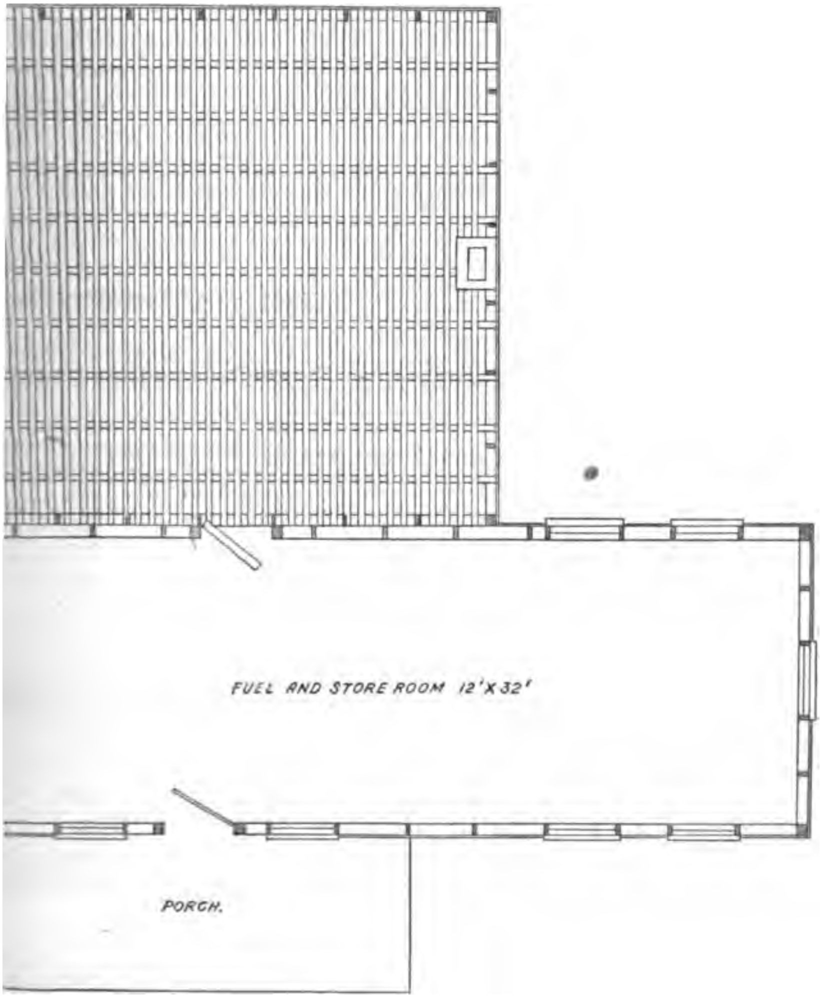


FIG. 20.—Second or dry-room floor of a hop-kiln evaporator.

Then it is desirable to avoid this expense, metal laths may be fas-ed to the inside of the studding and the room plastered so as to e it retentive of heat. If more perfect insulation is desired this be accomplished by nailing furring strips to the studding so as to it of placing short pieces of boards in a horizontal position between studs, thus dividing the space between the clapboards and the lath and plaster into two chambers instead of into one air chamber. The expense of this construction will, however, in many instances, exceed the cost of the 4-inch brick wall first suggested. These details must, however, be worked out to suit the person who is erecting the drier. Any one of the three methods described will be comparatively satisfactory.

The drying floor, which is usually situated about 10 or 12 feet above the floor of the furnace room, is composed of $\frac{7}{8}$-inch strips, which are carefully spaced, as shown in figures 20 and 21, from $\frac{1}{8}$ to $\frac{1}{4}$ inch apart, so

FIG. 21.—Detail of the floor construction of a hop-kiln drier, from below.

as to form cracks or spaces for the passage of the hot air from the furnace room to the chamber above. This chamber is made of sufficient height to admit of carrying on the necessary operations of spreading and stirring the fruit without inconvenience. The ceiling of this room is sometimes made horizontal and sometimes in the shape of an inverted funnel. In all cases, however, sufficient openings are left for ventilation and the building is provided at the comb with openings for allowing the heated air to escape. The exterior construction of such a building is shown in figures 22 and 23.

ıen the hop-kiln drier is to be used for drying raspberries, apples, ·n for the curing of hops, the floor, which is made of strips, as described, is usually covered with what is called burlap, a rather cloth, which is strong and will allow the heated air to pass through ily. In some instances floors constructed with very narrow cracks no covering of cloth over them, the fruit being spread imme- ly upon the floor. The common practice, however, is to use the and spread the fruit in sections or upon definite areas from 2 to hes deep, depending upon the character of the fruit to be dried. berries are usually spread about 2 inches deep, while apples may read as deep as 4 inches.

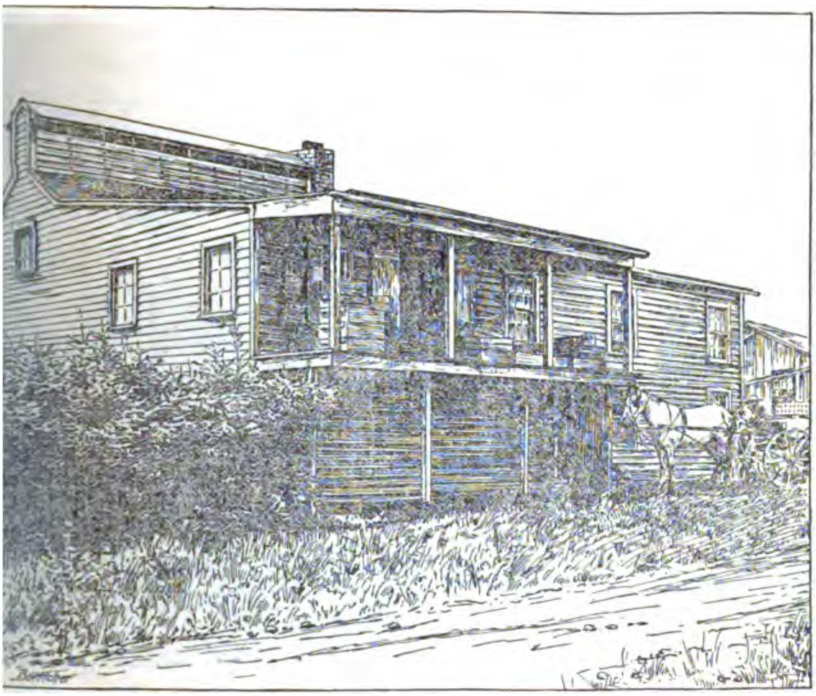


FIG. 22.—Elevation of building, plans of which are shown in figures 19 and 20.

As curing proceeds, the fruits, as soon as they have passed the soft ge which comes on immediately after spreading, are stirred at fre- ent intervals with a wooden-toothed rake or are turned over with a oden scoop. As the curing goes on, the depth of the berries creases, because of the shrinkage from loss of moisture. The area cupied by them is then restricted, so as to keep the drying fruit of nsiderable depth upon the floor. As the fruit is about to be removed om the drying room several layers are frequently combined so as to cupy very much less space. The fresh fruit, as it comes from the

field, occupies more floor space in proportion to the final pro
it does at any stage during the process of evaporation.

When the fruits are sufficiently dried, which may be recog
their adhering when pressed in the hands, and when there
percentage—perhaps 5 or 8 per cent—of comparatively sof
the product, they are ready to go into the curing box or on tl
floor. The fruits are usually removed from the kiln and
boxes, which are approximately 2 feet long, 8 inches dee
inches wide, and hold something less than a bushel. The cur
ess is completed by daily pouring the fruits from one box to
thus giving them a chance to become aerated.

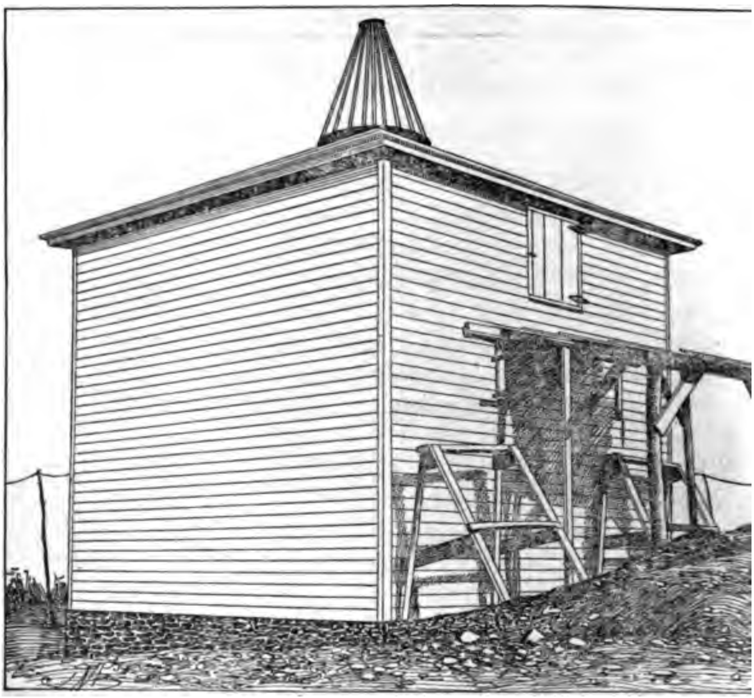


FIG. 23.—Elevation of building in which the floor construction shown in figure 21

Curing rooms.—In some cases a large floor, something like
ture malt-house floor, is used for the finishing or curing roo
berries are spread on this floor and frequently stirred with
scoop for several days before they are sacked for market. It is
however, by the advocates of the box system that this is mo
factory than spreading the berries on the curing floor, as it ke
in a more confined area and allows those berries which have
too dry in the process of evaporation to take up a small porti
from the berries which are undercured, thus resto

ce between the two, which is an advantage in the finished prod- These, however, are matters of experience and judgment, and ot be described with sufficient accuracy to offer a guide to the tor. Experience alone will provide the knowledge which will e one to determine when the fruit is sufficiently dry to be removed the kiln.

SUN DRYING.

e drying of berries on racks exposed to the sun is a practice ly in vogue in many of the raspberry-growing regions, and was, comparatively recent times, the only method of curing and car- or the fruits of the raspberry. One or the other of the forms of orators above described has, however, almost entirely supplanted primitive method of curing the fruit. This is largely accounted y two facts: (1) The product of evaporation, properly conducted, ore desirable, and (2) a somewhat larger yield is secured from a quantity of fresh fruit than can be obtained by the sun-drying ess. The method of sun curing is also inconvenient, in that it

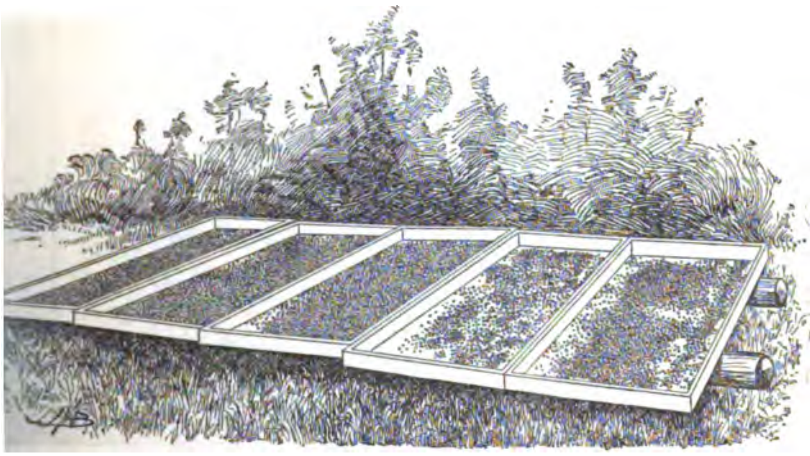


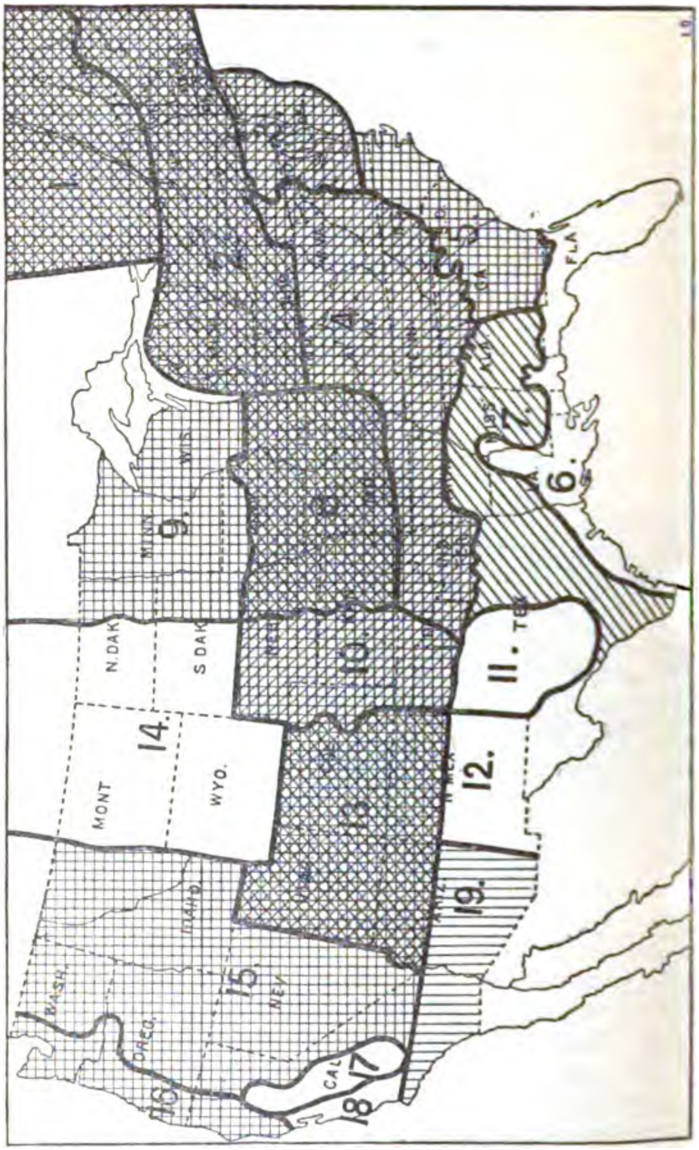
FIG. 24.—Sun drying.

iires a great deal of attention and provision for sheltering the fruit ise of showers, as well as coverings for the racks at night to protect n from rain or dew.

he racks formerly used for drying berries were constructed of inary plastering laths, 4 feet long and placed about one-eighth of nch apart. Over this a thin cloth or paper was spread. Now- ys, however, the drying racks are very generally constructed of it, thin, matched lumber and are very much larger than formerly. racks are now usually about 3 feet wide and from 6 to 8 or even feet in length. Some growers prefer to use racks about 4 feet are. A set of racks exposed for curing the fruit is shown in ire 24.

QUANTITY AND QUALITY OF THE PRODUCT.

As has already been suggested, the relative quantity of fr... duced by the different methods of curing described varies with t... of the operator, but it is universally conceded that a larger qua...



marketable product can be secured from a given bulk of fr... when properly cured in an evaporator than when cured by th... method of drying in the sun. A good evaporator product ... commands one or two cents more per pound than the sun-dri...

)rdinarily it is estimated that 3 quarts of fresh fruit will produce 1 ınd of evaporated or dried fruit. It is therefore an easy matter one to estimate the price which must be secured for evaporated it in order to put it on the same basis as the fruit sold fresh.

'ARIETIES ADAPTED TO EACH FRUIT DISTRICT OF THE UNITED STATES.

'he map (fig, 25, p. 34), shows at a glance the localities in which four types of raspberries, namely, (1) the European raspberry *ubus idaeus*); (2) the purple cane (*Rubus neglectus*), which is interdiate between the red and black raspberry; (3) the native black pberry, or blackcap (*Rubus occidentalis*); and (4) the native red pberry (*Rubus strigosus*) may be expected to grow and produce ›fitable crops.

)n the map, *Rubus idaeus*, or the European raspberry, is repreıted by lines which slope downward from right to left; the purple ıe, *Rubus neglectus*, by lines which slope downward from left to ;ht; the blackcap, *Rubus occidentalis*, by horizontal lines; and the tive red raspberry, *Rubus strigosus*, by perpendicular lines. With s key to the map it is an easy matter to determine the distribution each group in the United States.

Io explain the map more fully and to give prospective growers an 'a of the varieties adapted to a particular region, the appended list, ranged according to the commercial importance of the different rieties, as well as according to their botanical classification, has been epared. The names which are printed in italics are, in all cases, ose which are considered best adapted to the region for either culinary commercial purposes. There is such slight difference in the value the different sorts of any one group for dessert purposes that it s been deemed unnecessary to separate the list into subdivisions to ing out this point. The italicized names, therefore, may be taken those which are most productive and most profitable from a comercial standpoint for the locality in which they are mentioned.

DISTRICT No. 1.

European (*R. idaeus*).—*Clarke*, Fastolff, Franconia, Hudson River Antwerp, Orange 3rinckle's Orange), Vermont.

Purple cane type (*R. neglectus*).—*Shaffer*, Philadelphia, Columbian.

Blackcap type (*R. occidentalis*).—*Earhart*, *Gregg*, *Hilborn*, *Ohio*, *Older*, Doolittle, cCormick, Palmer, Souhegan, Lotta, Tyler.

Native red (*R. strigosus*).—*Cuthbert*, *Golden Queen*, *Miller*, Blair, Hansell, Loudon, arlboro, Turner.

DISTRICT No. 2.

European (*R. idaeus*).—Fastolff, Franconia, Orange (Brinckle's Orange), Vermont.

Purple cane type (*R. neglectus*).—*Columbian*, *Shaffer*, Caroline.

Blackcap type (*R. occidentalis*).—*Conrath*, *Eureka*, *Gregg*, *Hilborn*, *Kansas*, *Nemaha*, *hio*, *Palmer*, Cumberland, Doolittle, Lotta, Mills, Older, Souhegan, Tyler.

Native red (*R. strigosus*).—*Cuthbert*, *Golden Queen*, *Loudon*, *Turner*, Brandywine, [ansell, Marlboro, Thwack.

DISTRICT No. 3.

Purple cane type (*R. neglectus*).—Caroline, Columbian, Shaffer.

Blackcap type (*R. occidentalis*).—*Gregg*, *Kansas*, Cumberland, Doolittle, H... McCormick, Ohio, Palmer, Tyler.

Native red (*R. strigosus*).—*Brandywine*, *Cuthbert*, *Miller*. Golden Queen, H... Kenyon, Loudon, Marlboro, Turner.

DISTRICT No. 4.

Purple cane type (*R. neglectus*).—*Shaffer*, Caroline, Columbian, Reliance.

Blackcap type (*R. occidentalis*).—*Eureka*, *Gregg*, *Kansas*, *Palmer*, Doolittle, H... McCormick, Nemaha, Ohio, Winona.

Native red (*R. strigosus*).—*Cuthbert*, *Golden Queen*, *Loudon*, *Turner*, Brandyw... Hansell, Kenyon, Miller, Thwack.

DISTRICT No. 5.

Purple cane type (*R. neglectus*).—Shaffer.[a]

Blackcap type (*R. occidentalis*).—Doolittle, Gregg, McCormick, Souhegan, T...

Native red (*R. strigosus*).—*Brandywine*, *Cuthbert*, *Golden Queen*, *Loudon*, Turner

DISTRICT No. 6.

Not adapted to raspberry growing.

DISTRICT No. 7.

European (*R. idaeus*).—Clarke, Orange (Brinckle's Orange).

DISTRICT No. 8.

European (*R. idaeus*).—Clarke, Orange (Brinckle's Orange), Red Antwerp.

Purple cane type (*R. neglectus*).—*Columbian*, Shaffer, Caroline.

Blackcap type (*R. occidentalis*).—*Eureka*, *Gregg*, *Kansas*, *McCormick*, *Nemaha*, *Older*, *Palmer*, Doolittle, Earhart, Lotta, Souhegan.

Native red (*R. strigosus*).—*Cuthbert*, *Loudon*, *Thwack*, *Turner*, Brandywine, G... Queen, Marlboro, Miller.

DISTRICT No. 9.

Purple cane type (*R. neglectus*).—Columbian.[b]

Blackcap type (*R. occidentalis*).—*Gregg*, Ohio.

Native red (*R. strigosus*).—*Cuthbert*, *Loudon*, Marlboro, Turner, Miller.

DISTRICT No. 10.

Purple cane type (*R. neglectus*).—*Columbian*, Philadelphia, Reliance, Shaffer.

Blackcap type (*R. occidentalis*).—*Eureka*, *Gregg*, *Tyler*, Doolittle, Kansas, Mc... mick, Nemaha, Ohio, Palmer, Souhegan.

Native red (*R. strigosus*).—*Cuthbert*, *Marlboro*, Brandywine, Golden Queen, L... Turner.

DISTRICT No. 11.

Not adapted to raspberry growing.

DISTRICT No. 12.

Not adapted to raspberry growing.

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[a] Sparingly grown in this section. Not shown on map.

[b] Not shown on map, as it is less commonly grown than the other two types mentioned

DISTRICT No. 13.

ean (*R. idaeus*).—Fastolff, Franconia, Hudson River Antwerp, Red Antwerp.
e cane type (*R. neglectus*).—*Shaffer*, Caroline, Philadelphia, Reliance.
ap type (*R. occidentalis*).—*Gregg, McCormick, Ohio, Palmer, Souhegan*, Doolit-
isas, Nemaha, Tyler.
e red (*R. strigosus*).—*Brandywine, Cuthbert, Marlboro, Turner*, Golden Queen,
, **Thwack.**

DISTRICT No. 14.

dapted to raspberry growing.

DISTRICT No. 15.

cap type (*R. occidentalis*).—*Gregg, Kansas*, Ohio, Palmer, Souhegan.
e red (*R. strigosus*).—*Cuthbert*, Golden Queen, Loudon, Marlboro.
e cane type (*R. neglectus*).—Shaffer.[a]

DISTRICT No. 16.

le cane type (*R. neglectus*).—Shaffer.[a]
cap type (*R. occidentalis*).—*Gregg.*
e red (*R. strigosus*).—*Cuthbert*, Golden Queen.

DISTRICT No. 17.

adapted to raspberry growing.

DISTRICT No. 18.

adapted to raspberry growing.

DISTRICT No. 19.

ve red (*R. strigosus*).—*Cuthbert*, Loudon.

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indicated on map because it is of secondary importance to the other varieties mentioned.

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the number and title of each. Copies will be sent free to any address in th[illegible]
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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 214.

ENEFICIAL BACTERIA FOR LEGUMINOUS CROPS.

BY

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AND

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GOVERNMENT PRINTING OFFICE.
1905.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry.
Office of the Chief.
Washington, D. C., January 1[illegible]

Sir: I have the honor to transmit herewith a paper on Be[illegible] Bacteria for Leguminous Crops, and to recommend that it be [illegible] lished as a Farmers' Bulletin. This paper was prepared by Dr. G[illegible] T. Moore, in charge of the Laboratory of Plant Physiology, an[illegible] T. R. Robinson, Assistant in Physiology in the Office of Veg[illegible] Pathological and Physiological Investigations, and was submitted [illegible] Mr. A. F. Woods, the Pathologist and Physiologist, with a [illegible] publication.

Special attention is called to the fact that there is no monop[illegible] the methods and processes set forth in this paper. Recognizi[illegible] vast importance to the farmers of the country of an unrestricte[illegible] of the nitrogen-fixing organisms described, a patent was taken [illegible] the Government in the name of Doctor Moore. The object of the p[illegible] is to prevent any monopoly in the manufacture of the material. W[illegible] the manufacture and sale of the nitrogen-fixing organisms are [illegible] any reliable firm in the United States or elsewhere, the Departme[illegible] not hesitate to call attention to any attempt to deceive farmers [illegible] matter, either by the offering of spurious material or mate[illegible] prices which the Department knows by its experience to be exorb[illegible] This action is necessary to protect the farmers for whose direct [illegible] the entire work is designed.

I greatly regret to state that the supply of packages for inoc[illegible] legumes is completely exhausted for this season. Applicatio[illegible] material for use next spring should not be made before Septem[illegible] 1905.

Respectfully,

B. T. Galloway.
Chief of B[illegible]

Hon. James Wilson,
Secretary of Agriculture.

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ILLUSTRATIONS.

3ENEFICIAL BACTERIA FOR LEGUMINOUS CROPS.[a]

INTRODUCTION.

part which leguminous crops play in maintaining soil fertility ng been a matter of speculation among practical farmers and a t for critical investigation on the part of scientific men. Plants 3 family, the Leguminosæ (which, in general, bear their seeds in a : legume), when grown in contact with certain bacteria form upon roots small knots or nodules variously known as "nitrogen knots" itrogen traps" from the part they play in furnishing to the plants gen derived from the air. The primary object in undertaking vestigation of the fixation of nitrogen by these root nodules :o devise, if possible, some method of bringing about the arti- introduction of the necessary organisms into soils which were ally devoid of them, and at the same time to attempt, as far as ble, to correlate and reconcile the vast amount of conflicting nce that has been accumulated by various investigators in regard e exact nature of the organism, where the nitrogen is fixed, the : upon the host plant, and similar problems.

ROGEN, THE ALL-IMPORTANT ELEMENT IN CROP PRODUCTION.

er since anything has been known in regard to plant nutrition and ecessary part that various gases and minerals play in the success- rowing of crops, scientific men have realized the great importance nserving the world's store of nitrogen, and have made every effort r to husband or to increase all available sources of supply. In arly days, when it was first realized that nitrogen was so essential lant life—in fact, was at the very foundation of agriculture—no

[a] he very great demand for information on the subject of nitrogen fixation by soil lation has made it desirable to prepare this general account of the subject with al reference to the needs of farmers. The article on Bacteria and the Nitrogen lem in the Yearbook for 1902 is now no longer available for distribution, but a tin (No. 71 of the Bureau of Plant Industry) which treats more at length of this ct can be obtained from the Superintendent of Documents, Government Print- Office, Washington, D. C., by sending 15 cents in currency or postal money r.—A. F. Woods, Pathologist and Physiologist.

ed to calm the fears of those who predict a nitrogen famine, it ne that appeals very strongly to the farmer so long as the price s where it is.

E POSITION IN AGRICULTURE OF LEGUMINOUS CROPS.

ı the earliest days of agriculture it has been recognized that all belonging to the Leguminosæ had a decidedly beneficial effect ıe soil. Pliny wrote: "The bean ranks first among the legumes. lizes the ground in which it has been sown as well as any manure." gain: "The lupine enriches the soil of a field or vineyard as well very best manure. The vetch, too, enriches the soil and es no attention in its culture." Varro, in De Re Rustica, I, 23, : "Legumes should be sown in light soils; indeed, they are d not so much for their own crop as for the following crop, since they are cut and kept upon the ground they make the soil better. he lupine is wont to serve as a manure where the soil is rather nd poor." There are also in ancient writings many other refer- to the importance and necessity of including some leguminous n the regular rotation. Naturally, the explanations offered to nt for this beneficial effect were various, perhaps the most uni- belief being that the root system of these plants was much more sive than that of grains and root crops, and consequently brought ınt food from considerable depths, which not only served the ıe, but was likewise available for subsequent crops.

ring the past century various theories have been advanced to in the growth of legumes in soils nearly or quite deficient in gen, and the benefit to such soils from their growth, but it was ntil 1886 that Helriegel announced at a scientific meeting that the e of nitrogen for these plants was unquestionably the atmos- e. Two years later, together with Willfarth, he demonstrated act that the growth of plants in soil free from nitrogen always rred after the development of nodules or swellings upon the roots. r the results obtained by these two men were fully substantiated ıany other investigators, and the explanation of the long unsolved lem was made possible.

EFFECT OF ROOT NODULES UPON GROWTH AND YIELD.

ıe actual benefit of the presence of root nodules upon various ıminous plants has been so thoroughly demonstrated by numerous rvers, both in this country and abroad, that it hardly needs fur- proof at this time. The early work of Helriegel and Willfarth, ether with that of Lawes and Gilbert and of Warington in England, of Atwater and Woods in this country, was quite sufficient to ıonstrate the direct connection between the acquisition of nitrogen

in some way by the plant and the presence of the tuber-like swelli
on its roots; and there are few, if any, who would maintain t
this peculiar function is not, under most circumstances, distin
beneficial. Indeed, by using clean sand, burned free of all orga
matter, it is possible to demonstrate beyond question that leg
nous plants will make a more vigorous growth when furnished w
nitrogen by nodule bacteria than when it is supplied as fertil
and nodules are absent. In pot experiments with vetch the inocul
plants exceeded nearly three times by weight those receiving nitro
ous fertilizer (6.16 grams and 2.65 grams, respectively), while p
having no nitrogen supplied them were insignificant in size (wei
0.33 gram). With the exception of the nitrogen element, the nutr
solution used in watering the pots was the same in all three ca
Similar results have been obtained in the field.

G. L. Thomas, experimenting with field peas on his farm n
Auburn, Me., made a special test with fertilized and unferti
strips, and stated that "inoculated seed did as much without fertiliz
of any kind as seed not inoculated but supplied fertilizer (phospha
at the rate of 800 pounds and a ton of barnyard manure per acre."

With garden peas, S. N. Lowry, of Philadelphia, found that "ino
lated vines yielded one and a half the crop yielded from groun
inoculated, but which was manured;" and Jeremiah Gardner, of
ney, S. C., wrote: "My cowpeas were better than those of
who used commercial fertilizer. They ripened early and even
consider inoculation a boon to agriculture."

Federico Narro, of Saltillo, Mexico, noted the following result
alfalfa:

> I have seen the progress of the inoculated alfalfa in the fields of J. Garcia R
> guez, and, although failure was expected by the people who knew that he w
> to sow alfalfa without manure, it is already coming out nicely and more
> the alfalfa sown in land covered with 8 or 10 inches of manure.

NITROGEN FIXATION AS AFFECTING SUCCEEDING CROPS

A convincing demonstration of the effect upon a soil of a legum
crop bearing root nodules is to note the striking differences bet
crops of grain or vegetables that follow legumes and a similar
grown on fallow land, or following a grass or vegetable crop. Th
matter of such common observation that a rotation including
leguminous crop is the practice of every farmer who has a though
maintaining the fertility of his soil. It is easily proved that p
this benefit is due to the amount of nitrogen fixed by the bact
the root nodules and not to the unusual length of the root sys
other peculiarities of the plant. Careful experiments to establis
fact have been carried on by many of the experiment stations
United States, the results all tending to prove that a leguminous

ects the soil which bears it like the addition of a considerable amount nitrogenous fertilizer. Averaging results obtained in sixteen ates, the amount of nitrogen added per acre has been computed as 2 pounds; in Germany it is estimated at 200 pounds per acre.

When it is remembered that a high grade of nitrate of soda contains ly about 15 per cent of nitrogen, while much that is on the market ntains considerably less, it will be seen that a crop of nodule-bearing gumes is equal to from 800 to 1,000 pounds of nitrate of soda per re, which at the present rate for this fertilizer represents a value of om $20 to $25.

ARTIFICIAL INOCULATION OF THE SOIL.

Since the desirability of introducing a leguminous crop into rotation ms to be of such importance, and the benefits to be obtained from odule-bearing plant are so evident, it is not surprising that every ort has been made to obtain crops which possess the power of using nospheric nitrogen. It has been found, however, that, although in a eat many instances the organisms producing nodules are naturally undant in the soil, and the mere planting of the legume seed is suffi- nt to produce a crop capable of fixing nitrogen, there are also some alities which are devoid of the necessary bacteria, and in such places seed sown either fails to make a stand or the crop, drawing its rogen from the soil, is of no more benefit to the soil than a cereal other "main crop" whose yield might be a distinct source of profit. der these circumstances the attempt to grow the leguminous crop a clear waste of time and labor unless proper steps are taken to roduce into the soil the organisms adapted to furnish the plant with nospheric nitrogen.

SOIL TRANSFER.

To devise some means of artificially introducing into the soil the lule-producing organisms has become necessary, and naturally the nplest means of accomplishing this has been to transfer earth known contain the proper organisms, and capable of producing nodules, the fields where it was desired to introduce such bacteria. This -transfer method is one which has been practiced widely, both in country and abroad, oftentimes with the best results, but not with versal success. Reports have been received from various places ing that even where soil known to contain the proper germs was d the results were not satisfactory. That this failure was not to the character of the soil or other adverse conditions is proved the success of other methods of inoculation upon the same kind land at the same time. The large quantity of earth necessary to duce thorough inoculation often makes it a laborious and expen- e process when the fields to be treated are at a considerable distance.

In addition to the expense and labor involved, however, ther . more serious objection because of the possibility of transferring pl diseases from one field to another.

H. C. Coesten, of Walnut, Kans., reports having transplant "leaf blight" to his field by this method, and many instan known in the South of the wilt of cowpeas being disseminated b rying soil from one field to another. There can be no doubt th tain diseases of plants, the spores of which remain in the earth be widely disseminated by attempting to produce inoculation b transfer of soil; and where the disease is one which causes great age to leguminous crops and is readily transported, it has be necessary to abandon inoculation altogether.

There is also great danger of introducing objectionable weeds wh ever soil from one locality is introduced into another region. though the weeds may not have been serious in the first field, the gr numbers of dormant seeds which often require but the slight change in environment to produce germination are always a m and a number of instances have been reported to the Departme Agriculture where the desired leguminous crop was completely ch out by the introduced weed. The director of the Mississippi Exp ment Station writes: "Owing to the fact that our alfalfa field more or less full of Johnson grass, we are unable to send soil f purpose of inoculation without distributing this objectionable gr sections where the farmers are trying to keep it out."

INVENTION AND USE OF "NITRAGIN."

In order to escape the difficulties previously mentioned, a Ge botanist, Professor Nobbe, of Tharandt, conceived the idea of bri about inoculation by means of pure cultures. This was to be ac plished by isolating from the nodule the right organisms and then tr ferring them to tubes or bottles containing a nutrient jelly as a bas growth. To this culture of nodule-forming bacteria was give trade name of "nitragin." Seventeen different kinds of nitragi prepared from the nodules of as many different plants, and arr ments were made to have them put up on a large scale and p upon the market by a well-known firm of manufacturing chemist

Experiments with nitragin in Germany met with varying de of success. In some instances its use seemed to produce an ab formation of nodules, while in other cases no benefit could be obt In this country the results obtained by Duggar were very satisfa but other investigators were not able to secure inoculation. Th difficulties seem to have been in securing cultures of the proper . of virulence, and in preventing deterioration because of bei jected to too much heat or to varying degrees of moisture. Th of the culture was also of importance, the manufacturers limiti time of efficiency of the culture to about six weeks.

wing probably to the difficulty of maintaining the efficiency of the ire and the adverse conditions to which it was often subjected ng transportation, the percentage of failures in the use of nitragin so great that its manufacture was given up, and it is no longer ale under that name. Consequently, even though this prepara- had been found satisfactory in Europe, the necessity for devising method of producing nitrogen-fixing nodules free from the ctionable features of transferring soil remained. For this reason Laboratory of Plant Physiology of the Department of Agriculture rtook a scientific investigation of the root-nodule organism with ew to making practicable for use in the United States the pure- ire method of inoculation.

FORMATION OF ROOT NODULES.

fore any improvement upon methods already in use could be d for, it was necessary to become thoroughly acquainted with the

-Roots of young alfalfa plants showing nodules.

FIG. 2.—Roots of melilotus (sweet clover) showing nodules.

ise nature of the nodule-forming organism, for, in spite of the that these organisms occur in great numbers and that the interior he nodule constitutes what is practically a pure culture, there has

been the widest difference of opinion as to the character of t-
bodies.

One reason for the different theories in regard to the true ca-
the legume nodule has undoubtedly been the diverse forms as-
by the orga-
found in the n-
at different times
under different
ditions. This d-
sity of form
given rise to p-
classifying the-
riously as "fu-
like" bodies,
fungi, yeasts, "
teria-like" b-
and true ba-
(See figs. 12, 13,
14.) They are p-
erly to be reg-
as bacteria, t-
differing in som-
nor characters
the majority of t-
group. They
admission t-
plant through
root hairs an-
quire but a
time to incr-

Fig. 3.—Roots of crimson clover showing nodules.

greatly in number. The irritation thus caused in the root t-
results in the rootlet taking an altered form; that is, a nodul-
formed. These nodules vary from minute spheres to swellings
large as marbles, while the lobed, flattened forms sometimes occ-
clusters much larger. (See figs. 1 to 11.)

CROSS-INOCULATION.

Because of the fact frequently observed that one kind of le-
would not produce nodules in soil which abundantly supplied an-
legume with these growths it has been supposed that each le-
required a special and peculiar nodule organism. Efforts have
made to distinguish between these bacteria specifically, and sep-
names have been assigned to the microbes from the nodules of p-
beans, clover, etc. A study of the organisms involved revea-
fact that no real differences exist. Pot experiments with s-

'erent legumes, using a pure culture of the nodule organisms from ' of the series, have shown that it is possible to cause the formation nodules upon practically all legumes, no matter what the source of organisms. The organisms used in such cross-inoculation must, vever, first undergo cultivation upon an artificial medium deprived :ombined nitrogen.

'he wide differences shown by bacteria (as occurring in soils) in ir ability to infect various leguminous crops are due no doubt to g adaptation to the peculiar reactions afforded by the host plant. · this reason specific cultures will usually produce more abundant lules in a given time than a fixed or universal culture, although ›wn upon nitrogen-free media. The practical import of this is that vill be necessary, in order to obtain the best results, to prepare cific cultures for specific crops. For this reason the farmer, in curing cultures, should always furnish definite information as to kind of clover, peas, etc., which he wishes to inoculate.

INFLUENCE OF CLIMATIC AND SOIL CONDITIONS.

[oisture.—The readiness with which root nodules are formed varies ely with the degree of moisture in the soil. Experiments by Gain others have shown that with peas, beans, and lupines, watered and 'atered, the number of nodules in moist soil exceeded those in dry from ten to twenty times, and experiments in this country have ıonstrated most conclusively that the humidity of a soil greatly ›rs nodule formation. This fact must be due either to the inability he organism to come in contact with the root hairs in the absence ufficient moisture or to a failure to penetrate the root hairs under ı conditions, for drought is in no way fatal to the bacteria.

ir.—In artificial cultures it was conclusively shown that the organ- ı deprived of air soon perish, the nitrogen of the air especially g essential to growth. The importance of thorough working of soil to permit the free entrance of air becomes at once apparent. ıring a proper degree of tilth has the added benefit of conserving soil moisture.

ght.—Direct sunlight is injurious to the growing organisms, but ›ably has little effect when they are once introduced into the soil covered by harrowing. No degree of cold will produce death, gh multiplication is practically stopped at 10° C. (50° F.).

:idity.—The importance of neutralizing the acidity of certain soils ·der to be successful in growing clover, alfalfa, etc., is well known, the addition of lime is frequently recommended where such crops In such cases it is probable that the acidity of the soil not only ejudicial to the growth of the plant, but has likewise prevented levelopment of the nodule-forming bacteria. Thus the addition e lime serves a double purpose.

Clover sickness.—Much of the so-called "clover sickness" is prob due to the accumulation of acidity through continual cropping. I· organisms, once effective, have deteriorated and no longer render a· ance to the plants. In addition to liming, therefore, it will oft· found advantageous in such regions to introduce a fresh supply bacteria by artificial inoculation. This applies to a large porti· the eastern and central portions of the United States. Failure· secure inoculation with cultures sent out during the past year h in a large number of the cases investigated, been traceable · decidedly acid soil reaction. The importance of this factor can not too strongly emphasized, especially as the cure is, in most cases, · of application and inexpensive.

Testing soil for acidity.—Whether the soil is acid or not can be rea learned by bringing a strip of blue litmus paper (obtainable at · drug store) in contact with moist soil and allowing it to remain twenty-four hours; a change from blue to pink (or pinkish) will t· place if the soil is acid. Lime[a] (applied as ground limestone, or · slaked burnt lime) at the rate of 1,000 to 1,500 pounds per acre · usually be sufficient for a first application. It should be evenly · tributed and well worked into the soil before attempting inocula·

For special soils, however, there is reason to believe that by a· cial methods of growth adaptations of the bacteria may be brou. about, so that special cultures to suit such soils will be secured.

Nitrates.—The fact that the nodules do not occur abundantly up plants growing in very rich earth has been frequently observed. · only does the available nitrogen in the soil render the activity of · bacteria less essential to healthy plant growth, but the presen· nitrogenous substances seems to have a distinctly unfavorable ef upon the bacteria themselves. Aside from the proof of this · shown in artificial cultures it has been strikingly illustrated in practice, using the same culture to inoculate plants growing in · medium, and poor soils. C. E. Jones, of Carysbrook, Va., in rep· ing upon the inoculation of soy beans, furnished three lots of spe· plants, saying, "No. 1, from the poorer places, an excessive grow· nodules; No. 2, from loose sand and soil, quite numerous but sma· No. 3, from a rich, loamy spot, not so abundant (few in fact), and · plants having no nodules at all."

INFECTION WITHOUT FORMING ROOT NODULES.

The result of certain experiments with cultures sent out from · Department of Agriculture indicated that in these cases at least th· was a decided benefit from inoculation although no nodules appea· With soy beans the plants so inoculated made a decidedly better gr·

[a] See Farmers' Bulletin, No. 77, U. S. Dept. of Agriculture, "The Liming of ·

ın nodule-bearing plants inoculated with soil from an old field. The ›ck plants (not inoculated) were much inferior to both. The tests re carried on at one of the State experiment stations and careful servations were made.

Similar results were obtained with alfalfa, berseem, and kidney beans other localities, widely separated. Examination under the micro-›pe of specimens secured showed in each case that the smaller roots re infected with the bacteria usually occurring in nodules, and these cteria were thus in a new way assisting the plants by their power of ing nitrogen. Cases of this character must be more fully investi-ted before any conclusion as to the factors involved can be reached.

PROVED METHODS FOR GROWING AND DISTRIBUTING NODULE-FORMING BACTERIA.

The method of growth was found to have a determining influence on the virulence and keeping qualities of the cultures. Reference s already been made to nitragin; its liability to deterioration and lack of virulence of the organisms were factors which made this oduct a failure in field practice. The medium used for inducing owth was a nutrient jelly, the basis of which was an extract of legume ms and roots. This gave a rapid growth of the bacteria, but con-ned such a ready store of combined nitrogen that the organisms re not forced to utilize the nitrogen of the air and as a consequence on lost this valuable power. Overfed, they became inert and failed produce nodules when brought in contact with the host plant.

USE OF NITROGEN-FREE MEDIA.

To overcome this difficulty numerous combinations of nutrient salts re tried and it was found that growth would take place in a solution king nitrogen, and further that the organisms thus produced pre-ved their ability to fix nitrogen and form nodules to a degree herto unknown. Bacteria grown upon media of this character oved to be much more virulent than those cultivated on a rich nitro-nous base, and experiments on a large scale showed the greatest differ-e in the nodule-producing power of organisms grown by these two thods.

DRY CULTURES.

How to maintain the necessary degree of virulence now became a oblem of first importance in securing practical results. Even ough the efficiency of the culture be at its highest point, the mere t of its having to grow for a considerable time under artificial con-ions is apt to weaken it; consequently, the means of preserving and tributing the bacteria after they are propagated becomes fully as important as the method of obtaining them in sufficient quanti... such distribution. This is another reason why the German pr... sent out upon rich nutrient media failed to maintain its ori... strength, and if it had not been possible to devise some more ... factory way of delivering cultures to the farmer it is probable ... little success could ever have been attained by the pure-culture m...

FIG. 4.—Roots of red clover showing nodules.

The method ... has been emp... in the Departm... Agriculture for ... past year has ... to saturate abs... cotton in a liqui... ture of the no... forming orga... In this way mil... of the bacteria ... held within the ... ton, and after th... carefully dried ... they remain dor... in much the ... way as seeds, ... ing for the pr... conditions to r... them.

LIQUID CULTURE

The "dry cult... thus produced ... only to be immer... in water to ... the organism... growth. To ha... the growth, ... ever, it seemed best to furnish with the cotton culture two p... ages of nutrient salts, one containing sugar, magnesium sulphate, ... potassium phosphate, and the other ammonium phosphate. By ... addition of the first three ingredients to the water a solution is for... which is not well adapted for the growth of the organisms us... carried about in the air (yeasts, molds, etc.), but is well suited for ... multiplication of the nodule-forming bacteria. The addition of ammonium phosphate at the end of twenty-four hours tends to inc... still further the growth of these bacteria, which are already ...

·ted if the temperature has not been too low or too high. With food thus supplied, a period of two days gives a growth sufficient :hange clear water to a milky liquid, ready to treat seed or soil. ᵌ fig. 15.)

rocess patented.—The method being perfected, it was deemed advis- ᵌ that a patent should be taken out, thus securing for the use of Department of Agriculture the result of its own investigations guaranteeing to public that no ıopoly could be ntained by com- ·cial producers similar cultures. ler the provi- ıs of the patent, ·ever, no restric- ı is placed upon manufacture of :ient and prop- · prepared cul- ·s by such con- ns or individuals.

FIG. 5.—Roots of soy bean showing nodules.

ME OF INOCU-LATION.

t has generally n accepted as ᵌ that to secure ·ffective inocula- ı the organisms st be brought › contact with the nts at an early ge of growth. ›oratory experiments have indicated that after a month's time ·ction is less likely to take place. The result of field experiments ing the past summer indicates, however, that fields of several years ıding may, under some circumstances, be benefited by artificial ·ulation, either by (1) using the liquid culture as a spray, or (2) :ing with a quantity of soil to use as a top dressing.

I. W. Dunlap, of Holland Patent, N. Y., having more of the liquid :ure than could be used for some seed he was inoculating, mixed ·ith a light loam and spread it upon a part of a field already in clover. "The difference in color and size of the plants later on indicated perfectly where the soil had been distributed."

Mrs. J. A. Wells, of Bryn Athyn, Pa., tried watering pea vines a month old with culture liquid, and "the treated vines were fully twice the size of the others."

A report upon a four-year-old alfalfa field to which bacteria were added, made by U. J. Hess, of North Yakima, Wash., reads as follows:


FIG. 6.—Roots of hairy vetch showing nodules.

> The crop, which had been short, pale, and spindling, took on a darker color and a rank growth, and yielded, I think, about three times as much as formerly.

F. G. Short, of Fort Atkinson, Wis., writes:

> In July the Department sent me a sample of alfalfa bacteria, with directions for application. This was used on a field of alfalfa which has been newly seeded this spring and up to that time had shown a very small growth of yellow, rather stunted plants. I used the bacteria according to directions and can see there is quite a decided change for the better.

In this case the field was gone over with a sprinkling cart containing a large quantity of the liquid culture. By attaching to the sprinkler an inch pipe 16 feet long, drilled full of small holes, a sweep one rod wide was made, so that the application was comparatively inexpensive.

In the light of these and similar experiments, there can be no doubt that bacteria of a high state of virulence are capable of producing inoculation at practically any time during the life of the legume if the conditions in the soil are favorable. It is probable that similar results have not been previously noted, because bacteria of such high efficiency have not been used. While it can not be stated that as sati[illegible] ry an inoculation will be obtained in this way as by treating at ime of planting, it certainly seems that under most circumstances e a crop is failing for the lack of nitrogen-fixing bacteria it is h while making an effort to introduce them, even though the s be several years old.

PREPARING LIQUID CULTURE FOR FIELD USE.

hile no special knowledge is required in preparing a liquid culture the dry culture used as a "starter," it is distinctly necessary that user be possessed of plain non sense, the ability to read rstandingly, and willingness to ly with directions. If the ewife mixes yeast in the sponge leaves the pan in a chilly part ie room she is not surprised she finds in the morning that east has not "worked." If the ulture is treated with a similar gard for explicit instructions ordinary prudence, the culture not be held to account if the r fails to become cloudy. It d seem impossible, from the ness of directions given (see), to make such mistakes as revealed in a few reports. g a "pickle pail" where a clean et is required, boiling or placing culture on ice, and putting ened packages in a hole in the nd afford examples of such ders. Cultures plainly marked red clover," "common peas," have even been used to treat nonleguminous plants as corn, toes, lawn grass, and house plants. As the principles under- soil inoculation become better understood, failures due to such akes will be eliminated. Notions of magical power will be aced by the recognition of logical processes.

FIG. 7.—Roots of velvet bean showing nodules.

APPLYING THE LIQUID CULTURE.

fter the water containing the nutrient salts and bacteria-laden cot- has been allowed to stand until it becomes milky, it is necessary to oduce this culture into the ground. This may be accomplished in two ways—either (1) by moistening the seeds with the fluid, the teria adhering to their surfaces and consequently being in close pr imity at the time of germination, or (2) by mixing earth or sand the culture and spreading over the field as one would apply ferti Greenhouse and small plat experiments indicated no particular adv tage of one method over the other, and the hundreds of reports rec from all over the country show that either means of introducing organisms will produce satisfactory results if the directions are p erly followed.

The sheet of directions which has accompanied each package inoculating material, sent out by the Department of Agriculture, is as follows:

Directions for Using Inoculating Material.

(Method patented in order to guarantee the privilege of use by the public. Letters patent No. 75 March 22, 1904.)

Put 1 gallon of clean water (preferably rain water) in a clean tub or bu add No. 1 of the inclosed package of salts. Stir occasionally until all is diss

Carefully open package No. 2 and drop the inclosed cotton into the Cover the tub with a paper to protect from dust, and set aside in a warm twenty-four hours. Do not heat the solution or you will kill the bacteria—it never be warmer than blood heat.

After twenty-four hours add the contents of package No. 3. Within twenty more the solution will have a cloudy appearance and is ready for use.

To inoculate seed.—Take just enough of the solution to thoroughly moisten the Stir thoroughly so that all the seeds are touched by the solution. Spread seeds in a shady place until they are perfectly dry, and plant just as you untreated seed. If bad weather should prevent planting at once, the in seed, if thoroughly dried, may be kept without deterioration for severa The dry cultures as sent from the laboratory will keep for several months. prepare the liquid culture more than two or three days previous to the tim the seeds are to be treated, as the solution once made up must usually be us end of forty-eight hours.

To inoculate soil.—Take enough dry earth so that the solution will merely it. Mix thoroughly, so that all the particles of soil are moistened. Thoroug this earth with four or five times as much, say half a wagonload. Spread th ulated soil thinly and evenly over the prepared ground exactly as if sprea tilizer. The inoculated soil should be harrowed in immediately.

Either of the above methods may be used, as may be most convenient.

In addition to the above directions an information card accomp each culture, reading as follows:

Information for Users of Inoculating Material.

The inclosed package marked "No. 2" contains a dried culture of bacter culture treated according to the accompanying directions will produce a li ture, which, if associated with the proper plants, is capable of rendering ava these plants the free nitrogen of the air. This is accomplished through th tion of root nodules.

The bacteria are beneficial *only* in connection with legumes ("pod-forming" and are not applicable to other farm or garden crops. Each culture is adap *icular* legume crop, the name of which is stamped upon the package. Even with mes, these bacteria are of no decided benefit except when the proper nodule-ing bacteria are lacking in the soil, but a crop of nodule-bearing legumes improves soil for succeeding crops.

he bacteria are capable of making up for a deficiency of soil nitrogen, but where r elements, as potash and phosphoric acid, are lacking, inoculation will not do y with the necessity for fertilizers containing these substances. Mineral fertil-s should, however, never be applied so as to come in direct contact with inoculated .

his material is furnished you with the understanding that you will carefully fol- directions in its use, and will report upon the inclosed card your success or failure.

FIG. 8.—Roots of sweet pea showing nodules.

Iethods of treat- seed.—In the culation of small is or small lots eed the mechan- operations are imple as to need pecial comment. ere several hun- d bushels of seed to be treated, cial provisions st be made for roughly drying seed, so as to vent damage ough molding. ere enough floor ce is available, a hours are suffi- it to dry the ls if they are t well stirred a good circula- of air is main- ed. On some ranches in the southwest carloads of seed have been essfully treated and dried in this way without injuring their ninative power. (See figs. 16 and 17.) The seeds are spread out sprinkled with the liquid culture prepared in large tubs, care g taken to moisten every seed.

nother method, which permits no waste of the culture, is to place the in gunny sacking, immerse in the fluid, allow them to drain, and spread out to dry. In some cases special drying apparatus has constructed, using a warm blast (never above 100°F.) and passing moistened seeds along on a belt which deposits them thoroughly dried in the sacks. This method lends itself well to the requir of seedsmen who wish to treat several hundred bushels on short "Inoculated seed" may soon be a regular item of trade. The that the bacteria thus dried upon the seed remain effective for i lation purposes for several months makes this more than a pos and, with proper precautions, the effect upon germination need no objections. Indeed, evidence is not lacking that seed so trea that is, with due regard to temperature in drying, etc.—is actually erated in its germination, an advan which means much to the plant in season and in the struggle against w

FIG. 9.—Roots of lupine showing nodules.

R. C. Atkinson, of Wilkinsburg, reporting upon inoculated cowpea soy beans, has this to say: "Seaso very unfavorable, yet the inoculate came to a nearly perfect stand and m quicker growth. The difference was marked."

C. H. Elmore, of Applegate, Or. reports concerning alfalfa: "Seed al and lived through a dry summer on t dry hill land; bids fair for a good next year. Without treatment the did not germinate at all."

W. H. Meyer, of Chatham, N. J., of garden peas: "Seeds germinated what sooner than those uninoculate recommend it to anyone to use in pla bone dust."

USE OF FERTILIZERS IN CONNECTI WITH INOCULATION.

The object of inoculation is, of c to enable the plants to secure an ade supply of nitrogen without drawing the soil resources. A deficiency of other necessary plant foods as potash and phosphoric acid, must still be taken into account where experience has demonstrated the need of these fertilizer amount of inoculation can be expected to act as a substitute.

Some care in the application of fertilizers should be observ order to obtain the best results with legumes. Where soil ten become acid and liming is not feasible, the use of commercial pr tions containing a high percentage of acid is of questionable a bility. Mr. C. R. Spencer, of Chardon, Ohio, has the following on this point: "For fifteen or twenty years we were very succ raising clover. At present we can not get much of a stand, and many cases entirely fail. The complaint is general in this vicinity, ›me claiming that the acid used in phosphate is doing the mischief."

By using, wherever possible, fertilizers containing phosphates in nonacidulated form (as ground phosphatic rock or bone meal) the ndency to create a soil reaction unfavorable to legumes would be rgely avoided. Since the phosphoric acid in these fertilizers is in a ›rm not at once available, the application should be made some time ·evious to sowing, › as to permit the ›cessary decompo- tion.

FIG. 10.—Roots of sainfoin showing nodules.

Effect of fertilizers ›on bacteria.—The fect of fertilizers ›on the bacteria is so of some impor- ›nce. The caustic ›tion of concen- ated fertilizers rought into close ›ntact with inocu- ›ted seeds in sowing known to be inju- ous. Especially is ›is true if the seed ›ould still be in a ›oistened state after ·eating with liquid ›lture. Care should e taken that floors sed for drying in- culated seed are ›oroughly cleaned brushed and ·rubbed), especially the same floor space has served for mixing fertilizers. The liquid on ›e seeds would readily take into solution chemicals contained in the ›rtilizers, and the effect would be disastrous alike to seed and bacteria.

In no case should moistened seed be dried by mixing with pulverized ›rtilizers, clean sand or dirt being in every way preferable if it seems esirable to hasten drying in this way. Indeed, it has been demon- trated in actual field experiments by Mr. M. B. Waite, of the Depart- ›ent of Agriculture, that there is a considerable injury to the seeds themselves when sown in drills in contact with large amounts of mi eral fertilizers used in full strength. Careful laboratory experiment have established beyond a doubt the killing effect of commercial fe tilizers upon seeds when in direct contact. If the germ of the se can be thus injured when protected by a more or less thickened se coat, the effect upon sensitive bacteria attached to the seed and unpr tected can be nothing short of the absolute destruction of every orga ism touched. If the drill has previously been used with fertilizer, ca should be taken to clean thoroughly all parts that may come in conta with the seed. If fertilizer is to be used, it should be spread an mixed with the soil or drilled previous to sowing inoculated seed.

FIG. 11.—Roots of garden pea showing nodules.

CHOICE OF LEGUME FOR GREEN MANURING.

In selecting a crop to sow for bringing up worn-out or naturally poor soil, attention should be paid to its suitability for the soil, climate, and any peculiar local conditions. For instance, a plant requiring considerable warmth and sunlight, as the cowpea, should not be used as a cover crop in an old orchard affording much shade. For this purpose Canada field peas or clover would do better. In soils lacking lime (where lime is not easily obtainable) a plant capable of withstanding considerable acidity, as the cowpea or lupine, should be chosen rather than clover or alfalfa. In heavy clay soils holding much moisture, red clover or alsike clover will often succeed, though alfalfa can not possibly make a stand.

[a] Bul. 24, Division of Botany, U. S. Dept. of Agriculture.

oil conditions vary so greatly even in limited areas that no hard fast rules can be made for general application. Valuable hints

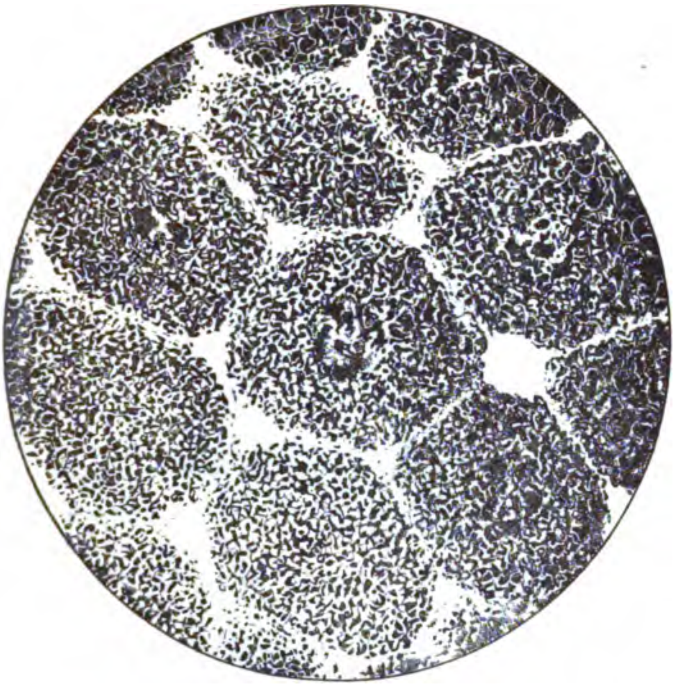
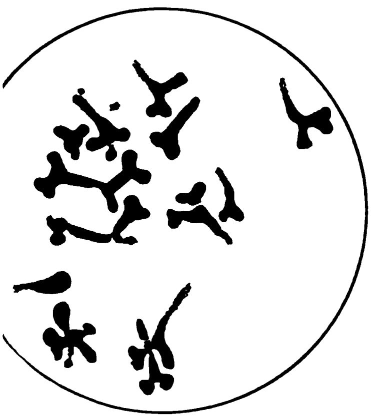


Fig. 12.—A few cells from a lupine nodule, magnified 1,000 times to show the bacteria.

often be secured by studying the native or wild legumes, and it so frequently the case that plants valuable as fertilizers are rated



13.—Branching forms of bacteria from a clover nodule; magnified 2,000 times.

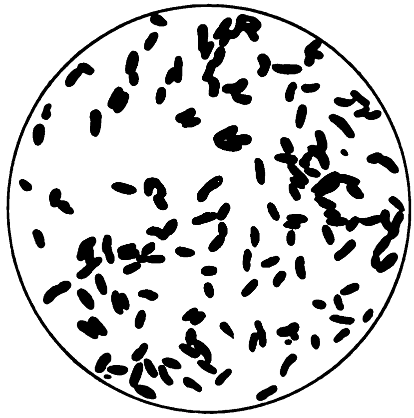


Fig. 14.—Rod forms of bacteria from a fenugreek nodule; magnified 2,000 times.

nere weeds, and their benefit is thus lost by neglect or intentional lication. The volunteer growths of sweet clover (Melilotus), Japan clover (Lespedeza), bur clover, beggar weed, and various wild be peas do much to improve land in disuse; and where they v interfere with subsequent planting they should be encouraged possession exclusion c leguminous especiall usually ra weeds.

FIG. 15.—Clouding of culture liquid (in flask on left) due to the growth of bacteria in forty-eight hours.

In this con it would be urge the w of such leg crimson clo hairy vetch are capable ing growth son of th when land is (or frequen bearing crops. Their effect in binding soil, preventing loss b ing, choking out weeds, etc., during the fall, winter, an spring months is a consideration only secondary to their gre lizing value when associated with the nitrogen-fixing bacteria.

FIG. 16.—Sprinkling Canada field pea seed with cultur method employed on a large fruit farm in Californi

It is not possible in a publication of this kind to take up in detail the adaptability of the various legumes under different conditions, but the farmer who has difficulty in selecting a suitable soil-renovating crop need only to write to his State experiment station or to the United States Department of Agriculture to receive public or suggestions to guide him in a wise choice.

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[a] Farmers' Bulletin No. 16, U. S. Dept. of Agriculture, Leguminous Pl Green Manuring and for Feeding.

HEN SHOULD THE FARMER RESORT TO ARTIFICIAL INOCULATION?

Гhe question naturally occurs to the farmer who reads of the wonder- work done by bacterial cultures, "How can I benefit by this discov- ?" To begin with, it should be clearly understood that the nodule teria are only useful with the plants which Nature has adapted to pro- re root nodules en these bacteria present. These nts are practically included in the guminous or pulse" family, and common forms wn are the clovers, as, beans, and tches. Some ex- riments have been ide by workers this country to fect the roots of rn, wheat, etc., th nitrogen-fixing cteria, but the sults were nega- e in every case.

Fig. 17.—Stirring seed moistened with culture liquid to hasten drying.

Assuming that the farmer has decided to sow some legume—alfalfa, r instance—the first question is, "Does my land need this treatment?" ie answer depends on several conditions.

WHEN INOCULATION IS NECESSARY.

.) Inoculation is absolutely necessary when—

(1) The land is at all poor or "thin" and has borne no legumes previously.

(2) The land has borne legumes whose roots were devoid of nodules. Even in soils rated as "standard," and capable of producing excellent crops of grain, etc., legumes lacking nodules frequently make a very poor showing.

WHEN INOCULATION IS DESIRABLE.

(B) Inoculation is highly desirable when—

(1) The legumes previously grown on the land belong to a group of these plants. For instance, Bokhara or sweet (Melilotus) and bur clover are the only common legumes give evidence of having nodule bacteria capable of inf alfalfa. Infection of soy beans grown in the United State first secured only after using soil imported from Japan.

(2) The soil produces a sickly growth of legumes even their roots bear nodules. This applies whether the legu crop to be sown is the same as the preceding one or not. introduction of the more active organisms furnished b cultures may solve the difficulty.

WHEN INOCULATION IS WORTHY OF TRIAL.

(C) Inoculation is worth a trial when—

(1) The crop, already sown, has made a stand but gives e of failing from lack of the nodule-forming bacteria.

(2) A field, which has previously grown a good leguminous begins to give even a slight indication that, all other con being the same, it is not producing the highest yield. situation is the hardest to detect, because it depends up gradual loss of virulence of the bacteria already in the soi the only way of being certain of this condition is to try in tion and note results.

WHEN INOCULATION IS UNNECESSARY.

Inoculation is unnecessary—

(1) In soils where the leguminous crops usually grown are pr ing up to the average and the roots show nodules in normal nu In such cases inoculation will give no material increase in yie will the soil receive additional enrichment thereby. This m accepted as a general rule, although cases have been reported ing increases beyond what could be reasonably expected, due probability, to the greater activity of the bacteria grown ir cultures. Whether the increase under such circumstances wou sufficient to make inoculation worth while would depend upo degree of deterioration which the organisms already in the so reached.

(2) In soils rich in nitrogen. Where plants can secure con nitrogen in the soil they will draw from this direct source though they are provided with root nodules. Mention has al been made of the effect of rich soil upon the ability of the bact

nodules. Growing legumes upon such soils where nodules are 'eadily formed is not advisable, as it is manifestly poor economy. ı the aid of the nodule bacteria, legumes can be made to produce ⁝ as well upon much poorer soils. Ground containing a high per- ıge of available nitrogen would thus be released for the growing 'ass, grain, or truck crops which do not possess facilities for util- · atmospheric nitrogen. Of course, the use of rich soil would be fied if the legume crop should happen to be the most profitable e region, or if the land should be of uniform fertility.

WHEN TO EXPECT FAILURE WITH INOCULATION.

ilure with inoculation may be expected—

When the directions for preparing the liquid culture are not 'ully followed. Reference has already been made to the necessity strict adherence to a few simple but necessary instructions. In nstance, two dry cultures derived from the same "stock culture" used by the same experimenter gave widely different results in ning fields. The first, prepared without proper reference to tem- ture and manner of application, resulted in the loss of the seed ı (alfalfa), no nodules being formed. In the second experiment, more care taken, nodules were produced in abundance and the l was a perfect success. The culture does not itself contain the ıgen, but simply the organisms which potentially have the power xing nitrogen, and which, if properly handled, will increase in numbers as to be of material benefit to the plants with which become associated.

When the ground is already thoroughly inoculated.

When the soil is so rich in nitrogen as to prevent the growth of ıle-forming bacteria.

When the soil is too acid or too alkaline to permit the develop- ; of either plants or bacteria.

When the soil is deficient in necessary plant foods, such as sh and phosphoric acid, as well as in nitrogen.

should also be borne in mind that inoculation will not overcome results due to bad seed, improper preparation and cultivation of and, and decidedly adverse climatic conditions.

fore attempting to secure the benefits of inoculation, the farmer ld first thoroughly inform himself upon the general culture of the to be sown. Neglect to do this simply invites failure. Sowing fa on hastily prepared land, on land foul with weeds, etc., has responsible for several hundred failures among our own experi- ters, and through the country at large the percentage is certainly ' as great. The readiness with which free publications covering ssential points in the culture of all common legumes may be obtained from the State experiment stations and from the [illegible] States Department of Agriculture renders it inexcusable to fail thr[illegible] ignorance.

CIRCULAR OF INFORMATION TO FARMERS.

The following circular letter was prepared as a reply to app[illegible] desiring to gain some experience with the pure-culture metho[illegible] ulation:

DEAR SIR: Your recent letter relative to nitrogen-fixing organisms [illegible] received.

The organisms for the common legumes, such as alfalfa, peas, bean[illegible] vetches, etc., will be distributed to applicants who desire to aid in t[illegible] efficiency of these organisms in different parts of the United States. A[illegible] rule the quantity sent to each applicant will be sufficient to inoculate [illegible] bushels of the seed for which the inoculation is desired. In special cases [illegible] when large quantities of seed are to be inoculated, directions for preparin[illegible] liquid will be forwarded, and as much as is desired can be made up at a [illegible] cents per gallon.

If you wish to secure inoculating material, it will be necessary to writ[illegible] stating what legume you expect to sow and giving approximately the dat[illegible] ing, so that we may send you the organisms in the best possible conditi[illegible] necessary, as our methods require the inoculation to be made either befor[illegible] time of planting the seed. Full directions for use are included in each [illegible] sent out.

The bacteria are beneficial *only* in connection with legumes ("pod[illegible] plants), and are not applicable to other farm or garden crops. Even wit[illegible] these bacteria are of no decided benefit except when the proper nodule-[illegible] organisms are lacking in the soil, but a crop of legumes with nodule-formin[illegible] improves the soil for succeeding crops. The inoculation process does n[illegible] with the usual method of sowing or subsequent cultivation.

When applying for inoculating material do not neglect to state the prob[illegible] of planting, kind of seed, and amount to be treated. In replying, please n[illegible] circular.

As the supply of inoculating material is limited, you should furnish the [illegible] information at once. Do not apply for these organisms unless you are rea[illegible] sure your soil needs inoculation.

Yours very truly,

A. F. Woo[illegible],
Pathologist and Ph[illegible]

Approved:
B. T. GALLOWAY,
Chief of Bureau.

The interest which this form of soil renovation has aroused [illegible] indicated by the fact that for spring sowing in 1905 the num[illegible] applicants that could possibly be furnished with these experi[illegible] outfits (in all, 10,000) was listed by February 15.

It should be added that no formula or recipe will enable a fa[illegible] to produce his own cultures. The pure culture, used as a "sta[illegible] can be prepared only by a trained bacteriologist with laborator[illegible]

In the "special cases" referred to in the above circular letter ıation is merely given as to what chemicals to buy in preparing amounts of liquid culture from the dry culture furnished.

FIELD TESTS BY PRACTICAL FARMERS.

of the foregoing discussion regarding the benefits to be derived inoculation and the methods devised for propagating and dis- ing the nitrogen-fixing bacteria amounts to nothing unless it can ›wn that these cultures really accomplish, under the general con- s to be found upon any farm, a decided increase in a crop over rown without inoculation. In order that the bacteria might the most thorough practical test possible the Department of ulture conducted during the year 1904 one of the largest experi- of this nature ever undertaken by any country. By the distribu- f cultures to practically everyone who was sufficiently interested uest a package it was possible to secure about 12,500 tests under ost varied conditions in almost every State of the Union.

DISTRIBUTION OF INOCULATING MATERIAL.

› following list indicates the number of packages distributed in State up to November 1, 1904:

I.—*Number of packages of inoculating material (or inoculated seed) distributed November, 1902, to November, 1904, arranged by States, Territories, and foreign tries.*

Where sent.	Alfalfa.	Clover.		Pea.			Bean.			Vetch.	Miscellaneous.	Total.
		Red.	Crimson.	Garden.	Cowpea.	Field.	Common.	Soy.	Velvet.			
Territory:												
bama	242	17	80	10	45	1	7	10	8	109	79	608
ska	......	1	......	1	......	......	......	......	......	......	......	2
zona	11	......	......	......	......	......	......	......	2	......	1	14
ansas	64	15	1	9	28	1	5	2	....	2	10	137
ifornia	171	21	4	61	15	120	41	3	1	30	23	490
orado	20	3	......	8	3	1	9	......	....	1	2	47
necticut	30	9	......	8	1	......	6	4	....	1	4	63
aware	10	2	10	2	3	......	1	......	....	2	3	33
trict of Columbia	28	12	6	6	2	......	5	......	2	6	4	71
rida	40	7	4	22	28	1	28	1	21	17	15	184
orgia	89	17	26	16	45	5	5	4	3	45	32	287
waii	4	1	......	1	2	......	1	2	2	......	......	13
ho	16	17	3	4	......	2	4	1	....	4	3	54
nois	147	101	3	17	39	8	11	33	1	8	48	411
liana	239	103	5	6	31	2	2	16	1	6	36	447
lian Territory	10	4	......	1	......	......	1	......	....	......	......	16
va	91	41	2	7	6	2	7	9	....	4	32	201
nsas	122	32	......	7	13	1	11	10	....	2	11	209
ntucky	66	55	8	13	22	1	5	9	....	8	31	218
uisiana	50	3	1	6	14	......	1	......	1	3	25	104
ine	12	21	......	9	......	......	11	1	....	2	5	61
ryland	91	28	6	8	13	1	6	7	1	4	9	174
ssachusetts	71	73	3	71	6	4	48	11	....	8	10	305
chigan	95	95	8	20	9	5	28	10	2	4	26	302
nnesota	34	38	2	6	......	......	6	1	....	3	5	95
ssissippi	87	3	4	2	5	......	1	1	....	20	19	142

TABLE I.—*Number of packages of inoculating material (or inoculated seed) distribut from November, 1902, to November, 1904, etc.*—Continued.

Where sent.	Alfalfa.	Clover.		Pea.			Bean.			Vetch.	Miscellaneous.	Total.
		Red.	Crimson.	Garden.	Cowpea.	Field.	Common.	Soy.	Velvet.			
State or Territory—Cont'd.												
Missouri	211	63	6	10	20		8	13		7	29	
Montana	34	10		1		1					4	
Nebraska	96	19		2	4		3	3		4	6	
Nevada	3				1						1	
New Hampshire	11	22		13	2		8	2		2	8	
New Jersey	68	32	12	9	7	4	14	2		5	3	
New Mexico	18	2		2			2					
New York	285	174	19	73	25	18	77	30	1	21	31	
North Carolina	200	54	64	8	48	3	5	11	5	67	38	
North Dakota	25	16		4		2	4			1	4	
Ohio	273	157	9	20	23	2	24	25	2	10	55	
Oklahoma	72	2	2	1	12		2	4		1	4	
Oregon	126	99	3	23	2	6	15	3		61	7	
Pennsylvania	128	108	15	63	14	8	46	17		13		
Philippine Islands	1											
Porto Rico	3	2		2	3		3	1	2		2	
Rhode Island	6	5	3	3			4	3	1	1		
South Carolina	70	15	48	8	28		5	1		35	31	
South Dakota	28	8		5	1	1	3	2	1	1	2	
Tennessee	185	55	7	17	26	1	10	5	2	9	29	
Texas	276	10	3	13	28	6	7	2	2	3	77	
Utah	1			2			2					
Vermont	23	21	1	6	1		8	2			2	
Virginia	541	184	68	26	114	2	7	48	5	56	86	1.
Washington	106	81	1	27	3	4	24	3		22	3	
West Virginia	34	19	2	5	13		3	6		2	3	
Wisconsin	51	45	3	13	8	4	10	11	1	7	7	
Wyoming	14			1			1					
Foreign countries:												
Australia	2			1	1			2		1		
British Guiana	1											
Canada	6	6		2		1	1	1		1		
Costa Rica	2				1			1	1			
Cuba	3			2	5		1	2	2	1	1	
England	2	1	1				3			2	1	
France		3		3								
India	2			2	3		3		3			
Mexico	3										1	
South Africa	1	1	1		1		1	2		1		
Unclassified	378	146	79	90	370	8	122	54	13	24	3	1,1
Total	5,129	2,079	523	778	1,094	216	676	391	86	647	871	12,4

REPORTS SHOWING PROPORTION OF SUCCESSES AND FAILURE

While it has been impossible to obtain reports from all experi menters the percentage of replies has been unusually large, and i quite sufficient to enable the formation of a fair opinion as to the valu of the cultures distributed. In calling for a report it was, of course understood that in some cases where the culture was used the result ing crop could not be a success, and the users were asked to indicat as far as possible, when the failure was evidently due to some fault i seed or weather. Likewise, if the soil was shown to have been stock previously with the proper bacteria and good crops were produc the use of inoculating material was not expected to be of benefit, a no difference would be detected upon treated and untreated land. is obviously difficult, however, to get all experimenters to make note of these conditions, a report upon the general result being abo hat can be expected in most cases. For this reason the sum- of the reports is not as favorable for inoculation as it probably d be if all of the experiments could have been followed in the same as is possible when such investigations are conducted upon a small . It should also be remembered that no selection of the region hich tests were to be made was possible. Experiments with inoc- d seed of crops manifestly unadapted for the locality in which were sown which were reported as a failure of the inoculating rial have been recorded as such. In spite of counting unfavor- reports of this kind, which by no fair adjustment should be ded, but which, on account of the impossibility of being certain e conditions, could not be thrown out, the average percentage of res is less than is generally expected from the indiscriminate ing of seed known to be good.

e tabulated reports so far as received up to December 31, 1904, ll of the principal crops are as follows:

TABLE II.—*Reports of inoculation experiments with principal crops.*

Crop plant.	1. Total number of reports.	2. Inoculation resulting in definite increase of crop.	3. Failures definitely ascribed to bad season, poor seed, weeds, etc.	4. No increase in crop; organisms already present in the soil.	5. No evident advantage from inoculation; nodules not formed.	6. Percentage of successful experiments.[a]
	1,380	667	399	70	244	73
over	680	391	156	98	35	92
pea	276	144	64	46	22	87
u bean	305	139	82	49	35	80
a	492	253	95	99	45	85
an	175	61	43	12	59	51
vetch	80	38	19	10	13	75
m clover	67	36	21	5	5	88
a field pea	23	23	7	7	....	100
bean	11	11	6	5	6	65
	8	3	1	3	1	75
pea	10	5	3	2	....	100
m	2	1	....	....	1	50
Total	3,540	1,772	896	406	466	[b]79

omputing the percentage of successful trials the number of cases where there resulted no evi- dvantage from inoculation (fifth column) has been compared with the number which were e successes (second column), experiments under columns 3 and 4 being, of course, disregarded.
erage.

SOME CHARACTERISTIC EXPERIENCES.

is believed that a careful examination of replies received from rimenters who have had no other instructions than those sent the inoculating material will demonstrate the success of the new iods devised by the Department of Agriculture in a way that ld be impossible by a mere discussion of results obtained in the ratory or greenhouse. Such intense interest has been shown ughout the whole country in succeeding with alfalfa that, for this , reports have been selected showing the distribution and results by States. The reports representing the various States are in many cases far from being the best received, selections being made to show the possibilities of soil inoculation under widely different climatic and soil conditions. For the other crops, only such are given as illustrate some special feature or furnish suggestions to prospective experimenters.

Alfalfa.

ALABAMA, *Tuscaloosa.* T. J. Ozment.—Seed treated with the bacteria produced 100 per cent more than untreated seed.

ARKANSAS, *Mount Ida.* D. Peters.—Made a crop where it would not grow before. Am of opinion that the inoculation is all right.

CALIFORNIA, *Sanger.* E. C. Southworth.—I had only material enough to inoculate 5 acres; seeded 25 acres to alfalfa. The inoculated seed grew, the other did not.

COLORADO, *Flagler.* Edwin Forrest.—I think it was greatly improved, as I got a stand which I never accomplished before. It grew to a height of 8 to 12 inches, bloomed, and made some seed. I left the crop standing as a mulch over winter. I planted in rows 16 inches apart so I could cultivate with a sugar-beet cultivator.

CONNECTICUT, *Granby.* Daniel P. Cooley.—The nodule formation is perfect. No crop has been harvested this season. Has been cut four times to kill weeds. The stand at this date (October 20, 1904) is good.

DELAWARE, *Townsend.* James Flanagan.—A heavy storm just as plants came up covered many of them, but those remaining looked nicely and have bacteria nodules on the roots.

IDAHO, *Freese.* I. E. Lobaugh.—Made fine growth for first year. Good stand. Clipped three times. Left on ground.

ILLINOIS, *Mount Carmel.*—W. F. Chipman.—Nodule formation on almost every plant examined yesterday, and foliage rich dark green. Fine, vigorous stand. I find more nodules on the alfalfa sown about a month ago than on that sown last May. The reason perhaps is the difference in the amount of ground covered with each package, the first being about 9 acres, while the last was spread over but 1 acre.

INDIANA, *Butler.* L. G. Higley.—Bacteria for alfalfa was received in good condition about May 1. I prepared it and mixed it with about 20 bushels of rich soil and sowed it on the field after plowing it. I sowed my alfalfa seed May 11, along with 2 bushels of smooth barley per acre. It has done better than any alfalfa that I ever sowed. It stands over a foot high nearly all over the field. There is hardly a square foot of land in the field that is not well set with plants. I took a spade to-day and went in the field to see if I could find any trace of the bacteria, and I soon found that the soil was full of it, every plant having lots of the nodules on the roots. I then went to a field of 2-year-old alfalfa, which never was treated with bacteria, to see if there were any nodules there, and after hunting a long time I found a few very small nodules, but hardly enough to be really worth mentioning. This field is failing and I will have to plow it up. Alfalfa will grow on real rich soil without its bacteria, but I believe it will grow better with it; and if the land is the least bit poor it will starve to death if it has not its bacteria.

INDIAN TERRITORY, *Pecasset.* Don Nolian.—We had tried it (alfalfa) twice before, this being the third trial. Had perfect stand and have cut three crops and have good covering for winter. There is about 1 acre in lot, and I have taken about 3 tons of hay from it, or a ton at each cutting.

, *Algona.* Judge W. B. Quarton.—I took one gallon of nice rain water and followed the directions received from your Department with the culture of bacteria, and received the identical results that your Department said I would. I personally inoculated this bushel of seed, then spread it out to dry, took it to the farm the next morning, and planted the seed. * * * I have been upon my farm many times between the middle of July and this writing, taking my pocket knife and digging down to the roots of the alfalfa plant. I have never failed to find plenty of thrifty-looking tubercles on the roots, they ranging from one to clusters of one hundred, and I am satisfied that my field is thoroughly and completely inoculated, and I believe that your method is a complete success. * * * I feel like congratulating your Department upon the very thorough and practical work that you are doing in the line of plant industry and especially as to leguminous plants. I hope that you will continue it. because the legume is the one plant above all others that fertilizes the soil and at the same time furnishes the protein necessary to balance the food ration in our corn-growing States like Iowa.

AS, *Halstead.* A. Murray.—The alfalfa inoculated could not have done better. I will not plant any after this without inoculation. I think inoculated alfalfa is as good at 1 year old as uninoculated is at 3 years old.

UCKY, *Berlin.* John A. Buser.—One acre was planted; one-half was inoculated, the other half was not. Received good stand in all parts. On examination of some roots the treated plants had root nodules and the untreated were barren.

E, *Wayne.* S. H. J. Berry.—Last year I tried to raise alfalfa but was unable to get a stand, but this year, by the use of the inoculation, I have a very pretty plot of this valuable grass. I believe it to be what my land requires.

LAND, *McDaniel.* William Bielefeldt.—Inclosed please find your card filled out as to general results. I did not harvest any hay off the field, but pastured it lately. I am sorry that I am not able to give you any definite figures on the crop, and as your card is not large enough to express my appreciation and enthusiasm for your method of inoculation you will please excuse this letter, in which I will try to sum up my observations of the experiment in the following: I inoculated 1,800 pounds of alfalfa seed with the material received. I dried the seed well after inoculating and sowed it from May 1 to August 15. The land is a medium heavy fine clay soil and originally, I think, a fairly good soil, but has been entirely farmed to death with continuous tobacco raising, and after that wouldn't grow any more they followed it up with wheat and corn till that failed to grow any more; then the farm was sold. So I can say the soil is in a very poor condition chemically and physically, so much so that on 2 acres sown with seed not inoculated, alfalfa failed to make a stand at all. But on all ground in the same condition the inoculated seed made a brilliant stand and is looking a real deep green in color, when nearly everything else is dried up, as we have had no rain for six or seven weeks. In all, allow me to say that in my opinion your Bureau has made the greatest discovery toward helping the growing of alfalfa that could be made, and that you may well be proud of it, and I thank you for giving me a chance to use it. A neighbor adjoining me sowed uninoculated seed three successive times on the same piece of ground and failed to get a stand; that is positive proof of the inoculation being a benefit.

IGAN, *Kiffie.* A. L. Rockwell.—Mixed bacteria with soil; sowed broadcast after seeding; harrowed lightly. Seed all grew and made a good stand. Other seed without bacteria failed.

Missouri, *Levy.* Thomas O. Hudson.—Planted in 1901. Alfalfa was sickly and yellow and spindling, and did not do any good till this year after inoculation. This year it has been dark green and thrifty, and I think it will be better next year.

Nebraska, *Atkinson.* H. E. Henderson.—I got a good stand where I had failed twice before. I think it the only safe and sure way to secure a stand.

New Jersey, *Vineland.* E. L. Bolles.—First cutting on May 25, 1904, of 2 to 3 tons from 1 acre (seeded August 25, 1903), nine months from seeding. Scores of trials without inoculation have been made in this section with universal failure. Alfalfa wintered well, while we had a killing winter for crimson clover.

New Mexico, *Nogal.* Ed. C. Pfingsten.—Soil inoculated shows bacteria on all roots examined. Inoculated plants from 20 to 30 inches high, others 6 inches.

New York, *Amsterdam.* Barlow W. Dunlap.—I have recently examined the plants in all parts of the field and find nodules on nearly every root. The same piece was sown with untreated alfalfa seed in 1902. The plants started well, but nearly all died before fall. I could not then find a single nodule on the roots.

North Carolina, *West Raleigh.* C. K. McClelland.—Four cuttings have been made; second and third cuttings contained much alfalfa. Examination shows plenty of tubercles on the roots, so inoculation was successful.

Ohio, *Granville.* Chas. B. White.—Excellent set. Contiguous soil, not inoculated, gave feeble stand. The ground was cut thrice, but left on field as mulch.

Oklahoma, *Lambert.* T. W. Croxton.—Good, a perfect stand, and of healthy color. On upland prairie.

Oregon, *Days Creek.* C. N. Wood.—My neighbor sowed alfalfa and red clover the same time I did, also with irrigation, equally as good seed, and equally as good or better soil, and his crop did not get large enough to clip at all this year yet, and it looks sickly, while mine is thick and a rich green in color. My crop of alfalfa and red clover is at least 60 per cent ahead of my neighbor's. Mine was inoculated and his was not. I shall use soil from the inoculated field to inoculate other fields of the same kind of crop.

Pennsylvania, *Muddycreek Forks.* Vallie Hawkins.—Sowed 3 acres without inoculation last year. Good stand, but few nodules. Had to resow this year (August 2[illegible], and inoculated seed. Roots are well supplied with nodules and I have a good stand, 8 to 12 inches high, on October 18.

South Carolina, *Williamston.* A. W. Attaway.—Very dry time on it, nevertheless a very good stand. Think inoculation very profitable. Others tried without inoculation and fell behind me.

Tennessee, *Columbia.* Horace B. Hanson.—It has tubercles formed on the roots; is looking fine and healthy. Some of it is on very thin land. I have been trying this plant on the same land for three years without success.

Texas, *San Antonio.* B. G. Barnes.—The inoculated appears to be more vigorous and healthy than that without inoculation, although the latter was planted first and originally came to a better stand by reason of the ground being in good condition at the time of planting, while the inoculated was not.

Vermont, *Randolph.* John W. Burt.—We think the result is very good. If we had cut as a crop this season we would have gotten a good yield, and we are confident that next year will show satisfactory results.

Virginia, *East Leake.* A. K. Leake.—It is 18 inches high and could not be more promising; looks splendidly. You will see by the samples I send you that it is full of nodules, showing in an astonishing manner the bacteria-bearing nodules. There are nodules on every plant I dug up. When I dug up some old plants from a field which has failed I saw no nodules. No one has ever succeeded with alfalfa here.

WASHINGTON, *Belma.* Chas. Richey.—Inoculation very beneficial. Growth had formerly been very poor; plants turned yellow and many died, making it hard to get a good stand. Now difficulty is overcome.

WEST VIRGINIA, *Berea.* John E. Meredith.—Have been trying to grow alfalfa twelve years, and have now the finest prospect of success I have yet experienced.

WISCONSIN, *Fort Atkinson.* "Hoard's Dairyman," November 11, 1904.—An experimental trial of this method of inoculation was made by Professor Short, one of the editors of this paper, last summer with very evident success. Our field already shows the good effect of inoculation. (The method consisted in going over an alfalfa field which was not thriving with a sprinkling cart containing the culture liquid. The operation was comparatively inexpensive, as a 16 foot pipe drilled full of holes was attached to the rear of the sprinkling cart, the water thus taking a sweep of nearly a rod in width.)

Red Clover.

CALIFORNIA, *Arcata.* William W. Turner.—A part of the ground was a loose sand, a deposit from the river. It was a hard matter to get anything to grow on it. Here is where my inoculated clover seed seems to grow and flourish. The rest of the ground was a sediment loam and very rich. It was not long before the pigweed started, and it came so thick that it choked out the clover, except what was on the sand. That is growing nicely; has a nice dark-green color.

CONNECTICUT, *Wolcott.* Samuel Wilson.—I sowed about 8 pounds of seed, not inoculated, all over field and 3 pounds of inoculated seed in the form of a cross. Result, cross distinct with clover; balance of field none.

ILLINOIS, *Anna.* J. W. Fuller.—Got good crop where I had failed eight years in succession.

Hillsboro. Thos. S. Evans.—I am pleased to report a complete success with the inoculated clover. The clover was the finest in this section.

Tamaroa. W. J. Appel.—Find that where I had failed to get a stand at previous sowing got fairly good one this time, and nodules of fairly good size on roots.

INDIANA, *Colfax.* T. C. Holloway.—The clover was pastured after the crop of wheat was taken off. Can give no exact figures. It was sown on white-clay land that has been producing very poorly. It now seems equally as good as that on the black land.

IOWA, *Muscatine.* Charles A. Price.—The clover was sowed with oats. The oats showed an increase of 15 bushels per acre over oats on same ground where no treatment was given. An examination of the clover roots showed 75 per cent more nodule formation than on that from untreated seed.

KANSAS, *Burlington.* John W. Alexander.—Plots 1 and 2, 4 acres each, yielded three-fourths to 1 ton per acre; seeded April 15. Plots 3 and 4, 1 acre each, not inoculated, but seeded at same rate and same time, very weak; not much growth and no hay cut.

KENTUCKY, *Adairville.* Martin Boyd.—One of our farmers tried it last year on 10 acres out of 100. The 10 acres is all he has now standing.

Hopkinsville. Ben C. Moore.—I cut 2 acres of clover which had been inoculated and 2 which had not been, and find that there is a difference of about 500 pounds per acre in favor of inoculated seed.

Winchester. Dr. M. S. Browne.—I have 40 acres on which wheat and blue grass were sown in 1902, and clover in February, 1903. There was a severe drought in the fall of 1903 which killed the clover, leaving the stand of blue grass on which inoculated clover seed was sown in February, 1904. Clover sprang up in April and made an unprecedented growth. On this meadow were grazed from 200 to 400 sheep and 25 cattle to July 10, when all stock was removed. We cut a good yield of hay in the midst of drought, August 15. We never before dared to graze spring-sown clover during the spring and summer, and very little in the fall. If we did and any drought came, it would die. This year the drought was worse and more protracted than last year, and the clover is healthy after all the grazing and mowing. This is unprecedented. Another 40 acres of similar land was plowed in October, 1903, and sown in winter wheat and blue grass. The wheat winter killed. This was sown with clover seed at the same time as the first field, but the seed was not inoculated. The result was a complete failure—the plants are mostly dead. This ground was prepared a year later and was in a good state to catch clover, but the inoculated field was really not in a fit condition when sown.

MAINE, *Augusta*. John Jackman.—The very best results. I soaked or moistened seed carefully, as per directions, and reserved small piece of ground for test; rest of ground was sown to same kind of seed, but catch on inoculated patch is noticeably stronger. It seems as if every seed came up and grew.

MARYLAND, *Grayton*. Rev. William Brayshaw.—Report on clover sown September, 1903, at Valley Lee, Md. I sowed two lots of seed side by side, one inoculated, the other with 100 pounds of South Carolina rock. Inoculated made double the growth and bade fair to give three times the quantity of hay.

MICHIGAN, *Fennville*. Chas. E. Bassett.—Inoculated part of field gave 12 per cent more yield, and nodules on roots were as large as small peas, while on that not inoculated the nodules were extremely small.

MINNESOTA, *Campbell*. N. W. Ware.—Bacteria nodules show in abundance and plants very thrifty. Sown on 15 acres of northwest Minnesota Red River prairie soil with best results. Former owner tried in vain for years to get a stand of clover.

MISSOURI, *Cabool*. C. L. Morris.—Sowed two plots. Plot 1 was inoculated and has made a fine growth. Plot 2, not inoculated, has nearly all died out. Plot 1, a success; plot 2, a failure.

Hale. E. P. Swartz.—Mr. William Morris, following instructions, sowed 7 gallons of clover seed on 8 acres. The season was such that he could not suitably prepare the ground, simply sowing it on the hard ground. The third day he harrowed the sown piece of ground once; could not cross harrow it. I was over to see it this fall, and am pleased to report the most magificent stand of clover I ever saw. A neighbor whose lands adjoin Mr. Morris had carefully prepared his soil, sowed the same day, and he did not get one-half the stand that Mr. Morris obtained. I think you have made a most important discovery—one that is of incalculable benefit to the farmer.

NEBRASKA, *Elgin*. Marcus Brown.—Inoculation successful, nodules appearing quite plentiful, though uneven. Crop appears best I ever saw in Nebraska.

NEW YORK, *Holland Patent*. H. W. Dunlap.—My tenant reports the best stand he has had during his occupancy of the farm, and that upon a hillside where until then he had never been able to make red clover grow. Plants I examined in August showed nodules in every case. Having more of the culture liquid than could be used upon the seed, I distributed this on some light loam, which, after stirring and drying, was broadcasted upon a small part of a field already in clover. My tenant reports that the color and size of the clover indicated the distribution of the soil perfectly.

Poughkeepsie. B. W. Russell.—My soil is clay loam and I have always had trouble to retain clover through the first winter's frost. Have delayed in my report to see the action. Am very much pleased and can say it is retained thus far and the best prospect for a crop that I have ever had. I seeded 5 acres after oats and of course did not harvest a crop of clover last year. The oats were the best I ever raised. They were watched by my neighbors all the season and all have pronounced it a success.

TH CAROLINA, *Loftis*. Benj. G. Estes.—I have a fine catch of clover where I have not been able to get clover at all. In fact, the farmers say clover will not grow here at all.

O, *Seaman*. Ira C. Howard.—A fine set on clay upland. I sprinkled the water that was left after soaking the seed over the ground in spots; every spot is plainly visible.

NSYLVANIA, *Southport*. F. L. Bray.—Clover looks fine in lot where inoculation was used; scarcely any in lot where no inoculation was used. Both lots with same soil, same methods of cultivation, same nurse crops, and same time of sowing.

GINIA, *Sandidges*. W. S. Gill.—Seed inoculated produced clover 18 to 20 inches high at this time and blooming. That not inoculated 6 to 8 inches high and sickly looking; not blooming. I have all confidence in the "bug" and believe it will restore clover to us again.

HINGTON, *Bothell*. Harry G. Brower.—Mixed the material according to directions and thoroughly wet 10 pounds of red-clover seed three times and dried each time. What liquid I had left I mixed with 25 pounds of dry dirt and sowed this on 1 acre; harrowed three times. Season was very dry, but the seed lived through and the ground has a good stand. In fact, I am the only one who has a good stand. People told me the soil was too poor for anything.

T VIRGINIA, *Thomas*. O. H. Hoffman.—The clover stand after the wheat was cut off last summer was the best that has ever been on the same farm for years. We had plenty of bacteria solution for this seed.

CONSIN, *Iron River*. Joseph Yerden.—I had sowed clover on same land two years in succession and could not get a catch. I used the inoculating bacteria that you sent me and have a fine stand of clover.

Cowpeas.

BAMA, *Gateswood*. Wm. C. Payne.—No apparent effect on old ground. On new good land, seed not inoculated did practically nothing and inoculated seed gave about 1½ tons per acre. A small plot of inoculated "Unknown" pea on good new land was immense. Yielded 3 tons per acre, and that not inoculated almost nothing on similar soil—new ground.

RIDA, *Pensacola*. Geo. W. Howes.—Result of inoculation good. I planted as a fertilizer on poor sandy black-jack land and got a third better results without manure, but inoculated, than on the same land with cotton-seed meal as a fertilizer.

RGIA, *Bluffton*. H. B. Harrison.—Increase of yield 100 per cent.

Rome. Hamilton Yancey.—The growth has been rank, of rich dark color over the entire field that was seeded. A difference in favor of the inoculated pea was quite noticeable. My neighbors and friends who have seen the field insist that the field is seeded with a different kind of pea. I wish to express to you my satisfaction and gratification with the experiment. I believe the work you are doing is of inestimable value to the farmers of our country in the future redemption and improvement of our lands.

NOIS, *Mount Vernon*. E. M. Dana.—Sowed in orchard. Each alternate space inoculated shows a great difference in rankness of growth over uninoculated, especially on yellow soil badly worn.

IANA, *Milan*. James Tribbey.—Cut for hay. Estimated difference between inoculated and uninoculated 300 per cent in amount of vines, hay, etc., in favor of inoculated. No difference in amount of peas.

SAS, *Walnut*. H. C. Coesten.—Inoculation was perfect and satisfactory. Would prefer this method of inoculation to the sowing of soil from field to field; by the latter a person is liable to transfer plant disease. I transplanted the leaf blight to my field a few years ago by doing so.

KENTUCKY, *Winchester*. Dr. M. S. Browne.—Estimated weight of hay increased threefold or more; peas fully as much increased.

LOUISIANA, *Lafayette*. Ray Fiero.—In 1903 I sowed peas on a side hill and the peas did not grow over 8 inches high, with very small nodules. This year the inoculated peas sown under same conditions made a growth at least four times as great.

MARYLAND, *Chaptico*. William H. Gardiner.—The 2 acres inoculated grew twice as large, as peas were more prolific than uninoculated part. In fact, the 2 acres were the only part harvested. The rest of the field was insignificant.

MISSOURI, *Marionville*. U. L. Coleman.—Where inoculation was used the peas did a great deal better and produced fully one-third more. I found few nodules where the inoculation was not used, but where inoculation was used the roots were literally hanging full of nodules, some as large as peas. I showed samples to several of our farmers, and they all stated they had never before seen as many nodules on one vine.

NORTH CAROLINA, *Asheville*. Fred Kent.—Inoculation very good. Farmers in the neighborhood wish to know how such peas are grown, as theirs were failures.

OKLAHOMA, *McCloud*. Jesse Hearn.—Rapid growth; quick development; 20 per cent increase in yield. Roots full of nodules. Land in fine shape for next crop.

PENNSYLVANIA, *Hartstown*. J. T. Campbell.—Where soil was inoculated the result was marvelous, four times as great as where there was no inoculation. Nodules one-half inch in diameter.

SOUTH CAROLINA, *Aiken*. Miss Louise P. Ford.—On 1 acre we planted cowpeas broadcast. On one-half of this acre we planted one-half bushel of inoculated cowpeas, on the other half acre we planted one-half bushel of uninoculated cowpeas, plowing them both in just the same way. About the middle of June, when harvested, we gathered 1,375 pounds of hay from the inoculated half acre; from the uninoculated half acre we gathered 750 pounds. The land is known as poor sandy soil, and we did not enrich. This is the result of Miss Pellew's and my experiment on Twin Flower farm.

Orangeburg. F. M. Rast.—I tried the inoculated by side of stable compost and will say that it was just as good as those fertilized with compost. I am well pleased with results.

TENNESSEE, *Ripley*. M. M. Lindsay.—Five times as much vines and leaves and two times as much peas as planted on same land without inoculation. There can be absolutely no doubt that above results are due to inoculating seed.

TEXAS, *Double Bayou*. G. Wolff.—My oats, which I planted after inoculated cowpeas, look very fine and on land that is too poor to make a crop of cowpeas without inoculation. I am a strong believer in inoculating the seed.

VIRGINIA, *Danville*. T. L. Smith.—The pea vines were the finest I ever saw. I measured some vines 12 to 15 feet long. I made three times as much hay to the same quantity of seed as I ever made.

Ionia. R. Dewsbury.—Peas on same ground as last year were more than twice as good, and no help given. Last year had no nodules; this year had. Something increased the yield of peas and vines 100 per cent.

Garden Peas.

FLORIDA, *Saint Petersburg*. S. S. Stults.—Most excellent results, compared with what we usually get from same soil and same treatment. I got four times as many peas as I did without the microbes.

MAINE, *Lincoln Center*. C. A. Brown.—Crop about double what I got with seed not inoculated. The stuff is worth a good deal for peas on my soil.

SACHUSETTS, *Boston*. Jesse M. Gore.—The pods were larger, fuller, sweeter, and two weeks earlier than peas planted at the same time and under similar conditions with the exception of the inoculation.

HIGAN, *Pellston*. H. L. Millspaugh.—We planted four rows of each seed each way; that is, four using inoculation and four without it, harvesting the peas as a green table crop. The results were very flattering to the use of the inoculating material—fully double yield.

HAMPSHIRE, *Franconia*. L. F. Noble.—There were bacteria bulbs everywhere more than an inch through. It was wonderful and it filled me with hope for the future.

Pike. H. E. Howard.—Sown same day on ground side by side where bushes had been cut and burned, with no other fertilizer. Inoculated plot produced about three times as much as the other.

YORK, *Clay*. Mrs. Arthur Hall.—Entirely successful. Yield wonderful. Culture applied to earth and sprinkled along pea rows. The soil now seems like sandy loam, whereas it was the heaviest of clay before. Celery following peas is very fine.

Northwood. John R. Spears.—The tall vine (3 feet high) was cut from a row that was treated with the culture of nitrogen-gathering germs. This sample fairly represents the growth of all the rows thus treated. The short vine (14 inches high) was cut from the row of vines not treated with the culture. It was the best vine among those untreated. The rows were 4 feet apart and the distance between the two plants was about 7 feet. If you recall that the seed was the Dwarf Alaska, the large vine will seem rather remarkable, I think. The nodules are particularly well worth observing. On July 3 I made the first picking from the plot. On 53 untreated vines, taken as they came, I found 102 pods; on 53 treated vines, taken as they came in the next row, I found 856 pods. The first picking well-nigh stripped the untreated row; the treated vines have yielded two good pickings since, and still another is now filling out. Vines first appeared above the ground on May 17, and they had reached a height of from 2 to 3 inches on June 1. The plot was then of uniform appearance as to the thrift of the vines. On June 1 I watered all the vines in the plot, except one row, with a solution or culture of those germs, made according to accompanying directions, and raked fine dry soil over the ground thus moistened. Since that date all the rows have been cultivated enough to keep the surface soil fine and free of weeds and grass, and all have been treated alike in every other particular. No fertilizer of any kind has been applied to any of the rows at any time before or since planting. The quality of the soil is uniform throughout the plot. The soil itself could have had no influence in producing the extraordinary difference in vine growth. If I seem to be burdening you with details, I must urge as an excuse the extraordinary interest excited by the wonderful success attained by the use of the nitrogen-fixing germs.

Utica. H. D. Pixley.—Every way satisfactory. Got as large a yield per acre as the five acres of peas in same field with heavy barnyard fertilization.

NSYLVANIA, *Bryn Athyn*. Mrs. J. A. Wells.—On April 14 I planted three kinds of peas. They came up well, but did not grow rapidly. I had inoculated the seed according to directions. On May 14 a neighbor, having obtained a culture for peas, spared some for me. I inoculated more seed and planted them; then having some of the liquid left, I added water at the rate of one-half pint to 2 gallons of water, and having hoed the soil away a little from the roots of the previous planting of peas (now 4 or 5 inches high), I watered them with the diluted culture and hoed the soil back. Well, now the watered planting of peas is a sight—tall, luxuriant plants covered with fine pods. They are the admiration of the neighborhood. The later planting that was inocula- not watered with the culture is doing better than any peas I have had - fore, but not nearly so well as the ones that were watered after they we

[*Later report.*] Four bushels of fine, well-filled pods were gathered. Hi our soil would not produce peas to amount to anything. My next-door bor has soil exactly similar to ours and manured it more heavily. H the same seed as I did, but my peas were decidedly finer.

Philadelphia. S. N. Lowry.—Vines yielded once and a half the crop vines from ground not inoculated but which was manured. The inoculated seed yielded full pods and the peas and beans were larg those from untreated seed.

Westchester. Edw. H. Jacob.—Inoculated peas fully matured by uninoculated did not flower at all. On September 15, 1904, inoculat were 18 inches high, uninoculated 8 inches high. Planting was shows big returns by inoculation. (Date of planting, August 15.)

SOUTH CAROLINA, *Gaffney.* Jeremiah Gardner.—My peas were better than of others who used commercial fertilizer; ripened early and evenly; stances unfavorable. I consider inoculation a boon to agriculture.

SOUTH DAKOTA, *Lead.* A. L. Read.—Sowed on yellow clay. Had great to loosen the ground enough to cover the seed. Impossible to Harvested about 17 gallons of peas of well-filled pods. On piece of same size, seed not inoculated, harvested less than one-half gallon of

WISCONSIN, *Janesville.* J. T. Fitchett.—Plants were stronger, blossomed earlier, stood dry weather better, and matured more peas than plant treated. In addition, I inoculated seed for four other parties, them to report to me. One man reports 50 per cent better yield. poor, and the bacteria showed more effectively by contrast. A mark dener reports a larger yield than from similar seed not treated; but the best feature was earlier maturity by two weeks. All report those planting on poor soil reporting the largest increase.

Beans.

ALABAMA, *Fruitdale.* George W. Dibble.—When the crop was ready for mark beans were picked from both plots. The plot that was inoculated ing and bearing fruit; on the other plot they dried up. When the gathered, the yield on the inoculated plot was more than double that other.

COLORADO, *Arvada.* A. B. Cole.—Planted 3 acres adjoining 2 acres unin The inoculated beans produced one-fifth more to the acre than adjoin

ILLINOIS, *Chicago.* Stuart S. Crippen.—Yield of beans was one-third above and product unexcelled in size and flavor for table use. Seed beans siderably larger than parent beans.

MASSACHUSETTS, *North Falmouth.* Ella M. Donkin.—The beans were the adm of all who saw them, and I invited all whom I could interest in the them. I had planted in another part of the same garden beans which, al supplied with fertilizer, did not amount to anything, and I decided to bacteria organisms, even if it were late in the season for planting. I them July 14, and early in September we had fine string beans to pods were large and of excellent quality. They continued to bear early frost killed the vines. * * * We examined the roots in stages and found the nodules well developed.

Worcester. James T. Rood.—Result of inoculation very satisfactory. bed and soaked beans. Tried both separately and together. About good in results. Inoculated plants caught up with previously planted uninoculated plants and gave more and better yield. Foliage greener and healthier.

HIGAN, *Saugatuck*. F. M. Kreusch.—I gathered the beans about September 20; have only thrashed part of them, but I am sure I will have five times as many as last year on the same ground. I think it is immense.

YORK, *Kingston*. Mrs. Clara N. Reed.—Pods very full of large beans. Some vines had a second crop. The inoculation has greatly enriched the soil, so that it is much better to use for other vegetables.

Penn Yan. John D. Buckley.—The ground was on a side hill, gravelly and sandy, and had been practically worked out. In spite of this and insect attacks I had the best piece of beans I ever raised. A farmer living near me planted beans twice in succession on the same land and I helped harvest the beans, but they were hardly worth the labor.

), *Linden Heights*. E. B. Champion.—Beans yielded fully one-half more than untreated. The green beans carried the largest-sized pods I ever saw, but the yield was not increased so enormously as in the case of the wax beans. In this case the increase was so marked as to cause wonder among my neighbors.

NSYLVANIA, *Cresson*. V. P. Sanker.—On ground which never before would raise a crop of beans, had marvelous crop this year, the heaviest ever raised in this locality. Planted seven rows in middle of field without inoculating, and the old conditions prevailed.

Northeast. John Wheeler.—Result of inoculation splendid. Refugee beans for canning factory. One-third acre yielded $50 to $60 clear profit. I think it can not be beat by use of fertilizer.

DE ISLAND, *Kingston*. H. J. Wheeler, director, Rhode Island Agricultural Experiment Station.—Concerning the wax beans and green-podded bush beans, both are continuing to show very striking benefits from the use of the inoculating material, so much so that I think it would be a very important matter, economically, if one were growing them on a large scale, whether the land was inoculated or not.

MONT, *Middlebury*. J. E. Sperry.—Gain from inoculation, 11 bushels per acre over seed not treated, planted side by side. There is no doubt but that it is a great help.

Soy Beans.

BAMA, *Rash*. W. W. Lee.—All inoculated but six rows. Inoculated began showing result of inoculation in a few days after they came up, and harvested 50 per cent more than the other.

RGIA, *Gainesville*. John E. Miller.—The soy-bean inoculation I got last spring was a complete success. I planted 10 or 12 acres on an old barren field, and they are from 12 to 36 inches high. Have not found a single one that was not inoculated. One had tubercles 26 inches from the base. I think your Department a great help to the farmers.

TUCKY, *Winchester*. Dr. M. S. Browne.—Twelve thousand five hundred pounds dry hay, ready for storing, per acre; ground where seeds were not inoculated at rate of 1,500 pounds cured hay per acre. Soil, medium bluegrass sod. Non-inoculated, a failure; inoculated, a wonderful crop. Date of planting, April 15; date of harvesting, July 25.

RYLAND, *Bynum*. Wilmer P. Hoopes.—Our soy beans drilled in with corn in rows 3½ feet apart, the whole crop making about 20 tons of silage per acre. The beans just covered the space between rows and yielded at least 2 tons per acre. The roots were just covered with nodules.

MISSOURI, *Marionville*. U. L. Coleman.—Where inoculation was used the bean a great deal better and produced fully one-third more beans. I fi nodules on the soy beans where not inoculated. The inoculation was

NEW YORK, *Maryland*. W. W. Stead.—There was about 75 per cent gain piece of ground of the same size which was not inoculated. I think th inoculation was a great success.

VIRGINIA, *Carysbrook*. C. E. Jones.—All of the inoculated hills showed ab dance of nodules, while only a total of four were found on the uninoculat notwithstanding the proximity of the inoculated seed, the roots of be often interlacing. One row inoculated by culture and one by soil fr roots having numerous nodules showed an equal number of nodules; th had none. I find that the roots show far more nodules than I have before, and this development seems more excessive on the poorer part field.

Simplicity. Mrs. Rose Fisher.—Nearly all plants had from 1 to 29 large nearly all located on the taproot about 1 to 2 inches in the ground. Ad ing field, not treated, showed but very few nodules.

Hairy Vetch.

ALABAMA, *Tuskegee*. George W. Carver, director, Agricultural Experiment Stat The inoculated plot grew vigorously—in fact, made an enormous growth made 7 bushels of seed to the acre. The other was so small that I thrash it out.

KENTUCKY, *Trenton*. Phil. E. Bacon.—Used vetch material with best result growth was very heavy and the roots as full of nodules as any illus have ever seen, some clusters fully as large as the end of my finger.

MISSISSIPPI, *Aberdeen*. Isaac H. Hunt.—Inoculated was better in every wa the untreated seed. We are very much encouraged by what we have seeded.

NEBRASKA, *Taylor*. Ray G. Hulburt.—Bloomed three weeks earlier; m larger plants. Oats sowed with it were larger. Roots of vetch pla crowded with tubercles, single and in masses. Sowed too close; germ untreated part in July, but it never caught up. Some plants 10½ feet h

NEW YORK, *Butterfly*. J. E. Baker.—Fine growth on very poor soil. On a gravelly knoll grew 6 to 8 feet and a mass of blossoms and pods. Have succeeded in growing anything on this piece before.

WASHINGTON, *Seattle*. David B. Porter.—Last fall I treated winter vetches solution prepared as directed and planted the same broadcast over a patch of ground with a good deal of clay, some blue and some shot turning the ground over in the spring, there was a network of roots thick sod about 8 or 10 inches deep and very heavily charged with the nodules, some roots having as many as 40 or 50. I have used other vegetable matter with this to form a humus and have now a fine which yielded very heavily this year.

WISCONSIN, *Germania*. C. E. Pierce.—The benefit was very plain, promoting growth, adding at least one-third to the crop.

Meadow Valley. C. H. Johnson.—Inoculation successful. Nodules in clusters on lower fibers of the roots, more scattering near the surface on high sandy land.

Crimson Clover.

ALABAMA, *Tuskegee*. George W. Carver, director of Agricultural Experi tion.—This was quite noticeable, that on the adjoining plot the stand as good as on the inoculated plot, but it grew very poorly. It remain and yellow throughout the season. The inoculated plot grew fairly well and was very rank and green in color. These plots were treated in every way alike, except in the matter of inoculation. One end of the inoculated plot did not get any of the inoculating material, and the small, inferior clover was very noticeable.

NSYLVANIA, *Bellefonte*. James A. B. Miller.—Fair catch on thin soil. About 6 inches high. Failure on same soil last year without inoculation. Seems thrifty and gives every promise of successful catch.

Joanna. H. E. Plank.—It is a satisfaction to inform you that there was a much greater mass of fibrous roots on the plants grown from the seed treated with the material than on the plants from the untreated seed. The nodule formations are much more abundant on the former class of plants. There is a good stand of clover.

ASHINGTON, *Spokane*. Henry M. Richards.—The results heretofore with the same amount of seed have been a very stunted growth and scant blooming. The seed prepared with the inoculating material has produced a most luxuriant growth and a perfect mass of bloom, an improvement so great that it is difficult to describe.

EST VIRGINIA, *Elm Grove*. George Fox.—Seed inoculated 50 per cent superior to the seed which was not inoculated.

Sweet Peas.

LIFORNIA, *Los Angeles*. W. L. Cleveland.—The seeds were treated in accordance with the instructions you sent me and then planted in the usual manner. The result of this seeding was a hedge of vines that grew to a height of about 8 to 10 feet, covered with a lot of fine, large blossoms that were the delight of the whole neighborhood. Across the street, and treated in the ordinary way with the same seed that I furnished them but without the inoculation, the vines scarcely grew 5 feet and the flowers were small and few. I consider the thing a success.

SACHUSETTS, *West Roxbury*. F. G. Floyd.—Plants were very luxuriant and about 12 feet high. Leaves very large and rotund; flowers very large and of fine color. Plants produced several double flowers—i. e., having two or three entire or partially formed standards.

JERSEY, *Newark*. William J. Hesse.—The crop was a complete success, while other growers in this location did not succeed at all. While I have no record of the quantity of the crop, I will say that I had a larger crop, better blooms of lasting quality than any other grower with the same amount of ground planted. I had two awards at the New Jersey Horticultural Society for these same blooms in June and July at Orange, N. J., and I know that had it not been for the inoculating of the seed I would not have been so successful.

Canada Field Peas.

IFORNIA, *Colton*. M. S. Ratliff.—By actual experience peas inoculated made fully one-half better growth than peas not inoculated. These peas were sown in an orange grove for green manuring.

Riverside. W. H. Backus.—I found bacteria everywhere; every spadefull, wherever test was made, showed bacteria on the fibrous roots, some at a depth of over 12 inches. I believe it is one of the best discoveries for the horticulturist yet found. I was not a believer at first in the field pea, and dug up vines every year for the last four years looking for bacteria. It took two or three years to get the bacteria in quantity. Now, with the culture sent out, if it is properly made up and the seed inoculated, one can get [illegible] one planting, the amount depending on the care, etc., and the grow dense that common weeds have no show whatever. Humus is gett to nothing on commercial fertilizers. I have an old orange grove, best in this section, but it has been going back in quality and quan last four years on liberal applications of commercial fertilizers. I have green manuring on this account, and wherever the field pea has been for a series of years the improvement is remarkable; where bur been allowed to grow during the winter and plowed under in the improvement is quite noticeable, as on my own place. I see no way cheap as inoculating the soil and sowing peas or other legumes. F are expensive, too stimulating, and when withheld for a year or two goes back rapidly. I believe if young groves were planted to from the start the soil would approximate to a virgin soil for years. phosphoric acid and potash were added from year to year as needed could save from $20 to $25 per acre every year on his fertilizer bills foot up a grand total for the entire section.

MAINE, *Auburn*. G. L. Thomas.—The product out of No. 1 strip without izer was as much as out of No. 3 with the heavy manuring. In other the inoculating culture had done as much for strip No. 1 as the barnyard ing had done for No. 3, while No. 2 (inoculated and manured) had as much as the other two strips combined. The growth in No. 2 was ively strong and luxuriant, and this was due to the nitrogen drawn air by the vaccinating cultures. No. 1 was fair yield and cost about cent as much as No. 2 and about 47 per cent of that for No. 3.

PENNSYLVANIA, *Hartstown*. J. T. Campbell.—Where soil was inoculated the was marvelous—four times as great as where there was no in Nodules one-half inch in diameter.

TEXAS, *Keene*. A. P. Wesley.—Nodules formed on vines when quite young growth was fine, while the land they were planted on was worn-out think it a success.

WISCONSIN, *Bay City*. Chicker Brothers.—A very satisfactory crop was raised failure had attended for seven years.

Velvet Beans.

FLORIDA, *Jacksonville*. E. H. Armstrong.—Thirty to 50 per cent increase where seed was not inoculated with the velvet-bean culture; same for Season dry, somewhat unfavorable.

LOUISIANA, *Cades*. C. E. Smedes.—Increased the nodules and the vines 30 per Vines were plowed under.

Berseem.

CALIFORNIA, *Berkeley*. David Fairchild.—You will be interested to know Berkeley this year there was an immense difference between the plots seem from treated and untreated seed, the former being several hundred cent better than the latter.

Peanuts.

VIRGINIA, *Poplarmount*. Charles Denney.—Inoculated a piece of land according your instructions, and planted Spanish peanuts. Increased yield at of 5 bushels per acre.

Miscellaneous.

PENNSYLVANIA, *Lockhaven*. George P. Singer.—I used them in my botany and study classes in this way: I furnished each student with a number of fine white sand. The same day they planted beans and clover, and same kind of seeds inoculated with the bacteria. Each pot was exposed to the same conditions and the inoculated compared as to growth with the uninoculated. There was no especial difference in germination, but when the plants had put forth their first leaves the ones inoculated began to grow much faster than their neighbors. It was not long until they were twice as high, and while the ordinary seeds produced plants stunted and ill-nourished, the inoculated seeds in many cases produced a large bean stalk with fully developed pods and beans. The clover seed showed the same result. Root nodules were formed in great abundance. All in all, it was the most interesting experiment I have ever tried in my classes, and it aroused a great deal of interest in the students. I am confident that if clover and beans will grow as they did for us in sand which was quite free from organic matter, your nitrogen-fixing bacteria will solve many problems for the intelligent farmer.

ɪᴛʜ Carolina, *Gibson.* Dr. N. M. McLean.—As to "nodule formation," a test was made by myself in person to determine this feature. Sterile soil (obtained from a sand subsoil several feet below the surface), to which was added a certain amount of phosphoric acid and potash, obtained from acidulated rock and muriate of potash, were placed in one-half gallon pots. Each legume tested was planted in a number of these pots. To a certain number a small quantity of the "inoculating material" was added, with others as "control pots." In each test a marked contrast was noticeable in a short time, the inoculated pots showing several times the plant growth that the control or uninoculated pots did, and in each case the inoculated pots showed a plentiful supply of nodules on the plant roots. An experiment on a large scale was then tried. A trench 3 feet broad and 12 feet long was dug out 30 inches deep. This was in a heavy clay-loam soil. The trench was filled with this same sterile soil used in the pots fertilized with the phosphoric acid and potash. In each square (3 feet by 3 feet) a legume was planted—alfalfa, crimson clover, soy beans, and velvet beans. Each variety of seed was inoculated with material you so kindly furnished, and in each test there was an abundant "nodule formation." In each one of these several tests the control pots and plots verified the results beyond the possibility of doubt. I hope next season to be in a position to make a tabulated report that may be of use to others. As to myself, I consider your discovery the greatest one of the age and hope you may live to see a universal acknowledgment of the same.

SUMMARY.

Owing to the direct effect of the nodule-forming bacteria upon ;umes, these plants are supplied with a source of nitrogen not avail-le to most other plants. Consequently, the legumes can flourish in oil practically devoid of nitrogen.

The effect of legumes upon suceeding crops of any kind is beneficial, :ause of the fact that the soil is enriched rather than impoverished these plants.

Where nitrogen-fixing bacteria are lacking, it is possible to introduce ɜm artificially either by transferring soil from an old field where the ɜired leguminous crop has been successfully grown, or by the use of re cultures of the proper organism.

The method of transferring soil is objectionable because of the :onvenience and expense, and is apt to be dangerous on account of e possible transfer of weeds, insect pests, and plant diseases.

The use of the German preparation, nitragin, has not been a s[...] probably owing to the method of growing and distributing the b[...]

In order to increase or maintain the virulence of nodule-fo[...] organisms, they must be cultivated upon nitrogen-free media. Gr[...] upon rich nitrogenous media tends to diminish and frequently [...] the nitrogen-fixing power, since this element can be obtained [...] easily from the medium than from the air.

Various external conditions, such as temperature, moisture, a[...] amount of nitrogen in soil, etc., all have a direct effect up[...] legume bacteria, and the failure of nodules to develop may o[...] traced to such a cause.

The nitrogen is fixed by the bacteria in the nodule and b[...] available by the action of the plant in dissolving and absorbin[...] combined nitrogen in these organisms.

The nodule-forming organism is a true micro-organism, and th[...] but one species, namely, *Pseudomonas radicicola* (Beyerinck) M[...] The difference in the infective power of bacteria from differe[...] plants is due to slight physiological variations which can be [...] down readily by artificial cultivation. Quicker and surer results,[...] ever, are obtained by preparing separately cultures for each sp[...] of legume.

It is possible (in rarely observed cases) for nitrogen-fixing ba[...] to penetrate the roots of plants and be of decided benefit withou[...] formation of nodules or any external evidence of their presence.

While it is desirable that artificial inoculation be made at th[...] of planting, experience has shown that under certain conditions [...] of several years' standing are improved by adding bacteria to th[...]

Inoculation is usually of no benefit to soil already containing [...] proper bacteria, although there may be exceptions. It need n[...] practiced where the soil is already rich in nitrogen, because, i[...] soils, nodules are formed with difficulty and are of little benefit. F[...] thermore, the use of such soils for growing legumes is gener[...] mistaken policy, especially if grown for green manuring.

The inoculation of seed and soil by means of pure cultures [...] and distributed according to methods devised by the Departm[...] Agriculture is shown by the reports of practical farmers to [...] distinct advantage when used under circumstances that will p[...] benefit.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 215.

LFALFA GROWING.

BY

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In Charge of Alfalfa and Clover Investigations, Grass and Forage Plant Investigations, Bureau of Plant Industry.

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1905.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., January 26, 1905.

Sir: I have the honor to transmit herewith and to recommend for ıblication as a Farmers' Bulletin, to replace Bulletin No. 31, Alfalfa · Lucern, the manuscript of an article on Alfalfa Growing prepared ſ Mr. A. S. Hitchcock, of the Office of Grass and Forage Plant ıvestigations of this Bureau, under the direction of the Agrostologist Charge.

The successful cultivation of this crop by individual farmers in most every State in the Union, together with the attention it has ceived in the agricultural press and in the publications and correspondence of the Department of Agriculture and the State experient stations, has created remarkable interest in alfalfa growing in the astern States, where until recently this crop has been grown on a ld scale in only a few localities. The cultivation of alfalfa is perhaps reading more rapidly at the present time than is the case with any her crop in the country, and the demand for information concerning is correspondingly urgent. This bulletin has been prepared to meet is demand. Special effort has been made to secure data applicable to e Eastern and Southern States, where experience with the crop is ost limited.

In the preparation of this bulletin much valuable information has en secured from the various State experiment stations and from rmers all over the country who have had experience with alfalfa owing.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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ILLUSTRATIONS.

ALFALFA GROWING.

HISTORY.

Alfalfa (*Medicago sativa*) has been cultivated as a forage plant for more than twenty centuries. It is a native of western Asia, was cultivated by the ancient Greeks and Romans, and its cultivation has been maintained in the Mediterranean region down to the present time. From Spain it was introduced into Mexico at the time of the Spanish invasion and thence to the west coast of South America, and in 1854 to California. It rapidly spread over the irrigated districts of the western half of the United States, where it is now cultivated almost to the exclusion of other forage plants; but success was obtained in the eastern half of the United States in a few localities only, such as central New York; Carver County, Minn.; southern Michigan; Lake County, Ill.; and Hamilton County, Ohio.

NAME OF PLANT.

The Arabic name "alfalfa" is the one by which the plant has been known in Spain, and this name accompanied the plant when it was carried to Mexico and the western United States. The plant is now generally known in this country under the name alfalfa, although it is called lucern (lucerne, or luzerne) in central Europe and in certain portions of the United States, where it was locally introduced from central Europe. It is also called lucern in Utah and adjacent parts of Idaho and Wyoming, where the name is pronounced with the accent on the first syllable.

DESCRIPTION OF THE PLANT.

Alfalfa is an upright, perennial plant, somewhat resembling red clover, but the purple flowers are in a long cluster rather than in a compact head. These clusters are scattered all over the plant instead of being borne on the upper branches, as in clover. The pods and seeds are shown in figures 1 and 2.

The plant has a long taproot, which descends to a great depth where the soil permits. At the surface of the soil is soon formed a strong crown from which spring the new stems, as shown in figure 3.

Young plants of sweet clover (*Melilotus alba*) closely resemble alfalfa, for which they are often mistaken. In later stages the sweet clover is easily distinguished by its tall growth, biennial habit, and white flowers. A seedling plant of alfalfa is shown in figure 4.

FIG. 1.—Alfalfa; *a*, *b*, seed pod; *c*, seed.

TURKESTAN ALFALFA.

A few years ago the Department of Agriculture imported from northern Turkestan a variety of alfalfa, which was distributed for trial to several experiment stations and a number of individual growers in various parts of the United States. This alfalfa, now generally known as Turkestan alfalfa, was found growing in semiarid regions, and showed great resistance to drought. The results of the experiments in this country show that it is somewhat more resistant to drought than the kinds already grown, and is probably better adapted than the ordinary kind to dry regions where alfalfa must be grown without irrigation. The Department is unable to supply more seed of this variety, as the original importation is exhausted. Several seedsmen advertise Turkestan alfalfa, but the seed that is advertised has not been given comparative tests to determine its value. Such value depends largely upon the part of Turkestan from which the seed is obtained; for Turkestan is a large country and not all the alfalfa grown there is of a particularly drought-resistant sort.

FIG. 2.—Alfalfa seed (*Medicago sativa*).

DISTRIBUTION AND AMOUNT OF CROP.

'he distribution of the alfalfa crop for 1899, shown upon the map, ıre 5, was compiled from the reports of the Twelfth Census, and ı prepared by placing in each county of the United States one dot each thousand acres grown in that county. Since 1899 the acreage t of the Mississippi River has considerably increased.

ACREAGE AND YIELD.

'he following figures are taken from the report of the Twelfth ısus, which gives the statistics on alfalfa for 1899, the most recent ıilable for the entire country. There were 96,114 farms reporting acreage of 2,094,011, upon which was produced 5,220,671 tons of ılfa hay, an average yield of nearly 2.5 tons per acre.

Alfalfa production in United States in 1899.

Divisions.	Acres.	Tons.	Average yield per acre.
th Atlantic division	6,236	13,776	2.2
th Atlantic division	1,067	1,618	1.5
th Central division	415,556	936,130	2.3
th Central division	41,537	74,875	1.8
stern division	1,629,595	4,194,272	2.6
Total	2,094,011	5,220,671	a 2.5

a General average.

The six States having over 100,000 acres of alfalfa, given in the der of acreage and yield, are as follows:

States producing most alfalfa.

States.	Acres.	Tons.	Average yield.
orado	455,237	1,107,471	2.2
lifornia	298,898	838,730	2.8
h	268,229	681,515	2.5
nsas	267,376	601,624	2.2
ho	160,029	425,706	2.6
braska	115,142	275,334	2.4

The highest average yield reported for any one State is that of 'ashington, which has an acreage of 35,166, with an average yield of 4 tons per acre.

The larger part of the alfalfa crop is grown in the western division, pecially in the arid regions where irrigation water can be supplied. ıere are many localities in the arid and semiarid regions where the cal conditions are such that alfalfa may be grown without irrigation, ıt the amount thus cultivated is relatively unimportant.

ALFALFA IN THE GREAT PLAINS.

The necessity for a leguminous hay crop in the Great Plains reg- just west of where red clover could be successfully grown early dr the attention of farmers t- to alfalfa, which was alr cultivated in the irrig- valleys lying east of t- Rocky Mountains. At t- the efforts to grow this pa- upon the uplands were partially successful. It w- found necessary to give pa- ticular attention to the pr- aration of the soil for seed bed. At the pre- time alfalfa is grown the uplands without irri- tion, in Texas, Oklaho- Kansas, and central N- braska, as far west as t- one hundredth meridi- The range of successful c- ture is being gradually e- tended northward in t- belt, and doubtless by me- of northern-grown seed a- falfa may ultimately pushed to the Cana- line.

FIG. 3.—Alfalfa, 3 years old.

Indeed, this crop is grown with fair succes- the experiment station- Brandon, Manitoba, and dian Head, Assiniboia, at various places in British Columbia and Alberta.

ALFALFA IN THE EASTERN STATES.

Although alfalfa has been grown for a long time on a small scal- many localities in the Eastern States, it is only within a few years th- serious attempts have been made to extend its culture and plac- among the important forage crops of this region. Alfalfa is now b- grown successfully on a field scale in the alluvial black bottom lan- the Red River in Louisiana, the Mississippi River from southern M- souri to New Orleans, the Yazoo delta in Mississippi, the black pr-

›elt of Mississippi and Alabama, the bluegrass region extending ı Tennessee to New York and Iowa, and various isolated but favor- localities elsewhere. The attempts to grow alfalfa in New Eng- have been successful in ·omparatively few cases. fact, however, that in ͻ cases these attempts been followed by suc- shows that the alfalfa in this region may be ·eciably extended when conditions required for rowth are better known. ry year sees an extension hward of the alfalfa area Minnesota, Wisconsin, New York. A particu- ŗ hardy strain has been ʌvn in Carver County, ın., for a number of ꞅs. The Minnesota Ex- iment Station has found ; the seed from this strain ꞩs satisfactory results, confirms the statement : alfalfa can be acclima- d in regions much ;her north than where it now commonly grown. alfa is a standard forage p in the limestone dis- :ts of southern Ontario, ι is grown here and there far north as Ottawa and southern Quebec. In Nova Scotia it can grown, but the soil conditions are unfavorable, and it does not npete with red clover.

FIG. 4.—Alfalfa seedling, 6 weeks old.

CONDITIONS REQUIRED BY ALFALFA.

CLIMATE.

:n mountain regions alfalfa growing is limited at high altitudes by ꞉ low winter temperature and also by the low mean summer tem- rature, the limit varying from 3,000 feet in the north to about 8,000 ꞉t in the south. Along the northern border alfalfa culture is lim-

ited by the low winter temperature. Northern-grown seed i
hardy than southern-grown seed, and by gradual acclimatiza
limit of the alfalfa belt will be gradually pushed northward.
result may be aided by the introduction from the Old World of
already accustomed to a cold climate, as has been illustrated
importation some years ago by this Department of a variety from
ern Turkestan known as Turkestan alfalfa, which showed itself
adapted to dry regions than the strains already grown in this
But other conditions modify the effect of the winter season.
nate freezing and thawing tend to loosen the growing plants and
them out. This action is not so likely to take place on an
where the plants are well rooted. Where the soil is cold and

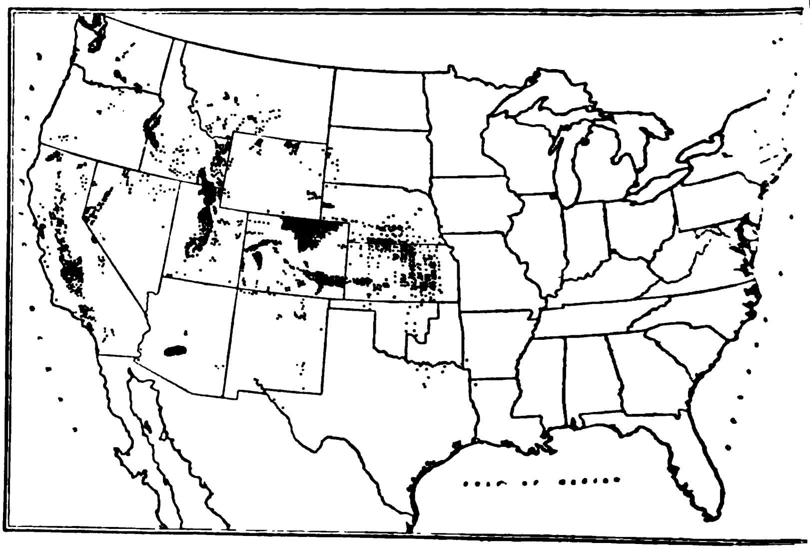

FIG. 5.—Map showing distribution of alfalfa in the United States in 1899. Each d
1,000 acres.

the spring, as is usually the case in New England, the growth of al
is greatly hindered, and this is given as one of the chief causes
ure by experimenters in that region. Good drainage and impr
ment of the texture of the soil will aid in preventing such failur

Although a well-set alfalfa field will withstand considerable dr
yet the growing of alfalfa is limited by insufficient rainfall unless
can be supplied by irrigation. In general, alfalfa requires ab
inches annual rainfall. In the southern portion of the United St
more than this is necessary, and in the North, on account of the
climate, a less amount may be sufficient. Much also depends upon
distribution of the rainfall, the water-holding capacity of the soil
depth to permanent moisture, the presence of seepage water
neighboring slopes, and other local or climatic conditions which af

evaporation or the available water supply through the growing on, so that it is impossible to state the necessary rainfall in other an approximate manner.

SOIL.

ıvorable conditions.—Alfalfa grows best in a well-drained, loamy with a subsoil sufficiently open to allow the roots to penetrate to a iderable depth; yet an examination of the soil in the various lfa districts shows that there is a much wider variation in the soil litions than has been generally supposed. In the irrigated regions soil is usually adapted to the growth of alfalfa and little difficulty xperienced in obtaining successful stands. However, like other ıts, alfalfa suffers if, from improper methods of irrigation, the soil omes too strongly impregnated with alkali. Old alfalfa fields may arently withstand considerable quantities of alkali, because the p-seated roots may be drawing their supply of water from lower ta, where there is less alkali.

ffect of alkali.—The relation of alfalfa to alkali soil has been invesıted by the California Experiment Station. It was found that the rance of salt solutions in the soil by young alfalfa plants is about ollows, which represents the amount of alkali in an acre of soil for upper 2 feet: Sodium carbonate, 1,200 pounds; sodium chloride, pounds; sodium sulphate, 1,200 pounds. Well-established plants able to withstand a much larger proportion of mineral salts. An alfalfa field in good condition was examined, in which the alkali sent in the upper 6 feet of an acre was: Sodium carbonate, 3,000 ınds; sodium chloride, 6,000 pounds; sodium sulphate, 102,000 ınds. In such old fields the plants shade the soil and prevent the face evaporation which tends to bring the alkali upward. If alfalfa o be sown upon alkali soil, the alkali should be first leached downrd by one or, if necessary, two thorough irrigations before plant-. With the alkali, or at least the excess of it, kept below 5 or 6 t by proper irrigation the alfalfa will thrive.

Acidity of soils and other unfavorable conditions.—In the eastern f of the United States, where irrigation is seldom practiced with s crop, the character of the soil is directly or indirectly closely ated to the successful cultivation of alfalfa. The Missouri Experint Station has shown that an acid soil is unfavorable to this crop, a t which has been corroborated by the experience of growers in the st. This unfavorable condition can be corrected by the application lime, the amount depending upon the degree of acidity. It may be any given case that the unfavorable factor is not the acidity of the il, but compact texture, lack of aeration, or some other condition ıich is corrected by the incorporation of lime or the accompanying lage.

Heavy clay.—In the Southwest, as in Arizona, where the soil never freezes and all moisture must be supplied by irrigation, and the fields are often pastured, alfalfa can not be successfully grown on heavy clay soils. Farther north in the irrigated district, where the soils freeze deeply or where the rainfall is sufficient to start the young alfalfa, it can be successfully grown on heavy clay soils. In the irrigated alfalfa regions temperature conditions, rainfall, and pasturage are all important in determining the suitability of a soil for this crop.

Excess of water.—An excess of water in the soil is a very unfavorable condition for alfalfa. Where the water level is near the surface, or where the surface water from heavy rains is unable to drain off rapidly, alfalfa usually fails. For this reason an alfalfa field is injured by being submerged from an overflow, or even killed if the water remains over the surface for too long a period. Experience has shown that when covered by clear running water the injury is much less than when a sediment is deposited or the water is stagnant. Ordinarily alfalfa will not withstand an overflow of more than a few days. Flooding in the winter is less injurious than during the growing season. On irrigated fields injury often follows from the accumulation of water in depressions after a flooding. The alfalfa is killed in these spots and noxious weeds gain a foothold.

Nature of subsoil.—It is generally stated that alfalfa requires a porous subsoil, but this statement must be modified. If the subsoil is near the surface and is of such a nature as to prevent the entrance of the alfalfa roots, alfalfa will probably fail; but many of the so-called impervious subsoils allow the roots to penetrate. The effect of the subsoil seems to depend on how it affects drainage and upon the texture and fertility of the surface soil. The reports of successful alfalfa fields upon subsoils of gumbo, hardpan, and stiff clay are too numerous to disregard. Near Syracuse, N. Y., there is an alfalfa field growing upon a rocky hill where the coating of soil is only 2 to 4 inches in depth. The success under such apparently adverse conditions is due to the fact that the roots are able to penetrate the numerous vertical cracks in the rock.

Need of fertility.—An important condition and one which is likely to be lacking in many of the worn-out eastern soils is fertility. It is very essential that the soil be in the condition usually described as fertile. This refers not only to the presence of the required mineral elements but to humus and to a favorable texture. It is not worth while attempting to grow alfalfa upon sterile soil. Such soil should be enriched by the addition of barnyard manure or other fertilizer or by the plowing under of leguminous crops. Compact, cold, or wet soil is unfavorable to the growth of alfalfa, and such soil should be drained and thoroughly aerated by cultivation to reduce it to the proper tilth.

ɛ. Sandy soil is usually not well adapted to alfalfa, partly because nay be sterile, lacking in humus, or too loose in texture. If a stand once obtained the crop may not suffer from lack of moisture, as there ısually a water supply below the surface. In the Southern States ıdy soil is so favorable to the growth of crab grass and other weeds

FIG. 6.—Nodules of nitrogen-fixing bacteria on the roots of alfalfa.

t alfalfa is soon choked out. In general, it is well to prepare sandy l by incorporating humus and fertilizing and by suitable culture to e from weeds.

NITROGEN-GATHERING NODULES.

t is well known that alfalfa, in common with other legumes, has on its roots nodules or tubercles (fig. 6) produced by certain teria with whose aid the plants are enabled to obtain a supply atmospheric nitrogen. By the decay of these nodules the soil becomes richer in nitrogen. Though alfalfa can grow without the presence of these bacteria, especially if the soil is rich and there is an abundant supply of nitrogen; yet under normal field conditions the growth is much more vigorous when these organisms are present, as indicated by the nodules upon the roots. The seedling plants are infected or inoculated from the soil if the organisms are present. Where these are not already present it is necessary to inoculate the plants artificially in order to produce the best results. This can be done by scattering upon the field soil from an infected field or by placing the bacteria directly upon the seed before sowing. The latter procedure has been rendered practicable by the use of pure cultures, a method perfected in the Laboratory of Plant Physiology of the Bureau of Plant Industry of the Department of Agriculture.

Throughout the region west of the Mississippi River and a considerable portion of the Eastern States this organism seems to be already widely spread in the soil. At the Illinois Experiment Station it has been shown that the organism upon the roots of the sweet or Bokhara clover (*Melilotus alba*) produces the same effect upon alfalfa as the alfalfa organism itself. Since this plant is widely introduced as a weed in most of the region east of the Rocky Mountains, the chances are good for natural inoculation in many cases. Experiments at the North Carolina Experiment Station seem to show that the same organisms occur upon the roots of bur clover. Nevertheless the natural inoculation upon the first crop may not be sufficient for needs. This appears to be shown by the fact that better results are likely to follow successive sowings upon the same land. But in any case it must be borne in mind that artificial inoculation of the seed can supply only one of the necessary conditions and will not prevent failure from other causes.

A Farmers' Bulletin, No. 214, on this subject (Beneficial Bacteria for Leguminous Crops) can be obtained without cost upon application to the Secretary of Agriculture.

CULTIVATION.

PREPARATION OF THE SOIL.

It is very important that especial attention be given to the preparation of the soil upon which it is proposed to sow alfalfa. Not being provided with creeping roots or stems, the plants will not spread as is the case with such grasses as Kentucky bluegrass or Bermuda grass. The individual plants become larger each year by the increasing size of the crown, but bare spaces in a field will not be filled in except new seed may be sown. Furthermore, the young alfalfa plant is quite tender and is easily crowded aside or choked out by weeds or checked in its growth by lack of moisture or by other unfavorable conditions

: these reasons it is highly desirable that a perfect stand be obtained the original seeding.

upply of plant food.—The soil conditions required for the best wth of alfalfa have already been pointed out. Assuming these ditions, it is still necessary that the soil should be fairly free from ›ds, especially such as are known to interfere seriously with alfalfa. case the soil, from overcropping or natural sterility, is not suffiıtly fertile, it will be necessary to add fertilizer in some form. It therefore, desirable to commence the preparation of the soil at it a year previous to sowing the alfalfa seed. The preceding crop uld be one which requires cultivation such as corn, cotton, or roots. : rotation may be such that if the alfalfa is sown in the fall there is e in the summer to plow the land and allow it to lie fallow. The ›ds may then be destroyed as they germinate, by occasional harrows. Although alfalfa can obtain its supply of nitrogen from the air en the plants are well started, it is necessary that the soil should tain plenty of this element at the time of sowing, in order to start young plants with a vigorous growth. The fertilizer which will omplish the purpose most quickly and most satisfactorily is good nyard manure, free from weed seeds. It is better to apply this to land at the time of growing the preceding crop, as the manure n has time to decompose and become available. Barnyard manure only supplies nitrogen and other elements, but it supplies humus the soil, and thus places it in a better physical condition. In place supplying the elements of fertility by an application of manure the rogen and humus may be supplied by growing a suitable leguminous p, such as red clover or Canada field peas in the North, cowpeas soy beans in the South. The foregoing may be summed up in the tement that the soil should be fertile and free from weeds.

'lowing and harrowing.—The mechanical preparation of the soil nediately preceding sowing depends much on its condition. For t results the field should be prepared as for a garden. There are alities in the western half of the United States where the soil is of h a nature that plowing is not necessary, especially if the field can irrigated; but in the Eastern States plowing, thorough harrowing, l the use of the disk, roller, or plank, according to circumstances, is be advised. Subsoiling has been recommended, but this is usually necessary. In the dry regions, where the subsoil is compact, subling will increase the water-holding capacity of the soil. If the l is wet by rain after being prepared, and is then harrowed as n as it can be worked, there should result an excellent seed bed to eive the alfalfa.

[t is not best to sow alfalfa on freshly plowed land, for a loose seed l is unfavorable to the young plants. One or two good rains before seeding improve the condition of the seed bed. It should, of cou- be harrowed as soon as in condition after each rain, to keep it fr- baking before seeding. Alfalfa should not be sown on a field that - just had a green crop turned under. Time should be allowed for new material to decay and for the acid to be worked out by one or t- good rains.

TIME FOR SOWING.

In the Northern States and in the irrigated regions of the West, alfa- is usually sown in the spring. In the Southern States sowing is - erally done in the summer or fall or very early in the spring. A- been pointed out, one of the greatest enemies of young alfalfa is w- and spring sown alfalfa is more likely to be choked out during summer by weedy grasses, such as crab grass, than is that sow- - the summer. Toward the northern limit of the alfalfa belt, how- the seasons are shorter and the plants may not be sufficiently st- to survive the winter in case the seeding is done in the fall. Furt- more, the time of sowing is likely to be influenced by the rot- of crops practiced upon the farm. Where a spring crop can be g- and removed in time to allow sowing the alfalfa in the summer t- is no loss of the use of the soil; but in the far North this does not - the alfalfa sufficient time to prepare for winter. In case alfalfa - be sown in the spring in the Southern States, the sowing shoul- done as early as possible. Fall sowing frequently fails in the S- from untimely drought. In such cases the land may be reseed- early spring.

SOWING WITH A NURSE CROP.

As a usual thing, at least from the standpoint of the alfalfa crop is best to sow the alfalfa alone; but it is customary in many loca- to sow with grain. If the conditions are well suited to the grow- alfalfa the stand may not be materially injured, and there is ga- the crop of grain; also the weeds are kept down while the alfa- getting started. Usually, however, there is a loss of alfalfa, resulting stand being less satisfactory than when the alfalfa is - alone. Whether this loss is sufficiently compensated by the gr- crop must be decided by the grower. If the crop of alfalfa the - year is as good as if it had been sown alone, the grain crop has be- gained where the sowing was done in the spring; but if the sta- injured such a gain would not compensate for this loss, as a p- stand can rarely be improved. A more satisfactory method, where - sowing is advisable, is to grow the grain crop in the spring and - pare the soil anew for the alfalfa. In the irrigated districts, - cially in certain parts of California, barley is commonly used - nurse crop. Beardless barley has been recommended for use i- Eastern States where a nurse crop is often satisfactory. Whan is used the sowing should be comparatively light, so as not to ther the alfalfa. If the grain crop threatens to be too heavy it ıld be mowed for hay.

AMOUNT OF SEED AND METHOD OF SOWING.

he seed may be sown broadcast or with a grain drill. The drill the advantage of distributing the seed more evenly over the sur- than is likely to be the case with hand sowing and of placing the at a uniform depth. It has the disadvantage of placing the seed deep unless special precautions are taken. In dry regions drill- is often an advantage, as it places the seed in contact with mois- . If drilling is employed in moist soil the shoes should barely h the soil. The seed is then covered sufficiently by the chain, el, or other accessory that follows the shoe.

here alfalfa is sown broadcast it is best to use a mechanical sower, ı as a wheelbarrow seeder, as the seed is distributed more evenly. seed should be well harrowed in, or it may be covered by means plank drag.

he amount of seed usually recommended is 20 pounds per acre n sown broadcast, and a less quantity (about 15 pounds) when n with a drill. If the seed is of good quality, the soil in fine ı, and the conditions for germination are favorable, less than 20 nds may suffice. Under exceptional conditions successful stands e been obtained with 5 or 6 pounds. Some growers use more than ounds, even 30 or 35 pounds, but this amount seems excessive, should be used only when necessary to counteract the effect of rly prepared soil or other unfavorable conditions. Although a k stand may be an advantage in choking out weeds, yet for the elopment and subsequent vigor of the plants, it is better to have a ıner but uniform stand. The individual plants then have room to elop a strong crown with the accompanying extensive root system.

TREATMENT OF AN ALFALFA FIELD THE FIRST SEASON.

)uring the first season following spring sowing the field should be ped with a mowing machine at intervals to keep down weeds, if latter show a tendency to choke out the alfalfa. If this is not essary and the alfalfa has made a vigorous growth, a light crop of may be obtained, or under favorable conditions even a second p. In those parts of the South where the conditions are favorable crops should be obtained the first season after spring sowing. At iontown, Ala., three crops have been cut the first season from rch seeding. Usually, however, returns can not be expected the t season from spring sowing, without irrigation, except in the ıth. In irrigated districts one or even two or three crops may be ained the first season. Some growers pasture during the fall after seeding. This is not to be recommended as it almost always inj- the stand, either by the trampling or the close grazing. When alfa- is sown in the spring with a nurse crop no attention may be neces- after cutting the grain except to clip the weeds if these become trou- some. In clipping to keep down weeds the cutter bar of the mow- should be set high, as the seedling plants are injured by close clip-.

It is very important, particularly in the Northern States, to - alfalfa to go into winter with a good growth—at least 6 inches -. If cut too late in the fall to grow a good winter covering it is - apt to suffer from winter killing.

If the alfalfa is sown in the fall no attention is likely to be neces- until the following season, when it is, if sown early, in about the - stage of development as that sown the previous spring.

SUBSEQUENT TREATMENT OF ALFALFA FIELD.

Although in most parts of the country alfalfa does not reach - maximum development until the third or fourth season, yet the tr- ment after the first season is similar from year to year. Alfalf- primarily a hay crop, although it is used in some localities and u- certain conditions for soiling, for silage, for a cover crop in orcha- and for pasturage.

If a good stand is obtained from the original sowing no further tr- ment should be necessary after the first season except to cut the - at the proper time. If from any cause the alfalfa should die ou- spots, or if the original stand was not uniform, or the field sh- require rejuvenating after a few years because of the compact- the best remedy for any of these difficulties is a thorough diskin- the spring, the disks being set so as to split the crowns vertic- Seed may be sown in the bare spots either before disking or af- if sown after, the field should be harrowed. If a field is in bad c- tion, it is usually best to plow up and reseed. It scarcely ever pa- at least where irrigation is not practiced, to coddle a poor stan- alfalfa. Many growers recommend disking every spring, even - the stand is good, and some have found it a paying practice t- after each cutting. Such disking will often prevent the encroach- of weeds. In the Eastern States alfalfa fields sometimes suff- check in their growth, tend to turn yellow, and otherwise sh- sickly condition. Oftentimes this condition is accompanied b- attack of the alfalfa rust or spot disease mentioned in a later pa- graph. The best remedy for such a condition is to mow the fi- The vigorous growth thus induced may overcome the diseased condit-

IRRIGATING ALFALFA.

As has been previously mentioned, the raising of alfalfa by the - irrigation is confined to the western half of the United Stateıostly to the arid regions. The irrigation water is usually supplied y ditches or canals which in their turn obtain water from mountain :reams. In a few localities, such as southwestern Kansas and south-rn Texas, irrigation water is obtained from artesian wells. On ccount of the deleterious effect from standing water it is essential that falfa fields should be as nearly level as possible. In California, here the fields are slightly sloping, they are divided into suitable nall areas called checks, which are separated by low dikes. The ıecks at different levels are irrigated separately, thus preventing ıe accumulation of water upon any given portion for too long a eriod. Where there is an abundance of water and it can be supplied will throughout the season, it is customary to irrigate in the spring efore sowing the seed; or, in the case of an established alfalfa field, efore growth starts and again after each cutting.

It is said, however, that greater yields are obtained if the flooding kes place before the hay is cut, and that in California an extra cutting ın in this way be secured. The flooding must be long enough before ıtting to allow the field to dry off sufficiently, or injury will be done by ıe trampling of the horses during mowing. It is thought that there less injury from scalding when the water is applied before cutting.

Minimum of water.—Where the amount of water is limited a much ss quantity than is ordinarily used will produce paying crops. The inimum amount of water to produce a crop of alfalfa and the time which the water should be applied depend upon the soil and climatic ınditions. Upon this point there is little available experimental data. elow are given the results of a series of experiments carried on in 103, by the Utah Experiment Station in cooperation with the United ;ates Department of Agriculture.

Utah experiment on amount of water required by alfalfa.

AMOUNT OF WATER AND DATE OF APPLICATION.

Date of each irrigation and amount of water applied.								Total of water applied.
First.		Second.		Third.		Fourth.		
	Acre in.		*Acre in.*		*Acre in.*		*Acre in.*	*Acre in.*
ne 16	3.360	July 29	3.359	....	....	....	....	6.719
ne 29	5.970	July 29	3.359	Aug. 19	3.359	....	....	12.688
ne 16	5.070	July 8	5.036	Aug. 6	5.003	....	....	15.109
ne 29	7.020	July 8	5.036	Aug. 19	5.002	....	....	17.058
ne 15	5.030	July 3	5.100	Aug. 1	5.036	Aug. 24	5.002	20.168
ne 20	6.774	July 8	6.694	Aug. 19	6.682	....	....	20.150
ly 8	12.490	Aug. 19	12.506	....	....	....	....	25.002
ne 20	8.303	July 6	8.352	Aug. 19	8.362	....	....	25.017
ne 15	6.320	July 6	6.248	Aug. 1	6.248	Aug. 29	6.250	25.066
ne 16	6.250	June 23	4.280	June 30	5.705	July 7	[a] 5.230	61.465
ne 23	6.250	July 7	6.220	Aug. 15	6.250	Aug. 31	6.250	24.970
ne 16	6.250	July 7	6.220	Aug. 6	6.750	Aug. 31	6.250	25.470
ne 23	6.610	July 7	3.720	Aug. 15	3.250	Aug. 31	3.750	17.330
ne 16	3.980	July 7	3.720	Aug. 6	3.750	Aug. 31	3.750	15.200

[a] This plat was given 5 inches of water on each of the following dates: July 14, July 22, July 28, gust 4, August 17, August 25, August 31, September 8.

Utah experiment on amount of water required by alfalfa—Continued.

DATE OF HARVEST AND YIELD OF HAY.

Date of harvest and yield of hay at each cutting.						Total yield of plat.	Calculated yield per acre.
First.		Second.		Third.			
	Pounds.		*Pounds.*		*Pounds.*	*Pounds.*	*Tons.*
June 26	264	Aug. 12	50½			314½	3.145
June 26	177	Aug. 12	101			278	2.780
June 26	261	Aug. 12	68½			329½	3.295
June 26	204	Aug. 12	108½			312½	3.125
June 26	191	Aug. 12	85½			276½	2.765
June 26	175	Aug. 12	74			249	2.490
June 26	93	Aug. 12	62			155	1.550
June 26	99	Aug. 12	44			143	1.430
June 26	224	Aug. 12	140			364	3.640
June 18	176½	Aug. 10	177¼	Oct. 16	120½	474¼	6.243
June 18	170½	Aug. 10	136½	Oct. 16	73¾	380¾	5.017
June 18	147	Aug. 10	141	Oct. 16	61	349	4.598
June 18	105	Aug. 10	112¼	Oct. 16	46	263¼	3.468
June 18	112½	Aug. 10	106	Oct. 16	35	253½	3.340

It will be observed that the maximum crop was produced by applying plenty of water throughout the growing season. However, it is also to be noted that a much less quantity of water when applied at intervals of three or four weeks produced a fair crop. Fifteen and 17 inches of water applied in this way produced more than half as much as 61 inches applied at frequent intervals. Furthermore, three irrigations of 15 to 17 inches produced about the same results as the same amount applied at four irrigations. In applying irrigation water to fields it is necessary to saturate the soil to a reasonable depth. All the water that drains off beyond the amount required for use is lost to the crop. It is not necessary to apply water again until the crop has removed a large part of the available supply.

ALFALFA FOR HAY.

CUTTING.

Alfalfa should be cut just as it is beginning to bloom. After the beginning of the flowering period the hay deteriorates rapidly in nutritive value. If the field is fairly uniform, the proper stage for cutting is when about one-tenth of the plants have reached the flowering period. (See p. 33.) The number of cuttings varies from two or three in the North, or at high altitudes in the mountains, to as many as ten in the irrigated districts along the southern border from California to Texas. The yield is from 1 to 2 tons per cutting, the first cutting being usually the largest, but the yield per cutting, especially for cuttings after the first, is usually less when there are several cuttings. In the alfalfa regions of the country the aggregate yield of hay is, under favorable conditions, usually from 5 to 8 tons per acre. It is customary in many localities to pasture the fields more or less after the last cutting.

CURING.

In regions where alfalfa is irrigated there is usually no difficulty curing the hay; but in regions where rains may occur during the ying season, especially in humid regions such as Louisiana, great re is necessary to produce well-cured hay of good color. Rains or en heavy dews spoil the color, changing it from the bright green manded by the market to a yellow or brown. Discolored hay may t be less nutritious for feed but it is less valuable upon the market. ie harvesting should take place with as little handling as possible in der to prevent the shattering of the leaves, which contain a large oportion of the nourishment.

Handling in the field.—The preparation of hay from alfalfa is essenılly the same as for any of the grasses, being modified somewhat by succulent nature, especially in the humid regions. On a commerıl scale the cutting is done by mowing machines drawn by from two four horses. The mowing should be commenced in the morning. the arid regions the making of hay from alfalfa is a very simple ocess. The air is so dry that the hay mowed in the morning may raked and stacked in the afternoon of the same day, but in the more ımid climates the difficulties increase. There is more moisture in e air, the green alfalfa is more succulent, and the curing process ust extend over a greater length of time. There is additional dan-r of showers or heavy dews wetting the hay before it is dry enough place in the stacks or barns. Where the alfalfa is especially sucılent the curing process may be hastened by the use of a hay tedder. hese machines are now in use in many places along the lower Mississppi and Red River valleys. When the hay is sufficiently dry it is ked into windrows and later thrown into bunches or cocks. In gions where heavy dews prevail and the curing will not be completed the day that the hay is cut, it is often advantageous to rake the ırtially cured hay into windrows at night and open them out again ie following morning. Another method is to throw the partially ıred hay into bunches, especially if there is a threatening rain storm, ıd to open out these bunches by hand upon the advent of favorable eather. It is often sufficient to throw the partially cured hay into ll narrow cocks, and allow them to remain until the hay is thorıghly cured. Such cocks should be as small as possible in proporon to the height in order that there may be a circulation of air and ss danger from heating. In Louisiana it is recommended that such ocks be covered with hay caps in order to protect them from equent rains.

STACKING.

Throughout the western half of the United States alfalfa is commonly stored in stacks in the field. Alfalfa stacks will not water as readily as stacks of grass hay. In the arid regions there is little danger from rains during the season of storage, but in humid climates it is necessary to store the hay in barns or else cover stacks with large tarpaulins, or they may be topped with grass; otherwise the percentage of waste is very large. In any case there is to be some waste, for which reason the stacks are made large, reducing the proportionate amount of waste. In the alfalfa region of the West the stacks are as high as the hay can be handled easily and may be 200 feet or more in length. The size of the stack is limited chiefly by the convenience in bringing the hay from the surrounding field. The hay may be pitched onto wagons, drawn to stacks, and unloaded by hand or by means of various mechanical devices. The method in most common use, however, for transporting hay from the field to the stack is by using some form of hay sweep, as it is called in many localities, "go-devil." These hay sweeps consist of a row of long teeth sliding upon the ground and pulled by two or four horses. In more modern forms it rests upon wheels, so that it may be lifted from the ground as soon as its load of hay is gathered. The sweep may gather hay from the windrow or from bunches. It is transported to the stack, where the sweep is disengaged from the load by means of backing away. Certain types of stackers will take the hay directly from the sweep and leave it upon the stack. The large stacks commonly used in the West are made possible by the use of hay stackers and derricks, by which means bunches of hay, consisting of several hundred pounds, may be lifted by horsepower to any part of the stack and deposited where desired.

BALING.

As is customary with all kinds of hay requiring transportation, alfalfa is pressed into bales when prepared for the market. The convenience in handling is such that alfalfa is frequently baled for local consumption. The ordinary bales of alfalfa weigh about 100 pounds. The hay for baling must be well cured or there is danger of loss from heating and subsequent spoiling. There are many types of baling presses used, most of them being operated by horsepower. There are still in operation a few hand balers, the bales in such cases usually being somewhat larger than those described. The baled hay for export to Alaska, Hawaii, and other transoceanic points is compressed by the process known as double compression, by means of baling machines operated by electricity or hydraulic power. The hay obtained by loosening the ordinary bale of hay is compressed into square or cylindrical packages of smaller and more compact form than the ordinary bale. The hydraulic presses used for making the so-called round bales are similar to those used for making the cylindrical bales of cotton. The measurements of the different types of double compressed bales are about as follows: Square bale 15 by 18 by 38 inches, weight 160 pounds; square bale for Alaskan trade 14 by 18 by 26 inches, weight 100 pounds; round bale, 2 feet in diameter, 24 inches long, weight 145 pounds, or 36 inches long, weight 260 pounds.

The saving of space in transit may best be understood by comparing the weight and cubic contents of baled and compressed hay. The ordinary bale of hay occupies 140 to 160 cubic feet per ton, the double compressed square bales 85 feet per ton, the round bales 55 feet per ton. There is an increasing demand for alfalfa hay for export.

PASTURING ALFALFA.

In all the alfalfa districts the fields are used more or less extensively for pasturing various kinds of stock. In the arid regions it is quite a common practice to pasture the fields after the last cutting during a portion of the fall and winter. Alfalfa is undoubtedly a valuable pasture plant, but must be used with some caution to prevent loss from bloating, in the case of cattle or sheep, and to prevent injury to the alfalfa field from trampling or overgrazing. Cattle and sheep will bloat as readily upon green alfalfa as upon clover.

Alfalfa is preeminently adapted to the production of hay, and except in the case of hogs its use as pasture is secondary. Where it is intended to use alfalfa primarily as a pasture plant for cattle, sheep, or horses, better results may be obtained by combining the alfalfa with some grass, such as brome grass in the Northwestern States, or orchard grass in the Northeastern States. The mixture is a more nearly balanced ration, gives a greater variety of feed, and is less likely to cause bloat.

DANGER OF BLOATING.

The cause of bloat is not known nor are the conditions bringing it about entirely understood. The danger of loss from this cause is always present whenever alfalfa is pastured with cattle or sheep. The loss from bloat in regions where alfalfa is regularly pastured is ordinarily small, although in some cases it is said to amount to as much as 5 per cent per annum. This loss is more than offset by the increased gain from pasturing, even for the limited time in the fall when the pasturing usually occurs, unless, of course, the animals are especially valuable. The conditions which usually cause bloat in cattle or sheep when fed upon clover, it is sometimes claimed, do not seem to be identical with those causing bloat when alfalfa is pastured. In some regions it is claimed by stockmen that bloat is more likely to occur when cattle are turned upon wet alfalfa, or when they are [illegible] a pasture when hungry. In other regions stockmen [illegible] conditions have little or nothing to do with the prevalence of bl... While there is always danger from bloat in pasturing alfalfa, it ... be cut and fed green as a soiling plant with comparatively little dan... But there are even cases on record where cattle, on the return ... appetite after being off feed, have bloated upon alfalfa hay.

DANGER OF OVERPASTURING.

On the other hand an alfalfa field must not be overpastured. ... previously stated the plants lack creeping roots or stems by wh... spread and can not fill in spots where the alfalfa has died. The ... grazing, especially of sheep, and the trampling of large number... animals is certain to injure the stand of alfalfa. While the pastur... of alfalfa in the fall may do no harm, it must be remembered tha... the warmer portions of the country this season is one of recupera... for the alfalfa plant. If not allowed to make some growth du... this period it may not be in condition to start up well the follo... spring.

PASTURE FOR HOGS, HORSES, AND POULTRY.

Alfalfa is an ideal pasture plant for hogs. There is no danger fr... bloat and with a limited number of hogs there is practically no in... to the alfalfa field. Vigorous alfalfa will support 15 to 25 hea... pigs per acre. It is best to limit the number of pigs to that wh... will be insufficient to keep down an alfalfa field. Cuttings of ... may then be made at intervals and the growth thus rejuvenated. ... the average pigs weighing 30 to 60 pounds in the spring will ma... gain of about 100 pounds each during the season. Although pigs ... be grown and fattened upon alfalfa alone, it is best to combine ... alfalfa with some kind of a grain ration. Alfalfa by itself is too ... in protein to give a balanced ration. Where pigs are pastured ... alfalfa alone they may be prepared for the market by feeding for a ... weeks upon corn. It is still better, however, to feed a third to a ... of a ration of corn or other grain during the time of pasturing.

In this way pigs may be prepared for the market within a ye... By feeding a smaller quantity of grain the time of preparation ... market is somewhat extended but the total cost may be less, espe... in the warmer portions of the country where alfalfa is available ... pasture during a longer period.

The pasturing of hogs may be accomplished by having more ... one field into which the hogs may be turned. By pasturing ... fields in rotation the alfalfa is given a chance to start and a lar... number of hogs may be pastured without injury to the field.

Alfalfa is frequently used as pasture for horses, although ... animals should not be confined too closely to this feed. Po... do well upon alfalfa, and it is recommended that a small patch be a... able to them in all cases where this crop grows successfully.

ALFALFA FOR SILAGE.

ıus far there has been comparatively little experience in the use falfa as a silage plant. Experiments with this plant have shown, ɜver, that when properly prepared and stored it is valuable for purpose. It is recommended that green alfalfa be brought ediately to the silo and then passed through a silage cutter. ut alfalfa has been placed in the silo, but the results have not been ıtisfactory as when the plants have been previously cut in the usual ner. The silage should be well packed and water added, if neces-. In localities where corn can be used as a silage crop there ld be no advantage in using alfalfa for this purpose; for, if the litions are suitable, it is better to use the alfalfa in the form of In humid climates, however, where the curing of alfalfa is ıded with difficulty, the crop may be utilized to advantage by ing in the silo. This is especially true of those localities where first crop of alfalfa is produced during the rainy season of the '. Under such circumstances the first crop may be saved by plac- in the silo, while the subsequent crops may be converted into hay. ome regions, especially where there is a winter rainy season, the crop of alfalfa may be delayed until the weather conditions are ıvorable to curing the hay. If silos are in use the last crop might uch cases be saved as silage.

he value of alfalfa as a silage plant has been tested at the Colorado ›eriment Station. It was found that it was necessary in that dry ıate to rake up the hay and bring it to the silo immediately after ıg cut; otherwise it would become too dry. With whole alfalfa spoiled layer was 3 inches on top and 1 inch on the sides, with a of about 10.7 per cent. With alfalfa cut in a silage cutter the iled layer was 2 inches on the top and half an inch on the side, h a loss of about 7 per cent.

ALFALFA AS A SOILING PLANT.

ılfalfa cut green and fed partially wilted is one of the best stock ls available, but in the great alfalfa districts of the United States crop is rarely utilized for this purpose. It can be so utilized to antage only where increased labor is compensated by the added ue of the alfalfa, as may be true when fed to dairy cattle. In Eastern States, and especially in the South, alfalfa is commonly d in dairy feeding, for which it is well adapted, since it gives a ge yield of very nutritious and palatable forage. There seems to little or no danger from bloat when alfalfa is used as a soiling crop.

ALFALFA IN A ROTATION.

In common with other legumes alfalfa has the power of gathering nitrogen from the air, as has been explained in a preceding paragraph. On account of this valuable characteristic alfalfa adds fertility to the soil on which it is grown. When the soil upon which alfalfa has been grown is used for other crops the increased fertility is quickly shown by the vigor of these crops. Not only is the soil richer in nitrogen, which would be true in the case of all the legumes, but other mineral constituents are made more available because of the penetrating power of the alfalfa roots. These roots extend to great depth, loosening up the soil and bringing up from below the deeper supplies of the various mineral elements.

In the sugar-beet districts of the West the increased fertility of the soil upon which alfalfa has been grown is shown by the increased yields of sugar beets for at least four years following.

USEFULNESS IN A SHORT ROTATION.

Alfalfa is not ordinarily used in a short rotation in the alfalfa districts. It is, however, well adapted to such a rotation in regions where it can be easily started and where it produces a profitable crop the first year, as it does in the South and the irrigated regions of the West. Even in those parts of the North where late summer sowing is practicable, the crop may be sufficient the next year to justify its use in rotations which permit it to remain down only one or two years. Whether alfalfa should be used instead of clover in short rotations must be determined by the relative yield of the two crops for the first one or two years. Ordinarily where alfalfa can be easily started from fall sowing it will outyield clover the next year, but in much of the clover country alfalfa is as yet too difficult to start to justify any general attempt to substitute it for clover in short rotations.

In the South and West where clover is not grown alfalfa can also be used to advantage in a short rotation wherever the system of rotation employed calls for a leguminous hay crop for two or three years. It may even be practicable to use alfalfa for one year in rotation in parts of the South where it will produce profitable crops when sown in the spring or in the season following fall sowing. While alfalfa is adapted under the favorable conditions mentioned to a short rotation, it may be still better adapted to a longer rotation, when profitable crops may be obtained for a series of years.

A SUGGESTION FOR ALFALFA WITH CORN.

In general, the rotations developed in the clover region have been based on the habits of the clover plant, which ordinarily does not produce profitable crops for more than two years. In sections wh lfa becomes thoroughly established, might it not be wise to revise rotations so that we may better utilize the possibilities of the lfa plant? Take, for instance, such a rotation as that suggested Mr. Joseph E. Wing, from his experience with alfalfa in Ohio: r years, alfalfa; one year, corn; one year, beardless barley sown alfalfa. The cultivated crop (corn) gives a chance to destroy ds, which are apt to get a foothold in the alfalfa field in four years' . This rotation is entirely practicable, and others based as directly he habits of alfalfa will, doubtless, in time replace the old clover tions.

ALFALFA WITH SMALL GRAIN.

he Wyoming Experiment Station demonstrated that irrigated land iously in alfalfa produced $8 to $12 more value in wheat per , $16 worth more of oats, and $16 worth more of potatoes than previously in potatoes or grain, and these gains were made with ost in fertilizing the land. The alfalfa was not turned under, but yielded crops of hay for five years.

lr. David Fairchild[a] states that wheat and alfalfa are successfully wn together at the same time on the dry uplands of North Africa. alfalfa is planted in rows 3 feet apart, and between the rows a of durum wheat is grown every other year.

n the irrigated regions of the western United States grain is occaially grown in combination with alfalfa, but rather as a suppletary crop. If the stand of alfalfa has been injured, a new seeding grain and alfalfa may be made in the spring and the mixture of lfa and grain hay harvested. It is said that in some regions barley own in the fall upon alfalfa fields, thus giving a winter crop of grain, e followed by the crop of alfalfa upon harvesting the grain.

OTHER USES OF ALFALFA.

lfalfa has been used as a cover crop in orchards and does very well, ough usually other crops are better adapted for this purpose.

Inder the system of cultivation used in California, it has been found rious to the orchards in that State. In dry regions it may rob the s of needed moisture, especially in young orchards.

s a honey plant alfalfa is to be highly recommended, and in regions ere alfalfa is extensively grown the honey produced is well known its body and richness of flavor.

SEED PRODUCTION.

All the alfalfa seed produced in the United States is now grown in region lying west of the Missouri River. In the eastern portion

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U. S. Dept. Agriculture, Bureau Plant Industry Bul. 72, Part I. Cultivation of eat in Permanent Alfalfa Fields.

of the Great Plains region extending from Texas to Nebraska, alfa seed is produced without irrigation. The great bulk of the s however, is grown by the aid of irrigation in the Arkansas Valley eastern Colorado and western Kansas, northeastern Colorado, nort Utah, southern Arizona, and the central valleys of California limited quantity of alfalfa seed is produced in the Niagara Pe-sula of southern Ontario. This seed is used in the Canadian tra. The dry regions of the West provide climatic conditions bett adapted to the production of alfalfa seed than do the more hum regions of the Eastern States.

If too much water is supplied to the crop during the time of flow ing and ripening of the seed, the strength of the plant goes to fol rather than to seed. This fact governs the choice of the one of successive crops to be saved for seed production. Any one of a sea son's crops may be used for seed providing the conditions are favora for the ripening and the season is sufficiently long. The time requ for the growing of one crop of seed is about equal to that requi for the production of two crops of hay. On the whole, the secon third crop is more often cut for seed than the first. This ma because the first crop would mature during a season more humid t that prevailing during the latter part of the year. Except in southern part of the United States a later crop than the third can be used because the proper maturing of the seed would be hind by the advent of cold weather.

HARVESTING FOR SEED.

The best time to cut an alfalfa crop for seed is when about ha the pods have turned brown. It is impossible to obtain all the which the plants produce because while the earlier flowers are matu the new flowers are produced in succession and the seeds from th flowers are shattered before those from the new flowers mature. T seed crop may be harvested in the same manner as for hay, care be taken to handle the crop in such a manner as to lose as little of seed as possible by shattering. Many seed growers use a self-bin for harvesting the crop. This is entirely satisfactory except wh the alfalfa is badly lodged. When the alfalfa is gathered in this ma ner it is thrashed from the shock, if practicable. Stacks are m only when thrashing machines are not available at the proper t Other methods of harvesting find favor in some districts. A mow machine with a special dropping attachment by which the alfalfa dropped at intervals has been recommended. When cured the can be readily gathered by means of barley forks and thrown wagons. Much the same result is obtained by the use of a self-ra reaping machine. The hay should be well cured before h gathered. In the dry regions, the cured hay may be thrashed from the windrow, from bunches, or from the stack, according to convenience. The straw produced from the thrashed alfalfa has considerable feeding value, estimated by those who have used it as being about half that of alfalfa hay, providing the curing was done under favorable conditions. The yield of seed should be from 5 to 7 bushels per acre. In wet seasons the yield may fall much below this; and, under specially favorable circumstances, may rise as high as 11 or 12 bushels per acre. The seed weighs 60 pounds to the bushel. In practice the decision as to whether the crop will be used for hay or saved for seed may depend upon the weather. This is especially true in the less arid regions, where the rainfall is an uncertain factor. If the season is wet and the conditions are such as to produce a large crop of hay, it is much better to use the alfalfa for this purpose. If the reverse conditions are present, the grower may decide to allow the crop to go to seed. In the nonirrigated districts the best seed is likely to be produced upon the drier upland fields where the growth is less vigorous.

FORM AND COLOR, AND ADULTERATION OF SEED.

Alfalfa seeds resemble those of red clover in size, but differ in not being so uniform in shape. The color should be a light olive-green. Darkened, shriveled, and discolored seed should be discarded. On account of the high price of alfalfa seed during the last two or three years a considerable quantity has been imported from Europe. Many samples of the imported seed have been found to be mixed with the seed of dodder, an enemy of alfalfa, which is described in a separate paragraph. The commonest adulterants of alfalfa seed are the seed of yellow trefoil (*Medicago lupulina*) and bur clover (*Medicago maculata* and *M. denticulata*). The plants of yellow trefoil and bur clover are easily distinguished from alfalfa by their smaller size and their yellow flowers. It is not often that home-grown alfalfa seed is adulterated. It sometimes occurs, however, that unadulterated seed is of poor quality, as shown by its brown color as contrasted with the light olive-green of good seed. Such seed should be discarded, as its germination is low.

FEEDING VALUE OF ALFALFA.

It is well known that alfalfa is a highly nutritious and palatable fodder for all classes of farm animals. All kinds of stock eat it greedily, either in the form of green alfalfa or as hay. Below are given tables showing percentage composition, digestibility, and the digestible nutrients in 100 pounds of green alfalfa and alfalfa hay, in each case compared with red clover.

Average percentage composition of alfalfa. [a]

Condition of forage.	Number of analyses.	Water.	Ash.	Protein.	Crude fiber.	Nitrogen free extract.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Fresh alfalfa	23	71.8	2.7	4.8	7.4	12.3
Fresh clover	43	70.8	2.1	4.4	8.1	13.5
Alfalfa hay	21	8.4	7.4	14.3	25.0	42.7
Clover hay	38	15.3	6.2	12.3	24.8	38.1

Average digestibility of alfalfa and red clover, percentage.

(Experiments with ruminants.)

Condition of forage.	Number of analyses.	Protein.	Crude fiber.	Nitrogen free extract.
		Per cent.	*Per cent.*	*Per cent.*
Fresh alfalfa	2	81	45	76
Fresh clover	2	67	53	78
Alfalfa hay	28	73	43	66
Clover hay	46	55	49	69

Digestible nutrients in 100 pounds.

Condition of forage.	Dry matter in 100 pounds.	Digestible nutrients in 100 pounds.	
		Protein.	Carbohydrates.
	Per cent.	*Per cent.*	*Per cent.*
Fresh alfalfa	28.2	3.9	12.7
Fresh clover	29.2	2.9	14.8
Alfalfa hay	91.6	10.44	39.6
Clover hay	84.7	6.8	35.4

The leaves of alfalfa are richer than the stems in protein, carbo- drates, and fat, but are poorer in crude fiber. The Colorado stat has shown that protein in the two cases is 13.12 and 8.61 whil digestible protein is 9.84 and 6.46 parts in 100 parts of dry matter. is therefore quite essential that alfalfa hay should be put up with little loss of leaves as possible.

Good, bright alfalfa hay that has not been wet by rains or de more valuable for feed than that which has been damaged by water. has been shown that where good hay contained 18.75 per cent prot in the water-free material, the same hay damaged by rains contai only 11.01 per cent protein.

RELATION TO OTHER FEEDING STUFFS.

Need of grain as a balance.—It will be seen that alfalfa is more nutritious than clover. On account of its high percentage protein it is not a balanced ration. For the best results the alf should be combined with some other feed which is rich in car hydrates. While animals may be fed and even fattened for

[a] Henry's Feeds and Feeding, Appendix.

market upon alfalfa alone, nevertheless a portion of the nutritive value of the alfalfa is lost in this way. The alfalfa does not give the best results. In order to balance the ration alfalfa should be combined with a suitable quantity of grain. This grain may be corn or barley, according to the availability of each.

Alfalfa as a dairy feed.—As an illustration of feeding alfalfa alone, may be mentioned the case of the dairy farms in the vicinity of Moneta, Cal., where the stock are ordinarily fed no other ration than alfalfa. Since alfalfa is not a balanced ration a number of local dairymen tried to replace a part of the alfalfa by sorghum, thus giving a more nearly balanced ration. The cows, however, did not give as much milk upon this combination as upon pure alfalfa. This result may be assigned to the fact that the cattle were unable to consume a sufficient quantity of the mixture to produce the same results as the alfalfa alone. These dairymen find they can secure a larger milk yield by feeding a little grain: but the increased yield does not pay for the grain, which is high priced in this locality.

EFFECT OF TIME OF CUTTING ON FEEDING VALUE.

The period at which alfalfa is cut has considerable influence on its feeding value. Experiments conducted in the different parts of the country are not in entire accord in regard to this. It has been shown, however, that the amount produced decreases from just before the blooming period until the plant is in full seed; it has also been shown that the first and second crops of hay are richer in protein than succeeding crops. The percentage of protein does not vary much from about the beginning of bloom until the field is one-half in bloom. From a practical standpoint, however, one must take into consideration the total weight of hay, the actual quantity of proteids contained therein, and the digestibility of these proteids at different times. It was thought at the Colorado station that the best time to cut the hay was at the period of full bloom. The Ontario Experiment Station concludes from experiments tried there that alfalfa yields more digestible protein when cut when about one-third in blossom. The consensus of opinion among growers, however, is that alfalfa should be cut when beginning to bloom. The total amount of nutritive material obtained at one cutting may be somewhat less, but the cuttings can be made more frequently, so that the yield of the entire season is greater. Experiments at the Central Station, Ottawa, Canada, show that more fodder and a larger amount of nutritive material was obtained by making four cuttings during the season than by making two.

Pigs in Nebraska.—Pig-feeding experiments carried on at Nebraska Experiment Station with corn and alfalfa hay showed the cheapest gains were made by means of corn and chopped al In this combination the greatest gains were made where the was three-fourths corn and one-fourth alfalfa, but where the was raised on the farm and there was no particular need of has the growth of the pigs, it was found that cheaper gains were with one-half alfalfa and one-half corn.

Cattle and hogs in Kansas.—At the Kansas Experiment Sta cattle fed upon a ration of corn and alfalfa hay gained much than others fed upon other rations. During the one hundre fifty-three days of the test the value of the gains made by the dif lots were: Corn and alfalfa hay, $109.74; barley and alfalfa, wheat and alfalfa, $44.91; corn and sorghum, $27.09; corn and pra hay, $56.96; corn and oat straw, $43.28. At the same station were fed on a ration of alfalfa hay and Kafir corn meal. The were 73 per cent more on this ration than upon a ration of Kafir meal alone. For every bushel of Kafir corn meal and 7.83 poun alfalfa hay the gain was 10.88 pounds, while upon Kafir corn alone the gain was 7.48 pounds per bushel. It is shown that the gave better results when cut early and that the chief nutriment wa the leaves, which should be carefully saved during the proce harvesting. An earlier experiment at the same station was tri determine the value of alfalfa pasture for hogs. The hogs were all to run upon the alfalfa during the summer and were fed a light ra of grain. After deducting the probable gain for the corn it was f that during the summer each acre of alfalfa pasture produced pounds of pork.

Steers in Utah.—At the Utah Experiment Station steers made a r rapid gain when fed upon early-cut alfalfa either with or without accompanying ration of grain. By early-cut hay was meant hay just before bloom. The gain upon this early cut alfalfa hay was third more than that upon hay cut when in full bloom or later. was also found that more hay was produced from the early cutt and that the third crop gave more rapid gains than either the fir second, which latter are nearly equal in this respect.

Substitute for bran, etc.—The New Jersey Experiment Stations ommend feeding alfalfa hay in the Eastern States as a substitute the concentrates usually fed in dairies there, such as bran, cotton meal, and dried brewers' grains. A satisfactory combination wa pounds of soy-bean silage, 8 pounds of alfalfa hay, and 6 pound corn meal. The advantage of this ration is that all the constitu

[a] N. J. Expt. Stas. Bul. 148, Feb., 1901.

›e grown upon the farm. The soy beans were cut just as the pods forming, run through a silage cutter, and placed in the silo withnixing with any other crop. A five-year test with alfalfa demon-ed that an average yield of about 20 tons per acre of green forage 1 be obtained, which is equivalent to about 5 tons of hay, which produced at a cost of $5.50 per ton. It is interesting to note that ration not only cost less but was a greater milk producer than the with which it was compared—36 pounds of corn silage, 4 pounds heat bran, 4 pounds of dried brewers' grains, and 2 pounds of on-seed meal. At the same station a comparison was made between tion containing 35 pounds of corn silage, 11 pounds of alfalfa hay, ›unds of mixed hay, 2 pounds of cotton-seed meal, and the same on in which the alfalfa hay was replaced by 4 pounds of wheat ı and 4 pounds of dried brewers' grains. The two rations contain same amount of protein. The conclusion was that alfalfa hay ld be substituted for the two concentrates, and was worth $11.16 ton as compared with wheat bran and dried brewers' grains cost-$17 per ton. In general, alfalfa hay may be substituted for bran he rate of about 1½ pounds of hay to 1 of bran. For the best ılts the hay should be chopped fine.

'rom experiments conducted at the Tennessee Experiment Station, vas shown that alfalfa or cowpea hay could be produced at a cost $3 to $5 per ton and could be substituted for wheat bran which cost to $25 per ton. Alfalfa hay can not be substituted entirely for ton-seed meal as the latter is so very rich in protein. It was calcu-ed that with alfalfa hay at $10 and wheat bran at $20, the saving ected by substituting alfalfa hay for wheat bran would be $2.80 for ry 100 pounds of butter, and 19.8 cents for every 100 pounds of lk.

PREPARED FEEDS CONTAINING ALFALFA.

On account of the value of chopped alfalfa hay for stock feed a prep-ıtion has been placed upon the market which is intended to take the ıce of the alfalfa hay. This preparation of ground alfalfa hay is own as alfalfa meal. At present this alfalfa meal is made in Nebraska d California. One of these preparations is said to consist of a mix-re of alfalfa meal and sugar-beet molasses. Such preparations, if ıde from the best quality of alfalfa hay, are convenient for feeding, pecially when they take the place of ordinary concentrates. A some-hat greater percentage of the hay is utilized by animals when finely ound than when fed in the form of hay. Circumstances must deter-ine whether this is the most economical method of feeding the alfalfa. ransportation charges on alfalfa meal are less than on alfalfa hay, r which reason it may compete seriously with alfalfa hay in regions mote from alfalfa centers.

ALFALFA FOR HORSES.

There is no doubt that alfalfa is an excellent forage plant for t both as pasture and as hay. Horses do well upon alfalfa pasture. care must be exercised that they do not injure the stand of alfa by trampling or by too close grazing. In the alfalfa regions of th work horses upon the farm may be fed the year round upon no ration than alfalfa. It is, however, generally conceded that h while heavily worked, should receive at least a small grain ra order to produce the maximum effect. This is especially true of horses and those which are worked upon the road. On the othe there is a prejudice against alfalfa as feed for horses which largely to unfamiliarity with this kind of hay. Horses as w other animals may not take alfalfa hay readily until they have a a taste for it. It has also been found that injurious effects may a sudden change to alfalfa hay from some other kind of feed. seems to be due to the large proportion of protein which may stimulate the animal. There are also certain other reasons why a is objected to by horse men. The manure is softer and more than that from animals fed upon timothy hay, and it is more diffi keep the animals and the stables clean. It is a fact, however, that use of alfalfa hay for horses is rapidly increasing.

ENEMIES OF ALFALFA.

WEEDS.

One of the most important factors in hindering the developme alfalfa on soil suited to its growth is the presence of weeds. I especially true in the more humid regions, and in the Southern S it seems to be the usual cause of failure on soils sufficiently ferti support alfalfa. Alfalfa is quite tender when it first comes up a young plants are easily crowded out by weeds. The weeds may ap about the same time as the alfalfa and thus prevent the latter obtaining a start. Alfalfa sown in the spring is especially vulner for which reason it is advisable to sow in the late summer or earl and to sow upon land which has been freed from weeds by pre cropping, tillage, or summer fallow. If the conditions are favo for the growth of alfalfa, a weedy field may often be saved by freq clipping with a mowing machine. In the sandy soils of the Sou States fall sowing, as described, may produce a good stand an good cutting may be obtained the following spring, after which c grass or other noxious weeds suddenly spring up and the alfal immediately choked. If the weeds are not too numerous, clipp with a mowing machine may save such a field. Harrowing may destroy some kinds of weeds, particularly crab grass. Old alfa ds may also suffer from weeds. This is usually due to the killing the alfalfa in spots from some unfavorable condition, the ground n being taken by an aggressive weed. In the irrigated regions h bare spots may be caused by water standing too long or by the mping of animals pastured upon the field.

'he Georgia Experiment Station recommends planting the seed in rs sufficiently far apart to allow of horse cultivation. Good results e been obtained upon the station farm, and the method is fre-ntly used upon a small scale in many parts of the South. Culti-ion between the rows will keep down the weeds until the alfalfa vell established, after which one or two cultivations between cut-gs will be sufficient for this purpose. This method increases the pense, but since in this region hay from legumes is high priced, the urns seem to warrant the extra expense. Rolling or disking aids preventing the old crowns from protruding too far above the rface.

Squirrel-tail and similar grasses.—Squirrel-tail grass (*Hordeum juba-m*), also called foxtail in Wyoming, barley grass in Utah, and tickle ass in Nevada, is a common weed in the Great Basin region; and other species (*Hordeum murinum*), called wild barley, barley grass, d foxtail, is common on the Pacific slope. The common dandelion is oublesome in parts of Utah and Idaho. In the limestone regions the Northeastern States bluegrass encroaches seriously upon alfalfa lds. Old fields that become weedy are often benefited by disking the spring and after the cuttings are made. Alfalfa has no method propagation by creeping roots or stems and consequently the plants not spread, but the disking kills the weeds and splits the crowns of ne of the alfalfa plants vertically, rejuvenating them. Seed sown on the vacant areas at such a time may improve the stand. Where weeds succeed in obtaining the upper hand it is best to plow up field and reseed it.

Johnson grass.—In many parts of the Southern States, especially the airie region from northern Texas to central Alabama, Johnson grass a pernicious weed. In those portions of this region where alfalfa is uccessful forage plant it has been found that when established upon hnson grass land the alfalfa will smother out the Johnson grass, or least hold its own by its side. Even though the alfalfa does not tirely kill out the Johnson grass, and there is consequently a mixture the two plants, they form a very nutritious combination and in hnson grass regions this is one of the best methods by which fields fected by this weed may be utilized.

If it is desired to establish alfalfa upon black land in Texas badly fested with Johnson grass, the ground should be plowe[illegible] ptember or October, harrowed to remove the roo[illegible] grass as much as possible, and then sown to alfalfa. The alfalfa starts much more readily than the Johnson grass during the cool weather of fall and winter. The following season the field should be mowed often enough to prevent the Johnson grass from getting ahead of the alfalfa. Since alfalfa recovers from cutting more quickly and will produce more crops than the Johnson grass, the latter is so much weakened and smothered that there is usually no trouble from this during the second or subsequent seasons.

FIG. 7.—Dodder plant on an alfalfa stem.

FUNGI.

The most important fungous disease of alfalfa is that known as rust, a spot disease caused by *Pseudopeziza medicaginis*. The plants turn yellow and show minute black spots upon the leaves. Mowing an infected field will usually overcome the disease by producing a vigorous growth.

In certain parts of the South, notably in Texas, alfalfa suffers from root rot, a disease affecting cotton in those localities. This disease is indicated by the whole plant turning brown and dying. The disease lives in the soil and occurs in well-marked areas. There is no cure, and the only preventive is to plant alfalfa on soil free from the disease.

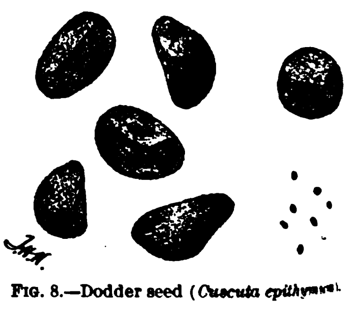

FIG. 8.—Dodder seed (*Cuscuta epithymum*).

DODDER.

This is an orange-yellow thread-like vine which grows as a parasite upon the alfalfa plants (fig. 7). The seeds of the dodder are somewhat smaller than the alfalfa seeds (fig. 8), but are not separated from them except by careful recleaning; consequently, they are often sown along with

'alfa seed, especially in that which has been imported. If a
ı badly infested it should be plowed up and devoted to some
:rop for a few years. Small infested patches should be carefully
ed by hand, or the patches should be burned by scattering straw
over them and setting fire. The dodder plant has no roots in
l and conseqently can be removed by cutting the alfalfa plant
o the ground. There are several other species of dodder or love-
:curring on other plants, but none of these will ordinarily attack
. It should be known that alfalfa seed intended for sowing is
:om dodder seed, as it is much easier to prevent the introduction
:h a weed than it is to remove it afterwards. Dodder seed is
hat smaller than alfalfa seed, is more angled, and is not curved
an-like in shape.

ANIMALS.

the Western States certain burrowing animals, such as pocket
rs, prairie dogs, ground squirrels, and field mice, are sometimes
lesome in alfalfa fields. These can be poisoned by grain soaked
ychnine or by pieces of fresh potatoes inclosing a small grain of
nine placed in their runs. They may be drowned out with water
acked with carbon bisulphid in their burrows. Rabbits often
e upon alfalfa fields, but they do little damage except upon small
es. Experimental plots near dwellings are likely to be anni-
d by poultry. Grasshoppers do much damage in the Plains
n. In some localities the alfalfa worm, which eats the leaves and
a web upon the plants, destroys a portion of the crop. Mow-
n infected field seems to check its depredations.

FARMERS' BULLETINS.

The following is a list of the Farmers' Bulletins available for distribution, show[illegible] number and title of each. Copies will be sent to any address on application to a[illegible] Representative, or Delegate in Congress, or to the Secretary of Agriculture, Wa[illegible] D. C. The missing numbers have been discontinued, being superseded by later

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 216.

IE CONTROL OF THE BOLL WEEVIL,

INCLUDING RESULTS OF RECENT INVESTIGATIONS.

BY

W. D. HUNTER,

Special Agent in Charge of Cotton Boll Weevil Investigations,
Bureau of Entomology.

WASHINGTON:
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1905.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., February

SIR: I transmit herewith a manuscript entitled "The Control of the Boll W... Including Results of Recent Ivestigations," prepared by Mr. W. D. Hunter, ... agent of this Bureau in charge of experimental work with the cotton boll ... This paper will replace Farmers' Bulletin No. 189. It contains the previous ... mendations of the Bureau of Entomology regarding the means of mitigat... damage by this very serious pest, with such minor modifications as have bee... necessary by the work of the past season. In addition, various topics, such ... territory infested, the present status of State quarantines against the boll we... other matters, are considered. I recommend that it be issued as a Farmers' Bu...

Respectfully,

L. O. HOWARD,
Chief of E...

Hon. JAMES WILSON,
Secretary of Agriculture.

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ILLUSTRATIONS.

THE CONTROL OF THE BOLL WEEVIL.

RECOMMENDATIONS.

The work of the Bureau of Entomology for several years has indicated that there is not even a remote probability that the boll weevil will ever be exterminated. As a matter of fact, no injurious insect has ever been exterminated. Some species, like the Rocky Mountain locust in this country, have died out more or less on account of climatic influences, and reasonably effective methods of combating others, like the Phylloxera in France, have been perfected.

Although the very large yields of cotton of former times may no longer be possible in the region now infested by the boll weevil, it is entirely feasible to produce cotton at a margin of profit that will compare favorably with that resulting from the production of most of the staple crops of the United States by following what has become generally known as the cultural method. This method consists of the following changes and modifications of the system of cotton raising, made necessary by the boll weevil. It was originally suggested by a careful study of the life history and habits of the pest, and naturally any improvements that may eventually be made will be the result of a continuation of that study. It has now been tested successfully on a large scale by the Bureau of Entomology, as well as by many planters, during three seasons. Of greatest advantage is the reducing of the numbers of the weevils by the destruction of the plants in the fall. The advantage thus gained is followed up by bending every effort toward procuring an early crop the next season.

(1) Plant early. If possible, plant seed of the varieties known to mature early, or obtain seed from as far north as possible. This recommendation is made as a suggestion for the benefit of those planters who have not taken care in the selection of the cotton seed for planting on their plantation. By far the best method for obtaining early seed is by selection in the field.

It is much better to run the risk of replanting, which is not an expensive operation, than to have the crop delayed. The practice of some planters of making two plantings to avoid having all the work of chopping thrown into a short period is very bad policy from the boll-weevil standpoint.

Early cotton of improved varieties has yielded from two to three times as much as native cotton under the same conditions, and in many cases much more. Planted at the same time, the early varieties [illegible] much earlier than native cotton.

Early-planted fields of either native or improved varieties have thus invariably yielded twice as much as late-planted ones.

The early varieties, in general having a small stalk and short tap root, are adapted only for rich soil. They also fail to grow well in the very light, drifting sandy loams of many of the river valleys of Texas which, in long seasons before the advent of the boll weevil, often produced the largest yields. In these situations early varieties will yield but little more than native cotton.

(2) Cultivate the fields thoroughly. The principal benefit in this comes from the influence that such a practice has upon the constant growth and consequent early maturity of the crop. Very few weevils are killed by cultivation. Much of the benefit of early planting is lost unless it is followed by thorough cultivation. In case of unavoidably delayed planting, the best course for the planter to pursue is to cultivate the fields in the most thorough manner possible. Three choppings and numerous plowings constitute the thorough system of cultivation that is made necessary by the boll weevil. The old plantation rule for the cultivation of cotton, "Once a week and once in the row," is an excellent one.

(3) Plant the rows as far apart as experience with the land indicates is feasible, and thin out the plants in the rows thoroughly. On land which in normal seasons will produce from 35 to 40 bushels of corn the rows should be 5 feet apart. Even on poor soil it is doubtful if the distance should ever be less than 4 feet.

(4) Destroy, by plowing up, windrowing, and burning, all the cotton stalks in the fields as soon as the weevils become so numerous that practically all the fruit is being punctured. This will generally not be later than the first week in October. Merely cutting off the stalks, by means of the triangular implement used for that purpose throughout the South, is by no means as effective as plowing, because the stumps remaining give rise to sprouts which furnish food until late in the season to many weevils that would otherwise starve. The plowing, moreover, serves to place the ground in better condition for early planting the following spring. In some cases turning cattle into the fields is advisable. Aside from amounting to a practical destruction of the plants, grazing of the cotton fields furnishes considerable forage at a time when it is generally much in demand. Nevertheless, cattle should never be turned into cotton fields in which Johnson grass has become started.

Recommendations 1, 2, and 3 are all aimed toward avoiding damage by hastening the maturity of the plants and do not involve the actual destruction of the weevils. Recommendation 4, however, reduces the number of the pests by destroying the very great proportion developing late in the fall, and is consequently directly remedial.

(5) It is known that at present fertilizers are not used to any considerable extent in cotton producing in Texas. There is, nevertheless, no doubt

that they should be—not that the land is poor, but that earlier crops may be procured. At present it is sufficient to call attention to the fact that it has been the uniform experience of experiment stations and planters in the eastern part of the belt that certain fertilizers, especially those involving a large percentage of phosphoric acid, have a strong tendency toward hastening the maturity of the plants.

The recommendations above made constitute the essential steps in the cultural system of averting damage by the boll weevil. In addition to these steps, however, all operations which assist in the growth of the crop are of decided advantage in regions infested by the boll weevil. There is thus a distinction between the cultural system of averting damage by the boll weevil and the proper system of cultivation of cotton. The terms are by no means synonymous. As a matter of fact the cultural system of averting damage by the boll weevil in some cases implies operations that would not be the proper ones in all cases for the production of the largest crop were the pest not present. This is especially the case in the early fall destruction of the plants, and also to some extent in the selection of early maturing varieties and in early planting itself.

A number of devices are possible for hastening the maturity of the crop in addition to those mentioned. For instance, thorough preparation of the land before planting is of very great importance; the packing of the soil by means of a roller immediately after the seed is planted insures rapid germination, and consequently also assists in advancing the maturity of the crop.

Necessarily the proper application of fertilizers is a complicated matter. Only the most general rules are possible for all conditions. The different soils on single farms require different compositions. Nevertheless, it can be stated that acid phosphate is the principal ingredient that the cotton plant requires, and that it has a very important function in hastening maturity. It also largely controls the action of the other essential elements, nitrogen and potash. The work of the southern experiment stations has shown that the nearest approach to a general formula for all soils is one that provides 10 per cent of available phosphoric acid, 3 per cent of ammonia, and 3 per cent of potash. This proportion is reached approximately by mixing 1,200 pounds of acid phosphate with 600 pounds of cotton-seed meal and 200 pounds of kainit.

The cultural means of obtaining an early crop, such as thorough preparation of the soil, selection of variety, early planting, fertilization, and cultivation will be dealt with fully in a Farmers' Bulletin, by Dr. R. J. Redding, director of the Georgia Agricultural [illegible] Station, which will soon be issued.

INTRODUCTORY.

The present bulletin is designed to bring together discussions of some of the features of the boll weevil problem in the United States that are of most immediate interest. Among such matters are the more recent developments regarding (1) the cultural system of avoiding damage by the pest, (2) the territory affected, (3) the loss occasioned during the season of 1904, (4) the present status of quarantine regulations, and (5) some minor matters. Some information, as, for instance, the description of the weevil and some portions of the discussions of the damage caused by the pest, are reproduced from Farmers' Bulletin No. 189, which was published in January, 1904. It is not intended in the present bulletin to include all of the results of the experimental work conducted during the season. In a general way, the work of this season has demonstrated the value of the recommendation that has been made previously. Any modification of the present approved system of controlling the pest must be the result of the continuation of experimental work during a series of seasons. Some modifications have been suggested by the work during the past season, but before definite general recommendations can be made it will be necessary for the experiments to be repeated during other seasons when the climatic conditions may be essentially different. It is the purpose of the Bureau of Entomology to incorporate the results of all this experimental work as soon as possible in an extended account of all that is known concerning the methods of combating the pest. The present publication includes all recommendations which have been demonstrated to have a general bearing and to be applicable to all portions of the region now infested.

The experimental field work of the Bureau during 1904 was done on experimental farms at a number of localities in Texas, where local conditions presented special problems in the attempt to control the boll weevil. The following is a list of the experimental farms which were in operation:

County.	Planter.	Acreage
Anderson	B. H. Gardner	100
Bexar	J. M. Styers	40
Karnes	W. H. Leckie	[illegible]
Limestone	J. L. Cogdell	[illegible]
Navarro	R. Beaton and W. T. Ferguson	[illegible]
Robertson	W. C. Anderson and E. S. Peters	25
Travis	Jefferson Johnson	100
Victoria	S. G. Reed and W. T. Tipton	[illegible]
Washington	J. E. Routt	100
Wharton	A. P. Borden	100
Williamson	C. C. Hooper	100

This work was conducted under contracts, according to which the planter agreed to prepare the soil, plant, and care for the crops accordance with the directions of the Bureau of Entomology. The prime object in the location of a farm at any particular point was to obtain typical conditions for an area which possessed characteristics that differentiated it from other cotton-producing areas in Texas. The most sharply defined of the different weevil regions in Texas is the portion of the State where volunteer or seppa cotton exists normally. The green parts of the plant persisting through the winter furnish the weevils an abundance of food in this region, of which they are deprived in other parts of the State. The consequence is that an unusually large number pass the winter successfully. Damage consequently begins in the fields earlier the following season here than elsewhere. This area normally extends about as far north as to a line between San Antonio and Houston. Another quite distinct region as regards its effect upon the habits of the boll weevil is found in the valley area of the central portion of the State. Between the latitudes of Navasota and Waco, approximately, there is a region in which no volunteer or seppa cotton is normally present. Nevertheless, the long season of growth of the plants furnishes the weevil food and means of reproduction until very late in the season. The cotton fields have generally all been cleared from forest land. There is consequently an abundance of timber which furnishes ideal cover for the hibernating weevils. In this region it has been the practice to devote exceptionally large areas or individual plantations to cotton. This is the result of the fact that cotton has been the most certain crop that can be produced, and that there are decided restrictions to diversified farming. There is not the opportunity which occurs south of this region for the cultivation of sugar cane and rice, and at the same time wheat and some other cereals which grow well north of the region under consideration do not prosper here. The limits of diversified farming are further restricted by the fact that many soils are not suitable for the cultivation of corn. The labor and general economic conditions have become centered in the production of one crop, and this has a very important bearing on the application of the cultural system. There is another distinct region which comprises the river valley area of the northern portion of the State. The hill region of central Texas, the prairie region of west central and northern Texas, the east Texas pine woods region, and the irrigated region of the western portion of the State also furnish peculiarities which cause the habits of the weevil to be modified, and consequently change materially the necessary means for controlling it. Of course there are many other regions in Texas where local conditions, as of soil, might bring about subdivisions of the regions that have been mentioned. However, these strictly local conditions concern themselves more with changes in the simple cultiva[illegible] crop than with changes in the general system of mitig[illegible] the boll weevil.

DESCRIPTION OF THE BOLL WEEVIL.

The following account of the means for identifying the boll weevil is taken mainly from Farmers' Bulletin No. 189.

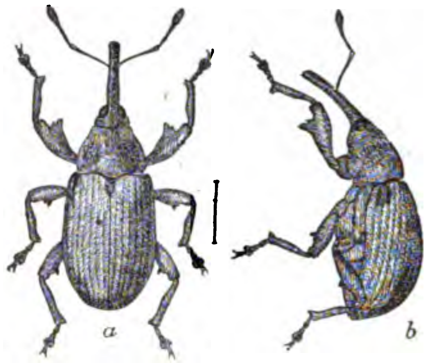

FIG. 1.—Cotton boll weevil: *a*, beetle from above; *b*, same, from side—about five times natural size (original).

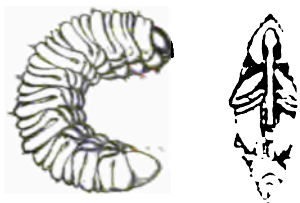

FIG. 2.—Cotton boll weevil: larva at left; pupa at right—about five times natural size (original).

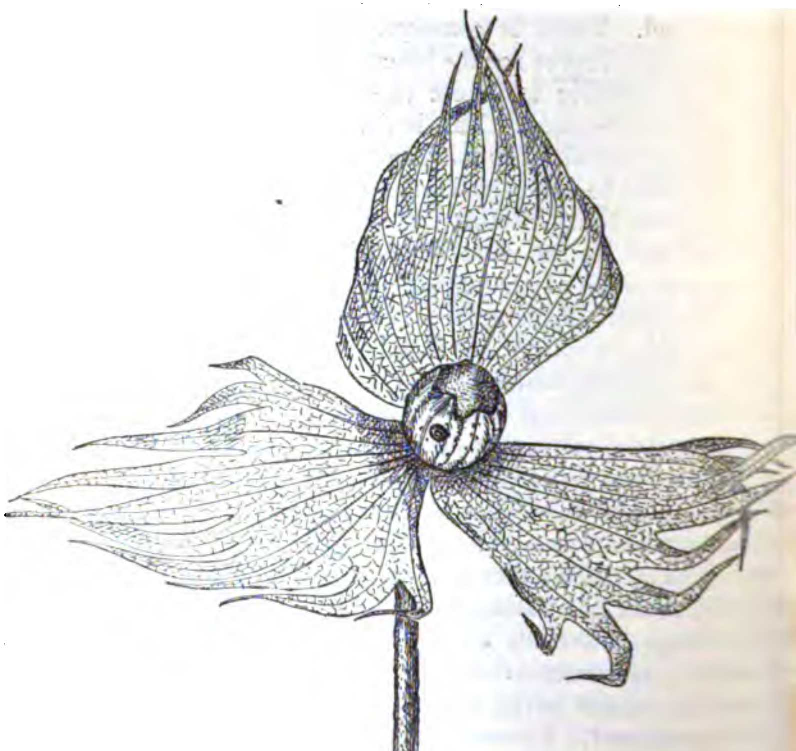

FIG. 3.—Cotton square flared, showing egg puncture of boll weevil—natural size (original).

Every intelligent planter in the weevil-infested area should be able determine the presence of the pest by its appearance and the evinces of its work; but planters who have never seen it may often be doubt as to whether some insect found damaging the crop is the boll evil, or whether flaring and falling of the squares is caused by some ıer unseen insect pest or by climatic conditions. For the benefit of ınters outside of the present weevil territory, in regions where the st is more or less likely to be found at any time, the following scription of the insect and its work is given. It is believed that this scription will enable any planter to determine whether the pest is at

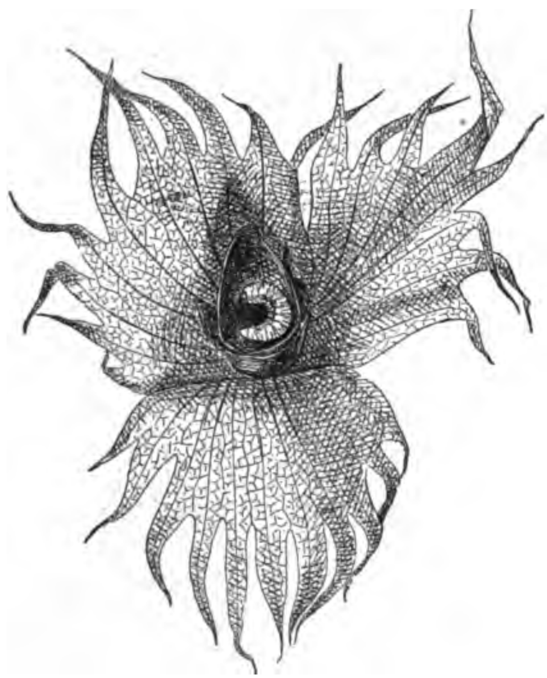

FIG. 4.—Cotton square cut open, showing boll weevil larva in position—natural size (original).

ork in his field, so that he may take the necessary steps to fight it at e earliest moment.

The adult weevil averages about one-fourth of an inch in length, ıging from one-eighth to one-third inch, with the breadth about oneird of the length. This measurement includes the snout, which is out one-half of the length of the body. The color is a grayish or a llowish brown. The general form will be understood from fig. 1. he insect exists in four stages—egg, larva, pupa (fig. 2), and adult. ll the stages, except the adult, occur only within the cotton square boll. The egg is deposited by the female weevil in a cavity formed eating into the fruit of the plant (fig. 3). It hatches, under normal conditions, in about 3 days, and the grub immediately begins to feed. In from 7 to 12 days the larva or grub passes into its pupal or transformation stage, corresponding to the cocoon stage of the silkworm. This stage lasts from 3 to 5 days. Then the adult weevil issues, and in about 5 days begins the production of another generation. Climatic conditions cause considerable variation in the duration of these stages, but on an average it requires from 2 to 3 weeks for the weevil to develop from the egg to the adult. The plainest indication of the presence of the weevil in a cotton field is the flaring (fig. 3) and falling of the squares or forms, which takes place generally between 5 and 10 days after the egg is deposited. However, as all planters are aware, heavy rains after drought, as well as other climatic conditions, have the effect of causing the squares to fall. If the planter should observe an unusual shedding of the fruit, he may easily determine the cause by gathering a few of the fallen squares. If, upon cutting open these squares, he finds a small, whitish, curved grub (fig. 4), there can be little doubt that the cause of the trouble is the boll weevil. Specimens should then be securely packed and sent to an entomologist for final determination.

TERRITORY AFFECTED.

During the season of 1904 the normal increase in infested territory occurred. About 15,000 square miles, representing approximately an area devoted to the cultivation of cotton of 900,000 acres, the normal production from which would be in the neighborhood of 350,000 bales, became invaded for the first time. This increases the infested area in the United States at present to about 32 per cent of the total cotton acreage.

One of the most interesting features of the situation during the past season has been the fact that the infested territory has been extended eastward much more rapidly than northward. Careful examinations of the portions of Indian Territory which the boll weevil is likely to reach first have failed to reveal any infestation. In fact, on the north the limitation of the infested territory remains practically the same as last year. This applies, however, only to the total infested area in which even isolated colonies of the pest have been found to exist. There has been a gradual northward advance of the limits of the region of what may be termed "gross infestation;" that is, where the weevils are to be found in considerable numbers in all cotton fields. This advance has extended from about the latitude of the northern portion of Ellis County to the latitude of the southern portions of Denton and Collin counties, a distance of about 36 miles.

The situation mentioned in the preceding paragraph leads to speculation as to whether the pest has not reached a northern limit beyond which its spread will be prevented or at least checked by climatic conditions. During the past year it has been found that there is at least one full generation less at Terrell, Tex., than at Victoria, Tex., 275 miles south of that place. With the very rapid multiplication of the pest, this means greatly lessened actual damage. The time when the maximum number of weevils per acre is produced is made considerably later, with a consequent manifest advantage to the crop. The lessened number of generations is due to three principal factors: (1) Later emergence from hibernating quarters; (2) greater time required for the development of the several stages; and (3) the earlier date of the first killing frost. These considerations would, theoretically at least, cause the weevil problem to become a much less serious one in extreme northern Texas than it has been in regions that have heretofore been infested, and the observations of the last season bear out this supposition. However, it is to be expected that there will be some adaptation on the part of the weevil to the climatic conditions in newly invaded regions, and this introduces considerable uncertainty in any prediction regarding future damage. The present indications are that the greatest damage by the pest will always be in the region south of the latitude of Dallas, Tex.

To the east there has been a general extension of the infested territory of about 50 miles. The pest has been found east of the Red River at three points in Louisiana, namely, Lockwood, Grand Ecore, and Shreveport. In that State the greater portion of six parishes is known to be generally infested, while in three others the weevils are known to occur in certain localities. Special opportunities for studying this spread were given by the cooperation which the Bureau of Entomology carried on with the Louisiana crop pest commission. It was found that there was an advance early in the fall due to the fact that the weevils were carried from place to place in seed for planting purposes. This was followed by considerable increase in territory due to the conveying of the seed cotton to the gins, and, most important, there was an advance due to an actual migration in August and September, which in many cases reached far beyond the limits of the territory covered by the first two means which have been mentioned.

At frequent intervals during the past season (1904) accounts of the occurrence of the boll weevil at various points far beyond the limits of the infested territory indicated upon the accompanying map (fig. 5) have appeared in the newspapers. It seems likely that the pest may at any time be carried to points far outside of the present infested territory through the ordinary shipments of cotton products. There is also some possibility that persons who have received live specimens from Texas for experimentation with supposed remedies may inadvertently introduce them into uninfested fields. In consequence of these probabilities, the Bureau of Entomology [illegible] attention to the reported occurrence of the weevil outside of the re[illegible] indicated upon the accompanying map. A number of reports orig[illegible] nating in Louisiana, Arkansas, and Indian Territory have been inv[illegible] tigated by entomologists connected with the Bureau. Thr[illegible] cooperation with State and station entomologists the Bureau [illegible] obtained specific information about reports originating in Georg[illegible]

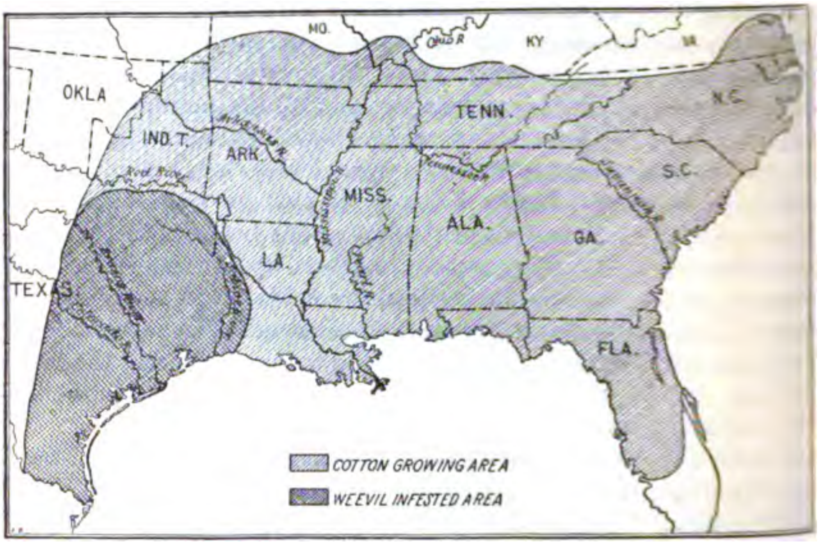

FIG. 5.—Map of territory infested by boll weevil.

South Carolina, and elsewhere. All such reports investigated [illegible] been found to rest upon a mistaken identification of some of [illegible] numerous insects more or less resembling the boll weevil which [illegible] been found in cotton fields.

DAMAGE CAUSED BY THE BOLL WEEVIL.

The following table, reproduced from Farmers' Bulletin No. [illegible] shows the great damage caused by the boll weevil:

Comparative estimate of amount of damage by cotton boll weevil.

Typical counties in which weevil was not present in 1899, but was present in 1902.			Typical counties in which weevil was [illegible] in either 1899 or 1902.	
County.	Product in commercial bales.		County.	Produ[illegible] merc[illegible]
	1899.	1902.		1899.
Caldwell	47,473	23,133	Montague	15,[illegible]
Colorado	30,923	11,493	Cooke	11,[illegible]
Fayette	73,238	31,200	Grayson	40,[illegible]
Gonzales	44,131	25,351	Fannin	[illegible]
Grimes	26,541	12,135	Lamar	[illegible]
Lavaca	42,484	22,906	Wise	17,[illegible]
Montgomery	10,272	3,660	Denton	[illegible]
San Jacinto	8,826	3,044	Collin	[illegible]
Travis	60,078	28,382	Hunt	50,[illegible]
Wharton	27,383	12,870	Delta	24,[illegible]
Total	371,349	174,174	Total	[illegible]
Decrease ... per cent		53	Increase ... per cent	

he first section of the above table shows a comparison of the pro-
:ion in ten counties in Texas in 1899, when the weevil had scarcely
hed them, and in 1902, when it had multiplied to such an extent
› be found in great numbers in practically all cotton fields. These
years were selected for comparison for the reason that they were
·tically identical in amount and distribution of rainfall and in
:r essential crop conditions. The second part of the table gives a
parison of the production during the same years in ten other lead-
counties situated so far north that the weevil had not affected them
ither of the two years used for comparison. It will be noticed
while in the counties of the first series there had been a decrease
roduction of 53 per cent, in the counties of the second series there
been an increase of 11 per cent. There seems to be no reason why
cotton production of the counties of the first series would not have
eased at about the same rate as was the case in those of the second
es had it not been for the damage caused by the weevil. This makes
.ir, it is believed, to conclude that the approximate damage caused
he insect was the sum of the decrease in one case and the increase
ıe other, or about 64 per cent.

here are two sources of possible error in these figures. One is in
likelihood of a change in acreage between 1899 and 1902 that may
have affected the two regions alike, and the other is in the proba-
;y that the two seasons were not exactly similar. In relation to the
point it must be stated that increases in acreage are generally the
ılt of conditions of the markets that would affect the whole State
e, and that if there were any increase in these years it would
›ably have been very much alike in either case. As to the possi-
;y of an appreciable difference in the seasons, it must be stated
the two regions are comparatively close together, and that a care-
examination of the records shows that they were remarkably alike
ll important respects. Nevertheless, it is the tendency of planters,
›on as the weevil becomes a serious menace, to devote more of their
l to other crops. Accurate figures on this point are not obtainable,
on the whole an allowance of a reduction of this kind that would
›unt for 10 per cent decrease in production would be ample. It
·efore seems to the writer that a figure in the neighborhood of 50
cent represents a very fair approximate estimate of the loss.

pon the foregoing basis, assuming that there is a loss of about 50
cent in newly invaded regions, but with an offset due to improved
hods in older regions, it seems very conservative to state that,
ing the season of 1904, the weevil caused a reduction of at least
,000 bales, representing a value, including that of the seed, of
ut $22,000,000.

There are many interesting features connected with the rela-
between the damage of the weevil and the present very large c r
crop (estimated by the Bureau of Statistics of this Department De-
ber 3, 1904, as 12,162,000 bales). The question has been raised a
why the weevil is a great menace in view of this large production a
the fact that the pest has now invaded at least 32 per cent of the co-
ton acreage in this country. The following appear to be the prin-
reasons for the present large production:

(1) The high price of cotton just prior to the time of planting
crop of 1904 undoubtedly had the effect of increasing the area
considerably.

(2) The boll weevil has not yet reached numbers in all its ra
sufficient to appreciably reduce the crop. The map on page 12 ou
the total area in which any weevils are known to occur. In per-
10 per cent of the territory thus considered infested only iso
colonies occur, and the general production has not yet been curta
In some of the northern counties of Texas the production coul
have been reduced by the weevil, although the statistics show co-
erable variation between the crops produced for the past s
years on account of changes in acreage and the ravages of other in-
like the bollworm.

(3) Throughout the portion of Texas where the bulk of the cr
produced—that is, north of about the latitude of Bremond—na
conditions combined to cause an unusually small number of wee
hibernate successfully during the winter of 1903–4. The prin
factor in this situation was the very early date of the first killing f
which was about thirty days prior to the average date for the past
teen years. This early frost destroyed a great number of imm
weevils in the squares and bolls which would otherwise have pa-
through the winter to damage the crop in spring.

(4) An important factor which has contributed to the produc
a large crop in the region just mentioned has been a lessened deg
damage by the bollworm. It is estimated by Mr. A. L. Quain
who has been in charge of a special investigation of the bollwor
the pest could not have caused more than half the damage in 19
was caused by it in 1903.

(5) The growing season was unusually favorable. The av
condition of the growing crop in Texas, from May to Septe
inclusive, as published by the Bureau of Statistics of this De-
ment, was 82 in 1904, as against 72.5 in 1903. The average con
for 1904 was, in fact, much higher than in even the season of
largest crop ever produced, namely, 1900, when the average con
reported for the months mentioned was 77.6.

(6) The season of 1904 was exceedingly favorable during the time of picking the crop, resulting in an unusually small. loss of lint from rains.

(7) The large amount of work done by the Department of Agricul-ure and commercial bodies which imported many carloads of improved eed doubtless contributed to the large crop produced.

A general idea of the effect of the ravages of the boll weevil in educing the crop in Texas may be obtained from the following table:

omparison of cotton acreage and production in Texas and Louisiana, in equivalents of 500-pound bales.

Year.	Texas.		Louisiana.	
	Acreage.	Crop.	Acreage.	Crop.
	Acres.	*Bales.*	*Acres.*	*Bales.*
1899	6,642,309	2,609,018	1,179,156	700,352
1900	7,041,000	3,438,386	1,285,000	705,767
1901	7,745,100	2,502,166	1,400,650	840,476
1902	8,006,546	2,498,013	1,662,567	882,073
1903	8,129,300	2,471,081	1,709,200	824,965
1904	8,704,000	3,030,433	1,920,000	898,193

It will be seen that while the acreage in Texas and Louisiana has been increasing at about the same proportion, the crop in Texas has decreased annually for the past six years (with two exceptions—1900 and the present year), while the crop in Louisiana has increased annually (with one inconsiderable exception—in 1903). That the boll weevil is the cause that has prevented Texas from keeping pace with Louisiana will be admitted by all. The exceptional years, 1900 and 1904, in which the production in Texas did not decrease, were undoubtedly those in which the conditions for the cotton plant were unusually favorable. Moreover, it is to be noted that in the first of these two years the pest had not reached far into the most productive counties.

A VARIETY TEST.

In order to test the suitability of a number of varieties of cotton for lanting in weevil-infested regions, during 1904 the Bureau of Entoiology planted the seed of 20 of the more or less well-known varieties t Calvert, Tex. Each variety was represented by a plat 5 acres in xtent. The soil was uniform throughout the acreage covered by this xperiment. The test was a severe one on account of unusually nfavorable local conditions. The crop was made several weeks late y successive frosts early in the season. By a comparison with the esults of the variety test conducted during the season of 1903, which was noted in Farmers' Bulletin 189 of this Department, it will be seen that the general advantage of the early maturing varieties over the late maturing ones is again demonstrated. During that season the Herndon variety turned out to be the most prolific. This variety was not tested during the season of 1904, for the reason that it was impossible to procure seed. It was a local variety known in only one county in Mississippi, and seems to have died out on account of the general desire of planters for varieties which have large bolls.

In reality the superiority of the early maturing varieties would be more in evidence than the following grouping would indicate. In arranging the planting of varieties in the field the earlier ones were placed nearest the timber. It was designed to have the varieties graded from the vicinity of the timber according to their relative earliness. Consequently the King variety was nearest the timber, and the Russell most removed. As is usual in such cases, the weevils appeared in the cotton near the timber first. For two weeks before any of the pests had appeared in the middle of the field they were causing considerable damage in the plats nearest the timber.

It is not possible to give varieties of cotton a complete test during a single season. The only correct basis for an estimation of the value of different varieties in weevil-infested regions is a repetition of experiments during several seasons. As has repeatedly been found to be the case in the tests of varieties of cotton which have been conducted by southern experiment stations, the changing climatic conditions alter the relative standing of the varieties very materially. In some cases a variety found during one season to be at the head of the list in production may, during the following season, fall far below. Work that has been conducted elsewhere in Texas indicates some probable modifications of general conclusions that might be drawn from this test. For instance, the Rowden variety would probably rank considerably higher than was the case in these experiments. Nevertheless, it is believed that the test conducted by the Bureau of Entomology in Robertson County will furnish the basis for a general idea of the value of some of the principal known varieties.

The lint from the varieties was given commercial grading as specified in the accompanying table, by a special committee of members of the Galveston cotton exchange, appointed at the suggestion of the writer by the president of the exchange.

The name "Georgia Truitt" applies to the seed of the well-known Truitt variety from Georgia. The name "Texas Truitt" is used to differentiate the cotton grown from Truitt seed which had been planted in Texas for one year. The same distinction applies to the names "King" and "Texas King."

Comparison of cotton varieties.

riety.	Yield per acre, seed cotton.	Percentage of lint.	Rank by yield.	Class.	Staple.
	Pounds.				
y	885.4	28.17	2	Barely low middling	Weak.
Truitt	719.0	27.76	5	Strict good ordinary	Fair.
	670.4	32.07	6	Low middling	Do.
	436.2	28.91	14	Low middling to strict low middling.	Poor.
ing	599.2	29.25	7	Strict low middling	Fair.
	483.8		12	Strict good ordinary	Do.
e	525.6		11	do	Do.
ruitt	511.4	27.75	8	do	Poor.
	863.4	31-32.53	3	Strict low middling	Do.
	427.2	33.28	16	do	Fair.
	387.0		17	Good ordinary	Poor.
	944.8	30-34.43	1	do	Very poor.
	214.2		22	Low middling	Good.
	338.8		19	Strict good ordinary	Very poor.
	566.6	29.95	9	Low middling	Good.
ing	599.2	27.74	7	Strict good ordinary	Fair.
	534.4	33.52	10	Strict low middling	Do.
	398.0	33.23	16	Good ordinary	Poor.
s	845.0	32.33	4	Good ordinary to strict good ordinary.	Do.
er	235.0		21	Strict good ordinary	Fair.
s	361.8		18	Good ordinary	Poor.
	428.6		15	do	Do.
	476.0	31.82	13	Low middling	Fair.
	323.2		20	Strict good ordinary	Do.

anged according to production, these varieties may be grouped following manner:

st group, yielding from 700 to 1,000 pounds of seed cotton per Tool's, Territory, King, Hawkins, Georgia Truitt.

ond group, yielding from 500 to 700 pounds of seed cotton per Shine, Texas King, Texas Truitt, Parker, Mascott.

rd group, yielding from 400 to 500 pounds of seed cotton per Van Nose, Meyers, Hetty, Dickson, Native.

rth group, yielding from 200 to 400 pounds of seed cotton per Russell, Eudaly, Berry, Welborn, Culpepper, Rowden.

anged according to class, the above-mentioned varieties may be d in the following manner:

r: Texas King, King, Native (No. 10), Mascott.

dling Fair: Dickson.

d Middling: Shine, Rowden, Parker, Hetty.

dling: Georgia Truitt, Texas Truitt, Meyers, Van Nose, Berry, King, Culpepper, Welborn.

v Middling: Territory.

d Ordinary: Hawkins.

inary: Russell, Tool's, Otto, Eudaly, Native (No. 23).

two "natives" represented two different lots of seed.

anged according to staple, the varieties stand as follows:

d: Rowden, Parker.

r: Georgia Truitt, Shine, Texas King, Meyers, Van Nose, e, Mascott, Culpepper, Hetty, Welborn.

ak: Territory.

Poor: Dickson, Texas Truitt, King, Russell, Otto, Hawkins, E. Native.

Very Poor: Tool's, Berry.

Arranged according to the average rank by class and staple varieties could be grouped in the following manner:

First Group: Texas King, Native (No. 10), Mascott.

Second Group: Rowden, Parker.

Third Group: Shine, King, Hetty.

Fourth Group: Georgia Truitt, Dickson, Meyers, Van Nost, Texas King, Culpepper, Welborn.

Fifth Group: Texas Truitt.

Sixth Group: Territory.

Seventh Group: Berry.

Eighth Group: Hawkins.

Ninth Group: Russell, Otto, Eudaly, Native.

Tenth Group: Tool's.

CONCLUSIONS REGARDING THE USE OF FERTILIZERS.

The Bureau of Entomology has not conducted any special tests of fertilizers. However, in the prosecution of a great number of general experiments, it has been necessary to make use of commercial fertilizers. In view of the lack of exact knowledge regarding the proper use of fertilizers in Texas, due to conditions which are in many respects dissimilar to those in regions where experiments with fertilizers have been conducted, it is considered advisable to present some of the incidental results along this line.

The uncertainty connected with field experiments during a single season is nowhere more marked than in the use of fertilizers. The benefits derived from the use of fertilizers depend upon soil and climatic conditions, as well as upon the preparation the ground is given. The climatic conditions may cause some fertilizers to be available during one season, while during another season no benefit might be evident from their use. During the season of 1904 the results of the use of fertilizers were confusing. However, some of the results that are doubtless of more or less general application are referred to in the following paragraphs. That these conclusions are approximately correct is shown by the fact that they agree in a general way with the results of the various State experiment stations which have conducted fertilizer experiments in the South.

On sandy post-oak land in Robertson County, in one case the application of a fertilizer consisting of 200 pounds of cotton-seed meal

100 pounds of acid phosphate per acre produced a yield of 900 pounds of seed cotton, which was 50 per cent more than the yield of the same variety of cotton in an unfertilized part of the same field. In another case, on similar soil in Robertson County, 200 pounds of acid phosphate (14 per cent available phosphoric acid) caused an increase of 163 pounds of seed cotton per acre. On river-bottom soil in Robertson County an application of 140 pounds of cotton-seed meal with 140 pounds of acid phosphate per acre caused an increase in yield of 180 pounds of seed cotton per acre. In this locality, as well as on alluvial soil in Wharton County, the application of 200 pounds per acre of acid phosphate having 14 per cent of available phosphoric acid did not increase the yield appreciably.

The most striking results from the use of fertilizers were obtained in the case of the work conducted in Washington County on heavy, sandy river-bottom soil, which had been planted in cotton or corn for at least fifteen years. The application of 200 pounds of acid phosphate increased the yield about 20 per cent. The application of 300 pounds of this fertilizer increased the yield in the neighborhood of 50 per cent, not only in the case of improved varieties, but also in the case of native cotton. The largest yields obtained anywhere during the season by the Bureau of Entomology were in this location. One field of native cotton, fertilized with 300 pounds of acid phosphate, yielded at the rate of 1,712 pounds of seed cotton per acre. Two other plats fertilized at the same rate yielded 1,632 and 1,437 pounds of seed cotton per acre, respectively. Some of the plats fertilized with the amount of acid phosphate that has been mentioned did not yield nearly as high; nevertheless the average on the fertilized plats reached in the neighborhood of 1,000 pounds of seed cotton per acre as against an average yield of 527 pounds of seed cotton per acre in the case of unfertilized plats.

Upon black prairie soil in Karnes County, 200 pounds of acid phosphate per acre on the average, with several different varieties of cotton, increased the yield considerably. On 30 acres of early maturing varieties and native cotton, the amount mentioned resulted in a net gain of $5.65 per acre. Heavier applications of acid phosphate, at 400 and 500 pounds per acre, did not result in a net gain greater than that mentioned in the application of 200 pounds. On the same plantation an application of 300 pounds of a complete fertilizer, analyzing 8 per cent phosphoric acid, 2 per cent nitrogen, and 2 per cent potash, caused an increase in the yield per acre of 253 pounds of seed cotton, resulting in a net gain per acre of $5.07.

A careful consideration of the subject of the fertilization of cotton in Texas, by Prof. R. L. Bennett, will be found in Bulletin No. 75, Texas Agricultural Experiment Station.

RELATION BETWEEN SEPPA COTTON AND WEEVIL DAMAGE

The winter of 1903–4 was unusually mild in Texas. The con-
quence was that the region in which volunteer cotton occurred exte
much farther north than normally. Some volunteer cotton occur
Texas every year, but its occurrence north of about the latitude
Victoria is unusual. During the year 1903–4 much volunte
seppa cotton was found as far north as Milam County. A line thro
the middle of Milam, Williamson, Travis, and Hays counties w
indicate the northward limit of the territory in which seppa c
occurred during the season. In many fields in Karnes, Wilson
other counties practically every root of the preceding year
wintered. It must be evident to any observer that this con
must conduce to the most successful hibernation of the weevils. T
are provided with food practically throughout the winter, and i
spring there is an abundance of green sprouts long before the pl
cotton has come up. The consequence is that there is a much s
mortality rate during the winter in this region than elsewhere. T
very great damage which was done in 1904, in the counties of
west Texas last mentioned, was due to the occurrence of this
cotton. By the latter part of June it was found that in some l
ties practically all the fruit on these plants had become inf
This resulted in at least one additional brood of weevils to pr
the planted cotton.

The Bureau of Entomology has repeatedly pointed out that
presence of volunteer cotton is the greatest menace to the cro
exists in southern Texas. The encouragement of such pla
undoubtedly the worst possible practice in weevil-infested r.
The disastrous experience of many counties in the southern po
the State during the past season has abundantly demonstrat
force of the warnings that have been issued from time to time.
staple produced upon seppa plants is exceedingly short and w
is not desired by the trade. Before the advent of the weevil, th
reason for encouraging such growth was to procure the fir
Now, on account of the fact that the presence of such plants inte
the seriousness of the weevil problem, any attempt to produce
from the stalks of the preceding year should by all means be d
aged. The proper procedure would be to destroy all the plants
field early in the fall, as suggested in the list of recommendatio

EXPERIMENT IN DEFERRED PLANTING.

In Texas some little attention has been attracted to the prop
eradicating the boll weevil by deferring the time of planting unt

in the season. The idea has been that by following with such a ctice after the early destruction of the plants in the fall the hiber- ng period of the weevils could be so lengthened that all would ish. From superficial considerations it would seem that late plant- instead of early planting would be the proper way to avoid damage the pest. In order to determine this point definitely, the Bureau Entomology conducted a special experiment at Victoria, Tex., ing the season of 1904. A field was selected which was isolated m all other cotton fields by a dense growth of huisache, the nearest ton being nearly a mile away. The field under consideration was cres in extent and had been planted in cotton during the season of 3, when the weevils became very numerous. The stalks were noved in the latter part of November. During the spring sprouts ang from a number of the roots remaining in the ground, but these e destroyed with hoes from time to time. After this preliminary atment the field was planted in King cotton on May 23. The cli- tic conditions in general were favorable, resulting in a rapid growth. July 15 an examination showed that the weevils were generally ributed throughout the field, although the damage at this time was great. On August 3, however, it was found that 90 per cent of the squares in various parts of the field were infested. By August no blooms whatever were to be seen. A small number of bolls re in evidence, but very few of them were open. This field yielded gether only 3,240 pounds of seed cotton, less than one-tenth of a e of lint per acre.

As a check upon the foregoing experiment another isolated field s selected which had been in cotton continuously for seven years. this case 5 acres were planted with seed of the Parker variety of ton during the last week in February. It was found that weevils de their appearance in this field in great numbers at approximately same time as they appeared in the field planted very late. The al yield on the 5 acres planted in February was 6,990 pounds of d cotton, or 1,398 pounds per acre.

As against a yield of about one-tenth of a bale per acre in the late- nted field we have, in the early-planted one, a yield of nearly a full nmercial bale per acre.

The evident conclusion from this experiment is that even under the st favorable circumstances late planting can not be relied upon to e the crop. Aside from the general difficulties in late planting and likelihood that the crop will be damaged by the other insect pests, eems that a number of weevils sufficient to thoroughly infest the d in a short time succeed in passing the prolonged period of hiber- ion. The late-planted cotton grew well, and the only important tor in reducing the yield was the boll weevil.

CONTROLLING THE BOLL WEEVIL IN COTTON SEED AND AT GINNERIES.

The possibility of controlling the boll weevil in cotton seed and at ginneries received special attention during the season of 1904.

The Bureau of Entomology employed a ginning expert, and many experiments were conducted with gins in actual operation. The results of this work have received full consideration in Farmers' Bulletin No. 209 of this Department, which may be had upon application. In this connection it is sufficient to state that the facility with which weevils may be transported from infested to uninfested localities in cotton seed has been fully demonstrated, and the exact points where danger may be avoided in the process of ginning have been determined. The two means of preventing danger from the transportation of weevils in cotton seed are (1) the fumigation of the seed, and (2) the application in ginneries of the devices that will more or less effectually remove the weevils from the seed. For detailed information the reader is referred to Farmers' Bulletin No. 209.

SUPPOSED IMMUNITY OF MEXICAN COTTONS.

Reported immunity from boll weevil attack of certain so-called Mexican tree cottons, with their possible value in the cotton-growing States, was investigated by an agent of the Bureau of Entomology during the month of September, 1904. As these cotton trees were said by their promoters to produce their first lint the second season from the date of planting, it was evident that if they were found to be affected by frosts their immunity from the boll weevil, if such a condition existed, could be of no practical value in this country. Persistent reports,[a] however, concerning the ability of the tree cotton to withstand frosts and its immunity against the attacks of the boll weevil, made it desirable for the Bureau to obtain reliable information at first hand.

Tree cotton grown from seed received from the locality in Mexico and from the cotton planter from whom practically all of the abovementioned reports emanated, was observed by the representative of

[a] The following quotation from a daily newspaper illustrates the character of the reports referred to: "The plant begins bearing when five years old and continues to be productive for half a century or more. In some instances a single tree is known to produce as much as 59 pounds of cotton in one season, the fiber being very similar to that of the cotton plant and adaptable to the same uses. It is immune against the boll weevil and all other insect pests, and, under proper conditions, the growing of it may be immensely profitable." The Mexican cotton planter, to whose cotton trees the above and like current reports referred, in a letter to a gentleman in Mexico City, a copy of which the writer has seen, states that the "tree cotton" begins to [illegible] staple in paying quantities at the age of *two years*.

Bureau growing under various conditions of soil, climate, and vation. The most significant conditions were found at San Bartolo, ite of San Luis Potosi, Mexico, at the hacienda of Espinosa y Cuevas os., this being the only locality where tree cotton was found grow- for which accurate temperature records were available. A com- ison of these records with the United States Weather Bureau records Brownsville, Tex.—which point represents the mildest climate of cotton belt of the United States—shows that both the minimum l daily mean temperatures of the two places are very nearly alike ring the winter months. At the Mexican hacienda referred to, the ners state that the tree cotton was injured by the light frosts dur- the winter of 1902–3 to the same extent as was the American land cotton growing there. An examination of many squares of tree cotton plants showed that fully two-thirds of them were ested by the boll weevil. At Cuernavaca, State of Morelos, Mexico, squares of a variety of cotton known among the natives as Algodon bol (cotton tree) were found to be badly infested by the boll weevil. all places where Mexican tree cotton was found entirely free from boll weevil it was undoubtedly due to the nonexistence of the ect in that section.

The observations mentioned in the foregoing paragraphs lead to the nclusion that there is no variety of cotton in Mexico which is immune the boll weevil. This conclusion is borne out by experiments con- cted at Victoria, Tex., with cotton plants grown from the seed of a ge number of varieties procured in Mexico and Cuba.

FUTILE METHODS SUGGESTED FOR CONTROL.

n some quarters of Texas and Louisiana there is still considerable sunderstanding about the habits of the boll weevil, and many fal- ious suggestions are proposed from time to time. The supposition sts in many quarters that the boll weevil is attracted to lights. A nber of machines based upon this idea have been constructed. The sibility of attracting the boll weevil to lights was one of the first tters relating to the pest to be investigated by entomologists. ring September, 1897, Mr. J. D. Mitchell, of Victoria, Tex., naturalist and cotton planter, set out trap-lanterns in cotton fields Victoria County for one night. The insects captured were sent the Bureau of Entomology for examination. In all 24,492 speci- ns were taken, representing approximately 328 species. Divided ording to habit, whether injurious or beneficial, the result was: urious species 13,113 specimens, beneficial species 8,262 specimens, a neutral character 3,117. The interesting point in connection h this experiment was the fact that not a single specimen of boll weevil was found, although the lights were placed in the midst of a field where the insects were very abundant. Since that time other investigators have looked into the matter carefully. Lights have been kept burning in cotton fields. In no case has a single specimen of the boll weevil been captured in this manner, although thousands of species of insects have been taken. The public misapprehension about the possibility of capturing the boll weevil with lights is due to the fact that a somewhat similar insect, *Balaninus victoriensis*, and other acorn weevils, differ from the boll weevil in that they fly at night and lights exert a strong attraction for them. During certain seasons the acorn weevils are exceedingly common in Texas, and great numbers of them fly to the electric lights.

The old idea, the fallacy of which has been explained repeatedly by entomologists for the past fifty years, that sulphur can be forced into the system of plants to make them immune to insect attack, sometimes creeps out with reference to the boll weevil. The method is entirely useless. Sulphur is not soluble either in water or acids. It is consequently impossible for it to be taken up by the plants. In chemical combinations, in which forms only could it be assimilated by the plants, there is nothing to indicate that it would have special insecticidal properties. The usual form in which the use of sulphur has been recommended in Texas is that the seed should be soaked before planting in water containing it. Money used in this manner is entirely wasted.

Undoubtedly the most important fallacious remedy that has ever been proposed for the boll weevil is Paris green, which received a great deal of attention during the season of 1904. The urgent demand for a specific remedy on the part of the planters was evidenced by the extensive use of this substance. At least 25 carloads were used in Texas during three months. A portion of the great attention that Paris green attracted was due to the fact that early in the season a certain number of weevils may be killed by it. The number destroyed in this manner early in the spring really means nothing whatever to the crop later, when the plants have put on squares and the poison no longer reaches the pest. It has been demonstrated that the great majority of the weevils do not emerge from hibernating quarters until the plants begin to put on squares. Those that emerge in this manner can not be affected by any amount of Paris green that might be applied. The Bureau of Entomology has had fields dusted repeatedly throughout the season, but without benefit. The results of many experiments with Paris green will be found in Farmers' Bulletin No. 211 of this Department.

Among the futile means of controlling the boll weevil the large number of machines that have come to public attention from time to time must be included. There is some possibility that ultimately an effective machine may be perfected. Careful tests which have been made with all those proposed up to the present time, however, do not show any decided hope in this direction. These machines have been designed to poison the insects, to jar them and the infested squares from the plants, to pick the fallen squares from the ground, to kill by fumigation, and to burn all infested material on the ground. It is estimated that over one thousand machines of a certain class, designed to jar the weevils and infested squares from the plants, were sold in Texas during the season of 1904. The testimony of all users of these machines is now to the effect that they are entirely useless as far as the increasing of the crop is concerned. As each one of these machines was sold for $40, the loss to the people of the State can be seen to be very great. By such means it is, of course, possible to capture a certain number of weevils in the field. The great number remaining and their rapid rate of multiplication render this small number entirely inconsequential.

The Bureau of Entomology follows the general policy of investigating all machines that are proposed; but no machine has yet been found sufficiently effective to be recommended. In fact, there seems at present to be little probability that such a machine will ever be perfected.

A great number of poisons to be used as sprays and in other forms have been proposed. It is usually supposed that some exceedingly toxic substance has been discovered which, in a very diluted quantity, will kill the insects with which it comes in contact. Other applications are designed to repel the insects from the plant by some supposedly offensive property. It is almost needless to state that all these proposed remedies are entirely without value.

QUARANTINES AGAINST THE BOLL WEEVIL.

In the attempt to prevent the introduction of the boll weevil several State legislatures have enacted laws which either in themselves restrict the shipment of commodities believed to be likely to convey the pest, or authorize State crop pest commissions or State entomologists to promulgate and enforce rules and regulations to this end. Unfortunately there is very little uniformity in State regulations now in force. Some States have quarantined articles that are admitted unrestrictedly by others, and, moreover, from time to time numerous modifications of the regulations based upon these laws have been made. This has resulted in endless confusion to shippers and transportation companies. The natural commercial course of at least 5,000 carloads of Texas farm products was either interfered with decidedly or prevented entirely by the operation of these laws during the season of 1904. In view of this situation the Department of Agriculture suggests the following plan for a State law, providing for quaras well as for eradicating possible isolated colonies that may be discovered, and also providing a means of enforcing remedial work at the earliest possible moment. It would be decidedly to the interest of all the States concerned to bring their regulations into conformity with these suggestions as soon as possible. The Department's suggestions are based upon a careful study of the habits of the boll weevil during several seasons, as well as upon knowledge gained from a large amount of inspection work which devolved upon the Bureau of Entomology in consequence of the State laws now in effect. It is believed that they will furnish sufficient protection and at the same time not interfere unnecessarily with shipping. They are based upon the suggestions toward a uniform quarantine system adopted by representatives of practically all the principal cotton-producing States who met at Jackson, Miss., August 2, 1904, with such modifications as seem advisable as a result of the subsequent study by the Bureau of Entomology of the means by which the pest is disseminated.

SUGGESTIONS FOR A UNIFORM STATE BOLL-WEEVIL LAW.

(1) Plenary authority should be delegated to a board, the executive officer of which should be an entomologist, to take whatever steps may be found necessary for eradicating or controlling the boll weevil.

(2) A prohibition against bringing into the State, or having in possession, live boll weevils should be included, with a suitable penalty affixed.

(3) Definite authority should be given the officer or officers in charge of the boll-weevil quarantine matters to establish from time to time such rules and regulations as may be necessary.

It is considered that the foregoing provisions are sufficient for the law itself. Many other matters growing out of quarantine work deal with changing conditions and consequently should be covered by rules and regulations which may easily be changed as the occasion demands. These regulations should include an absolute quarantine against cotton seed, seed-cotton, cotton-seed hulls, baled cotton (whether compressed or flat), and corn in the shuck from infested territory. The basis for this recommendation is that the weevil has been found to be transported easily in cotton seed and other cotton products. As will be specified later, there is, under some conditions, considerable danger in the shipment of baled cotton. Corn in the shuck is included for the reason that it often furnishes hibernating quarters for weevils. This absolute quarantine should be modified to the extent of allowing the shipment of any of the foregoing articles after they have been properly fumigated under the direction of the Bureau of Entomology. The quarantine should be directed against all territory infested or h may become infested, rather than against a list of certain ties.

long list of other farm products have been quarantined by various es. This list includes hay, wheat, oats, cowpeas, fruit, vegetables, and rice products. The Department of Agriculture does not con- that there is any appreciable danger in the shipment of these modities at any time of the year. Numerous examinations that been made have failed to reveal the presence of weevils, and from the previous extensive shipping from infested portions of as to all parts of the South no infestation has been found to have lted, it can not be considered necessary to extend quarantines to r these products. It is true that there may be danger in such ments under certain circumstances, nevertheless there seems to be nore danger in connection with these articles than there is in the ment of general merchandise or in the interstate movement of ty box cars. The boll weevil does not feed upon any of these arti- . Specimens may possibly occur among them, but their presence ns no more likely in such situations than in any articles of com- ce which may be stored in the neighborhood of cotton fields, or ch may pass through regions where cotton fields from which wee- might fly at any time are situated in the vicinity of the railroad. work which has been conducted by the Bureau of Entomology, in peration with the Louisiana crop pest commission, has given many ortunities for determining whether certain farm products are ly to convey the boll weevil. Every colony found in Louisiana ing 1904 has been studied carefully. In no case has there been suspicion that the pest was conveyed to new regions in any com- lities except those against which a provisional absolute quarantine uggested.

t does not seem feasible to allow the shipment of certain commodi- during some months and exclude them during others. Some he rules and regulations now in effect quarantine hay, for instance, ept during July, August, and September. The supposition in these es has been that during those months the weevils will be found in cotton fields, while during the remainder of the year they may e taken flight to hibernation quarters, thus infesting a large num- of commodities that would be uninfested during the other months. a matter of fact, it has been found that there is usually an extensive ht of weevils as early as the middle of August. Shipment of hay moss would therefore be practically as dangerous during summer it any other time of the year. However, it is not considered that h danger at any time is great enough to warrant the inconvenience t is caused shipping interests by the enforcement of quarantines.

Some of the States have also quarantined bedding used by common riers with shipments of live stock. The Department does not consider that there would be any danger whatever in the use of [illegible] or straw for this purpose.

Household goods have caused great confusion in quarantine re[illegible] tions. The origin of the quarantine of household goods on the p[illegible] of several States was the knowledge of very extensive emigrat[illegible] negro tenants from infested portions of Texas to all parts of the S[illegible] It is the custom of such emigrants to carry along small quantiti[illegible] special cotton seed, as well as to use cotton seed or seed cott[illegible] packing furniture and other articles. As these practices involve [illegible] possible shipment of some of the commodities which should be q[illegible] antined, it is suggested that the shipment of household goods sh[illegible] be prohibited in all cases where the consignments are not accompa[illegible] by affidavits attached to the waybill stating that no cotton seed or [illegible] articles named as dangerous in a preceding paragraph are include[illegible]

The quarantine officer should have ample authority to modify [illegible] special cases, whatever rules and regulations are promulgated. [illegible] special cases might occur, for instance, in the treatment of baled co[illegible] There is no doubt that a general quarantine should be enforced ag[illegible] this product. There is considerable danger in shipping baled cott[illegible] mills where cotton fields are adjacent, since the bagging around [illegible] that have been stored near gins in infested territory might easily [illegible] weevils. Nevertheless, a general quarantine should not be ma[illegible] apply to shipments of baled cotton to mills in the cities, or to ship[illegible] to ports for direct export. Many similar cases where special [illegible] may be necessary will arise from time to time. The best metho[illegible] providing for such cases is to grant considerable breadth of auth[illegible] to the quarantine officer.

PRESENT QUARANTINES OF THE SEVERAL STATES.

Quarantines designed to prevent the importation of the boll w[illegible] are now in force in the following six States: Alabama, Ge[illegible] Louisiana, Mississippi, North Carolina, South Carolina. The[illegible] directed against all counties in Texas and parishes in Louisia[illegible] are indicated as infested on the map on page 12, as well as again[illegible] counties or parishes as may become infested in the future. The f[illegible] ing pages give the substance of the present restrictions. For fu[illegible] particulars the quarantine officers of the several States should [illegible] addressed directly.

Alabama.—The following act of the Alabama legislatur[illegible] approved October 6, 1903:

AN ACT To prevent and prohibit the importation of seed from cotton affected with the [illegible] weevil.

SECTION 1. *Be it enacted by the legislature of Alabama,* That no person shal[illegible] or bring into the State of Alabama any seed from any cotton affected with [illegible] own as the Texas boll weevil, nor the seed from any cotton from any place where cotton has been affected with said boll weevil.

SEC. 2. Any person who violates the provisions of section 1 of this act shall guilty of a misdemeanor, and on conviction shall be fined not less than ten dollars 0) and not more than five hundred dollars ($500).

H. 877, No. 559, approved October 6, 1903.)

Recently (January 25, 1905) the State board of horticulture of abama has adopted quarantine regulations against the boll weevil, sed upon the recommendation for a uniform system of quarantine les made by the association of official entomologists of the cotton belt, association consisting of State entomologists, together with agents the Bureau of Entomology of this Department. By these regulaons an absolute quarantine is established at all seasons of the year ainst cotton seed, seed cotton, hulls, cotton-seed and seed-cotton cks which have been used, cotton picker's sacks, corn in the shuck, sacked corn, unsacked oats, unsacked wheat, and unsacked cowpeas. uring the months of July, August, and September there are no strictions against the importation of hay, straw, sacked wheat, cked oats, sacked shelled corn, sacked cowpeas, and unbaled Spanish oss, but during the remaining nine months of the year the importation to the State of any of these articles from quarantined counties or rishes is prohibited. Through shipments of quarantined articles ay be made in cars which must be tightly closed, and no unloading is lowed during transit through the State. Household goods to be ipped from the infested territory into the State of Alabama must be companied by an affidavit attached to the way bill stating that no arantined articles are contained in the shipment as packing or otherse. Baled cotton can be shipped into the State only in tightly osed cars.

Particulars regarding the Alabama quarantine regulations may be tained by addressing Prof. J. F. Duggar, Experiment Station, uburn, Ala.

Georgia.—Previous to August 15, 1904, the Georgia State board of tomology had authority, by virtue of the legislative act which eated it, to enact such regulations as it deemed necessary to prevent e introduction or dissemination of injurious crop pests or diseases. n August 28, 1903, this board adopted a regulation prohibiting the troduction of cotton seed from Texas except under a certificate from authorized State or Government entomologist stating that the seed d been fumigated in such manner as to kill any stage of boll weevils hich might be contained therein. On August 15, 1904, an act of the neral assembly of the State of Georgia was approved whereby cotn seed, seed cotton, cotton-seed hulls, or cotton lint in bales or loose, ts, hay, fodder, husks, straw, forage of any kind, corn in the husk, or all material packed in anything originating on a farm or plantation, is prohibited from being brought into the State except when there is attached thereto a certificate signed by an authorized State or Government entomologist to the effect that said material was grown in and was shipped from a point where, by actual inspection, the Mexican cotton boll weevil was not found to exist.

Mr. R. I. Smith, Capitol, Atlanta, is the present quarantine official in Georgia.

Louisiana.—A special session of the State legislature enacted a law approved December 15, 1903, creating a Louisiana crop pest commission, which was authorized to promulgate and enforce such rules and regulations as seemed necessary in order to prevent the further spread or introduction into the State of the Mexican cotton boll weevil. The original rules and regulations of this commission were adopted on February 5, 1904, and since then have been amended in many particulars. At first prohibiting the importation of all farm products from practically all cotton-producing counties in Texas, they were afterwards modified, at the suggestion of and by arrangement with the Bureau of Entomology, in such a manner that all farm products except cotton seed, seed cotton, hulls, cotton-seed and seed-cotton sacks, hay, and straw were accepted for importation from Texas into Louisiana on the certificate of the Entomologist of the United States Department of Agriculture or his duly accredited representative. Corn, wheat, oats, and other grains, and cowpeas, by this arrangement, were to be certified to only during the months of July, August, and September. On December 14, 1904, the crop pest commission raised all quarantine restrictions on the last-mentioned commodities. Cotton seed, seed cotton, hulls, cotton-seed and seed-cotton sacks, hay, and straw in any form, whether as a packing for household goods, stuffing for mattresses, pillows, and cushions, or feed for stock, are absolutely prohibited from being shipped into Louisiana from 131 listed counties of Texas considered to be infested, as well as all others which may become infested with the cotton boll weevil, or from being shipped from an infested parish in Louisiana into an uninfested parish. Shipments through the State of quarantined articles must be handled in original tightly closed cars without unloading at any point within the State.

The present regulations prohibit the importation of household goods from infested localities when any of the above-mentioned quarantined articles are used as packing or in any other way. Shipments of mattresses, pillows, and cushions, filled with cotton, hay, straw, shucks, or other quarantined articles, are prohibited. Shippers are required to execute affidavits to the effect that mattresses, etc., have been filled with the substance contained for at least eighteen months before pment, otherwise such articles must be emptied. The affidavit is accompany the way bill.

Mr. Wilmon Newell, Shreveport, La., is the quarantine officer of s State.

Mississippi.—An act of the State legislature entitled "A boll weevil arantine act," approved March 18, 1904, empowers the State entologist to prevent in every possible and practical way the introduction the Mexican cotton boll weevil into that State by adopting and enforcg rules and regulations governing the transportation of farm prodts. A quarantine was instituted against 131 Texas counties and one uisiana parish, as well as all other communities and parishes in which e boll weevil might be found to exist. The quarantined articles included tton seed, cotton-seed hulls, cotton-seed meal, sacks used to hold ese materials, hay, oats, straw, and corn. Nursery stock, fruit, and rden truck were accepted under these rules only when accompanied a certificate of inspection by the Entomologist of the United States epartment of Agriculture. All farm products passing through the tate of Mississippi were required to be in tightly closed cars and not pened, unloaded, or sidetracked for more than twelve hours during ansit across the State. These rules were amended to permit, during e summer months, the unrestricted shipment of oats into and through e State. On September 1, 1904, the rules and regulations referred above were rescinded in toto, and a new set of rules went into effect, ased on the recommendations for a uniform system of quarantine ules by the association of official entomologists of the cotton belt. These rules and regulations specify the same quarantined territory as did those for which they were substituted. An absolute quarantine is stablished against cotton seed, seed cotton, hulls, seed-cotton and otton-seed sacks (which have been used), cotton-pickers' sacks, corn n the shuck, unsacked corn, unsacked oats, unsacked wheat, and nsacked cowpeas from the quarantined territory. During the months of July, August, and September there are no restrictions against the mportation of hay, straw, sacked wheat, sacked oats, sacked shelled orn, sacked cowpeas, unbaled or baled Spanish moss, but during the remaining nine months of the year all of these articles from quarantined counties and parishes are prohibited from entering the State of Mississippi. Through shipments of quarantined articles must be in tightly closed cars, which must not be unloaded while in transit through the State. Household goods to be shipped from the infested territory into the State of Mississippi must be accompanied by an affidavit to the effect that no quarantined articles are contained as packing or otherwise in the shipment. Baled cotton can be shipped into the State only in tightly closed cars.

Prof. G. W. Herrick, Agricultural College, Miss., is the quarantine officer of this State.

North Carolina.—By virtue of authority from the State legislatu to prevent the importation of crop pests, the North Carolina pest commission early in 1904 adopted rules establishing a quaranti against all localities where the Mexican cotton boll weevil is known exist. The quarantine was absolute, and applied to cotton, cotton cotton-seed meal, cotton-seed hulls, hay, oats, corn, rice, straw, chaff, and other grain or material likely to harbor any stage of boll weevil. On August 15, 1904, new quarantine regulations adopted and substituted for the previous ones, conforming very nea with the recommendations of the association of official entomolo of the cotton belt, and also with the Alabama and Mississippi ru which have been described in previous paragraphs. The North Ca lina quarantine regulations now in force differ from those of the Sta of Alabama and Mississippi only in the following particulars: Co and cotton-seed meal are included among the articles against wh the quarantine is absolute at all times. The restrictions concern Spanish moss in the North Carolina regulations specify only unte moss, as do those of Alabama.

Prof. Franklin Sherman, jr., Raleigh, N. C., is the quarantine o in this State.

Oklahoma.—The Oklahoma legislature is now considering a boll we quarantine act. At the time of writing, however, no definite ac has been taken.

South Carolina.—In South Carolina, as in Alabama and Georgia, t quarantine regulations are entirely embodied in the laws of the St and consequently not as readily modified to conform with the chan conditions and a better understanding of the methods of dissemina of the boll weevil, as is the case when authority to promulgate ru and regulations is invested in a commission or in the State entom gist. The law established to guard against the introduction of t Mexican boll weevil into the State of South Carolina was approved February 25, 1904. The commodities quarantined against were cott seed, oats, and prairie hay, shipped directly or indirectly from infe points in the State of Texas.

Prof. C. E. Chambliss, Clemson College, South Carolina, can f nish information concerning the interpretation of this law.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 217.

SSENTIAL STEPS IN SECURING AN EARLY CROP OF COTTON.

BY

R. J. REDDING,

Director of the Georgia Experiment Station.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1905.

LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Washington, D. C., February 13, 19[illegible]

Sir: We have the honor to transmit herewith a paper entitled "Essential Steps in Securing an Early Crop of Cotton," by Col. R. J. Redding, director of the Georgia Experiment Station, at Experiment, Ga.

Colonel Redding has directed carefully planned and exhaustive experiments in cotton growing for many years, and the results of his experience will prove of great value throughout the South. The work which has been done by Colonel Redding is of particular interest at this time in view of the gradual extension of the boll weevil into the more eastern portions of the cotton-growing area, since protection from the weevil damage largely depends upon the production of an early crop. We therefore recommend the publication of this paper as a Farmers' Bulletin.

Respectfully,

B. T. Galloway,
Chief Bureau of Plant Industry.
L. O. Howard,
Chief Bureau of Entomology.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

ESSENTIAL STEPS IN SECURING AN EARLY CROP OF COTTON.

INTRODUCTORY.

n Farmers' Bulletin No. 189 of the United States Department of riculture, issued in 1904, it was stated that "The work of the ision of Entomology for several years has demonstrated that there ot even a remote probability that the boll weevil will ever be erminated," and "The steady extension of the territory affected the weevil from year to year, until the northern boundary is far th of the center of the cotton production in the United States, has vinced all observers that it will eventually be distributed all over cotton belt. In ten years it has gradually advanced a distance of ut 500 miles, and will undoubtedly invade new territory at about same rate. It is not at all likely that legal restriction of any d would prevent or materially hinder this spread."

These conclusions must be accepted as of the highest authority, ce they have been reached by qualified scientific investigators after eful laboratory and field experiments, conducted for several years l on a large scale in the older weevil-infested region of Texas. The tter therefore is not a local problem, confined to Texas and nearby tes, but affects the entire cotton-growing region. At the indicated e of migration it is very probable that within ten or fifteen years ery portion of the cotton-producing region will have been invaded. is well therefore for the cotton growers northward and eastward Texas to prepare for the worst by learning the methods that have en found effective in minifying the ravages of the weevil and such er remedies or palliatives as may be developed meantime, and be epared to apply them whenever it shall become necessary. In view the immense importance and value of the cotton crop the subject s indeed become of national, if not international, importance.

The bulletin mentioned, however, gives assurance that "although e very large yields of cotton of former times may no longer be posle, it is nevertheless entirely feasible to produce cotton at a margin profit that will compare favorably with that involved in the production of most of the staple crops of the United States by follo[illegible] what has become generally known as the 'cultural methods.'" Am[illegible] the most important of these methods are those directed toward [illegible] ing an early development of the cotton plants and an early matur[illegible] of the largest possible proportion of the crop, and the object of t[illegible] bulletin is to discuss the practical details which have been found nec[illegible] sary and effective in promoting early maturity.

The writer may be pardoned for stating that most of what app[illegible] in the following pages is directly based on a long personal experi[illegible] as a practical cotton grower and the superadded results of fifteen [illegible] secutive years of field experimentation at the Georgia Experim[illegible] Station. It was partly the purpose of many of these field experim[illegible] to discover the conditions of fertilizing and culture that were eff[illegible] in promoting early maturity of the crop and the particular varie[illegible] best suited for securing such early maturity. It may be well to st[illegible] that during the whole of the fifteen year period the work has b[illegible] supervised by the writer, as director of the station, and the practi[illegible] details have been superintended continuously by Mr. James M. K[illegible] brough, the agriculturist of the station.

THE SPECIFIC STEPS TO SECURE EARLY MATURITY.

THE PREPARATION OF THE SOIL.

The steps necessary to secure early maturity will be discussed in [illegible] natural order of cultural succession, rather than in the order of th[illegible] importance and effectiveness in producing the desired result.

Little need be said in regard to the character, quality, and locat[illegible] of soil best adapted to the production of an early crop of cotton, [illegible] on every well-managed farm a regular system of rotation of cr[illegible] should be practiced, which would successively bring into cotton c[illegible] ture most, if not all, of the soils of a given farm. It may be stat[illegible] however, that the naturally well-drained hills and uplands of the cott[illegible] belt are better adapted for the purpose than the level prairies, [illegible] that the soils of the latter are better than the alluvial bottoms of t[illegible] rivers and larger streams.

Plowing.—The first attention should be given to such preparation [illegible] the soil as will enable the farmer to plant the cotton seeds at the e[illegible] liest practicable date. To this end it is desirable that the first brea[illegible] ing, whenever practicable, should be done in the early autumn. I[illegible] district already seriously infested with boll weevils, and where cott[illegible] is to follow cotton, a two-horse middle breaker may be used to pl[illegible] up the rows of stalks, and these stalks may be raked into windr[illegible] immediately and burned. Where the land to be prepared has j[illegible] made a crop of corn or small grain the plowing may be in rather na[illegible] row "lands," using a two-horse turn plow or other preferred imple-nt, running the lands whenever practicable at right angles to the ended direction of the rows of the following cotton crop and open- well the dead or finishing furrow of each land. These well-opened shing furrows can result in little harm under any ordinary condi- ns, and will serve a valuable purpose in quickly draining the soil superfluous moisture during a wet winter and early spring season, ich might otherwise delay the final preparation and subsequent nting.

?inal preparation of the soil.—The final preparation of the soil, which uld be finished at least a week before the date of planting, consists opening furrows and depositing fertilizers (when fertilizers are d), in throwing up with a turn plow or disk plow a well-formed l, and in opening up a well-defined water furrow between the beds. e object of the beds and the water furrow is to secure the prompt noval, especially during a wet season, of surface water from the mediate soil that is to receive the seeds. It may often occur that nting may proceed along the middle of such beds when, if the soil d been broken flush, it would be impracticable to plant or even to r the soil in any manner or for any purpose. The open water rrows serve the purpose of relieving the immediate seed bed of cessive moisture after the crop has been planted and during the rly stages of growth of the delicate plants. In close, tenacious, isture-retentive soils this detail of preparation is especially impor- it. It is also particularly demanded on low-lying, naturally moist ils, such as are found near water courses and bayous.

Depth of plowing.—The depth of the preparatory plowing may not indicated except by a general rule, varying in its application to fferent soils according to their character and depth. It should be of ch depth and thoroughness as will secure a mellow, permeable seed d of 6 to 10 inches in depth. On a very thin soil, with a poor d tenacious subsoil a few inches beneath the surface, the plowing ould be deepened each year as the increasing store of humus (decayed getable matter) warrants. Subsoiling has not often been found to y for the extra expense, in comparison with deep turning and thor- igh pulverization, aided by the harrow.

Harrowing.—The seed beds should be harrowed lengthwise once or ice, if necessary, to secure a fine, mellow, moist surface for the ception of the seed, the last time just ahead of the planting machine.

FERTILIZERS.

Character.—As a general rule, the composition and character of the rtilizers should be adapted to the particular demands of the plant be grown, rather than the exigencies of the soil, especially when uite liberal applications are to be made. But when early maturity f the crop is especially desired these artificial helps, at least in part, should be of a quickly soluble character so that the plant food r be available to the plants during the first few days of their grow. For general purposes a fertilizer containing about three parts of av able phosphoric acid to one each of nitrogen and potash has be found very satisfactory in the worn uplands of the eastern Gulf South Atlantic States, where the largest quantity of fertilizers is u But when early maturity is desired an excessive amount of nitro should be carefully avoided, especially if the nitrogen is in orga form, such as cotton seed, cotton-seed meal, dried blood, etc., th materials supplying available nitrogen but gradually, and contin to a later period of the crop, thus inducing a later growth and lat maturity.

Application of fertilizer.—Acid phosphates and potash salts should deposited in the soil and covered in by bedding from one to th weeks before the date of planting. If cotton-seed meal or dried bl or stable manure be relied on for the requisite supply of nitro these should also be applied and well incorporated in the soil of t furrows on which the beds are to be formed. It would be bett apply the stable manure a month or more before the date of plant. Carefully conducted, repeated experiments have shown that the br casting of commercial fertilizers for a crop of cotton is not nearl effective and profitable as is their concentration and thorough mix with the soil underneath the rows of plants. In applying very lar quantities of fertilizers to cotton, it is admissible to divide the s between the bedding furrow and one or both of the listing furro In one of the experiments conducted at the Georgia station a bro cast application of 1,000 pounds of a well-balanced fertilizer actu resulted in a smaller increased yield of cotton than followed the app cation of 500 pounds "in the drill," as just described. It is a highly probable that a broadcast application of fertilizer tends dire to produce later rather than early maturity.

Fertilizer for prairie soils.—On rich alluvial and prairie soils—capa ble of producing three-fourths bale to 1½ bales per acre without th aid of fertilizers—nitrogenous manures and fertilizers should sparingly applied, or only as will be indicated under the head "Planting," as such soils are naturally inclined to produce a large luxuriant "weed" and a late crop of bolls, and this tendency wou be promoted by their free use. The small amount of nitrogenous fe tilizer that is admissible on such soils and advisable on all oth should be so applied that the young plants may utilize it just as soo their tiny rootlets shall have put forth and commenced their search f plant food. The nitrogenous ingredient advised for this purpose the method of applying the same will be given under the head o "Application of fertilizer with seed," page 10.

Proportion of elements in fertilizer.—As already stated, the most ective proportion of the three so-called valuable elements has been ınd to be about three and one-third parts of available phosphoric d, one part of nitrogen, and one part of potash. This proportion uld be maintained in either of the following formulas:[a] 10 to 3 to 3; 9 to 2.70 to 2.70; or 8 to 2.40 to 2.40; or 7 to 2.10 to 2.10, etc. e so-called "standard" cotton fertilizer, the 8 to 2 to 2 guano, is but ittle deficient in nitrogen and potash, being relatively the same as to 2¼ to 2¼.

On highly improved soils and on such as are naturally very fertile, our dark alluvial black soils and "new grounds," the most effective ıgle element of plant food is phosphoric acid. In many cases this the only fertilizer that should be applied, and it should be employed the form of an acid phosphate. The direct effect of phosphoric id is to induce the formation of squares and bolls rather than weed." Experiments at the Georgia Experiment Station and at her stations clearly indicate this, thus confirming the popular belief.

SELECTING THE VARIETY AND PLANTING.

Selecting.—In the effort to secure early maturity of the crop there no more important factor than the selection of an early variety of otton. The opinion prevails to some extent that there is "no great ifference" in the matter of earliness between the several varieties rown in the country, and that quick maturity is dependent more on onditions beyond the control of the farmer than on good judgment ı the selection of a variety whose habit is to bloom early, mature uickly, and open its bolls rapidly. This would be a much more erious mistake if such opinions were generally entertained, and it is ortunate that little need be said on this point. But it may be true hat even those who recognize the importance of choosing an early ariety do not fully realize its significance.

Variety tests.—At the Georgia Experiment Station a "variety test" f cotton has been carefully conducted in each of the last fifteen years. Among several points of merit, that of early maturity has had a promnent place in these tests, and it is fortunate that this work has been o long and so continuously conducted under the direction of the same fficers.

[a] In stating a fertilizer formula in this bulletin the three usual "valuable elements" will be stated, without naming, in this order: Available phosphoric acid—nitrogen—potash.

Table 1.—*Showing the actual and comparative yields per acre of certain early [illegible] cotton and the average yields of all the varieties tested for fifteen years (1890–19[illegible]).*

[Compiled from bulletins of the Georgia Experiment Station.]

Year.	Date of planting.	Number of varieties.	Early varieties and averages of all.	Yield per acre, pounds of seed cotton					
				First picking.		Second picking.		Both pickings.	
				Date.	Pounds.	Date.	Pounds.		
1890	Apr. 21	23	King	Sept. 9	583	Sept. 22	965	1,5[illegible]	
			Jenkins Gold Dust		523		606	1,129	[illegible]
			Average of 26 varieties		166		796	962	[illegible]
1891	Apr. 22	17	King	Sept. 7	187	Sept. 20	568	75[illegible]	[illegible]
			Jenkins Gold Dust		219		560	77[illegible]	[illegible]
			Average of 17 varieties		80		400	480	1,2[illegible]
1892	Apr. 18	25	Truitt	Sept. 9	494	Sept. 28	589	1,0[illegible]	
			King		572		468	1,0[illegible]	
			Jenkins Gold Dust		624		442	1,0[illegible]	
			Average of 25 varieties		343		566	909	1,2[illegible]
1893	Apr. 21	14	King	Sept. 5	236	Sept. 26	966	1,2[illegible]	[illegible]
			Average of 14 varieties		70		700	770	1,[illegible]
1894	Apr. 17	15	King	Sept. 20	517	Oct. 8	550	1,0[illegible]	
			Average of 15 varieties		147		455	602	1,[illegible]
1895	Apr. 18	18	King	Sept. 17	335	Sept. 25	541	[illegible]	
			Average of 18 varieties		166		436	602	1,[illegible]
1896	Apr. 14	20	King	Aug. 19	627	Aug. 31	703	1,3[illegible]	[illegible]
			Average of 20 varieties		302		636	[illegible]	1,[illegible]
1897	Apr. 20	21	Mascot[a]	Sept. 3	926	Sept. 14	350	1,276	
			King		787		430	1,217	
			Average of 21 varieties		478		635	1,113	1,[illegible]
1898	Apr. 18	30	Mascot[a]	Sept. 7	1,145	Sept. 20	567	1,712	
			King		998		500	1,49[illegible]	[illegible]
			Texas Bur		940		849	1,7[illegible]	[illegible]
			Average of 30 varieties		745		865	1,610	1,[illegible]
1899	Apr. 24	25	Shine	Aug. 21	291	Sept. 4	625	[illegible]	
			King		330		477	[illegible]	[illegible]
			Mascot[a]		229		506	[illegible]	
			Average of 25 varieties		180		416	[illegible]	1,[illegible]
1900	Apr. 27	21	*Average of 21 varieties*	Sept. 10	318	Sept. 19	410	72[illegible]	1,[illegible]
1901	Apr. 24	26	Mascot[a]	Sept. 9	652	Oct. 3	686	1,3[illegible]	
			Roby		338		842	1,1[illegible]	
			Average of 26 varieties		264		806	1,070	1,[illegible]
1902	Apr. 22	26	Greer[a]	Aug. 20	507	Sept. 2	271	77[illegible]	
			Roby		316		362	67[illegible]	
			Average of 26 varieties		253		385	6[illegible]	[illegible]
1903	Apr. 27	21	Greer[a]	Sept. 7	374	Sept. 22	474	848	[illegible]
			Cook's Improved		174		442	61[illegible]	[illegible]
			Texas Bur		223		440	66[illegible]	
			Average of 21 varieties		184		370	[illegible]	1,[illegible]
1904	Apr. 18	24	Greer[a]	Sept. 2	411		580	991	
			King		478		506	98[illegible]	
			Average of 24 varieties		146		498	64[illegible]	1,[illegible]

[a] *Mascot* and *Greer* are selections from the original *King*, and each has proved equally earl[illegible] the same time more productive.

What Table 1 shows.—Table 1 has been compiled from the ann[illegible] cotton culture bulletins and permanent records of that station. It is intended to show the comparative as well as absolute yields of seed cotton per acre of one or more distinctively early varieties, and the average yields of all the varieties tested in each year. The date of planting, the dates of the first and second pickings, the yield of each ear[illegible] variety, the average yield of all the varieties in each year's test at ea[illegible] of the first two pickings, and the total crop yield of each are given i[illegible] the columns under proper headings. It is believed that the table will be easily understood by any reader.

In the column headed "Both pickings," the yields per acre of the first and second pickings are added together, thus showing the yi[illegible] of each variety up to and including the second picking and permitti[illegible] comparison of the yields at either of these two pickings, as well as e sum of the two. This is followed by the "Total yield" of the crop each variety at the final picking. The number of pickings varied different years from four to six, being usually five. It is believed at this exhibit of the yields at the first and second pickings is the ost convenient and effective means of determining the relative earli-ss of the different varieties, and the method has been uniformly acticed at the Georgia station.

It will be noticed that no early variety was included in the test of 00, owing to the fact that the grower of whom seeds of a standard rly variety were ordered failed to deliver them in time.

As stated in the footnote to the table, Mascot and Greer are both lections from King, first brought to general attention as a very rly variety by the published tests of the Georgia Experiment Sta-on, commencing in 1891 and repeated annually, excepting four ears. In the eleven years in which the King was tested it stood, in oint of earliness: First, five times; second, five times; third, once. n point of productiveness: First, once; second, three times; third, nce; fifth, once; thirteenth, once; eighteenth, twice; twenty-fourth, nce, and twenty-seventh, once. The variety maintains its earliness s an apparently well-fixed quality, but has declined of late years in otal productiveness, being excelled by two of its progeny—Greer and Iascot—the former improved by selection in north Alabama, and the atter in the same manner near Macon, Ga.

The main object of the exhibit in Table 1, however, was to show the upreme importance of selecting an early type when the object is to ecure a large early harvest.

Planting.—Of course the planting should be done as early as past experience in a given locality and on a given soil has shown to be rea-onably safe. The suggestions in regard to preparation of the soil ncluded some details intended to facilitate planting immediately when he right time arrives. The day of the month and the proper condi-tion of the soil as to moisture should control and determine when to plant rather than the temperature of the air, the direction of the wind, or the appearance of certain wild flowers. "Plant when the soil has been properly prepared and is in good workable condition, and when the proper date has arrived" is a good rule.

Just ahead of the planting machine the beds should be harrowed or boarded off, so as to leave a smooth, fresh, moist surface. This may be rapidly and effectively done with a heavy board on edge, extending across two rows and drawn by one mule by means of shafts attached. Let the seed fall in a fresh, mellow, moist bed and be immediately covered from 1 to 1½ inches in depth. In droughty soils or sections it is often important to compact the soil over and around the seeds in order to secure prompt germination. If the soil is rather dry a more effective plan is to cover the seeds 2 to 4 inches deep with a slight ridge, and scrape this ridge off within a few days or a week.

Application of fertilizer with seed.—At the time of planting it has been found an excellent practice to apply a few pounds of readily soluble fertilizer directly in the furrows with the seed. For this purpose a portion of the fertilizer intended to be bedded on may be reserved (say 40 to 50 pounds per acre); but nitrate of soda has been found most convenient and effective and it should be applied at the rate of 25 to 40 pounds per acre. The effect of this small dose of quickly soluble and immediately available nitrogen is to cause the young seedlings to be very strong and vigorous on their first appearance, and to grow more luxuriantly during the first few weeks after planting, enabling the farmer to commence the work of cultivating and thinning to a stand some days earlier and with more confidence. The experience of a good many years justifies a strong indorsement and recommendation of this simple detail. The nitrate of soda may be applied by strewing it along behind the planting machine either immediately or within a day or two. No covering is necessary.

A crop so reenforced and encouraged at the very start will be more likely to escape injury from plant lice, cutworms, and the like, as the more vigorous young plants will be able to resist the effects of rough or careless working. In the early history of the use of commercial fertilizers (mostly imported guanos), it was a favorite expedient of the writer to "roll" his planting seed in Peruvian guano, first thoroughly wetting the seed and using the fine, dry guano as a "drier." For this purpose 6 pounds were found to be ample for a bushel of seed. Not the slightest injury to the seed ever resulted from the practice; but the dark green, vigorous appearance of the plantlets was most remarkable. It was a good practice, resulting in great saving of planting seed—a desideratum when seeds of a desirable variety are scarce and high priced—as well as in securing a good stand of vigorous, healthy plants.

A simple, easily constructed machine for "rolling" the seed may be made in an hour by any carpenter: Take an ordinary iron-bound whisky barrel. From the middle of one side, saw out a square hole extending across two or three of the staves, or, say, 10 or 12 inches square. Batten together the pieces sawn out so as to form a shutter for the opening, and fasten with thumb buttons. Run a 2 by 2 inch wooden axle through the center of the heads, with a common winch at one end; mount the barrel like a grindstone, on two posts set in the earth. To operate it, put in 2 bushels of cotton seed and an ordinary pailful of water. Turn the barrel slowly back and forth a few minutes until every seed is wet. Let the superfluous water drain ay for a half minute. Then add about 12 pounds of any suitable e. dry powder, such as Peruvian guano, land plaster, slaked lime, ad dust, or sweepings from beneath a house. Turn the barrel back d forth slowly a few times and the seed will be found ready to ant, "every one to itself."

SPACING THE PLANTS.

The proper width of row was not considered under the head of preiring the land, at which time such width is usually determined, cause it may be more properly discussed in connection with the acing of the plants in the rows. The width of row and distance etween plants in the rows are complements; as one increases, the her decreases.

Repeated experiments, both in corn and cotton culture, conducted nder the writer's direction, have resulted in proving most concluvely that the nearer the plants are placed on a square, the greater ill be the yield of crop. If an area of 12 square feet is to be assigned each plant, it were better—certainly they would prove more productive—to space them 4 by 3 feet or 3 feet 5½ inches by 3 feet 5½ nches than to space them 6 by 2 feet or 8 by 1½ feet.

Assuming the proposition as admitted, the greater cost of cultivatng narrow rows is also admitted, and it remains for each farmer to letermine for himself, after careful experiment, whether the greater ield of the narrow rows will be sufficient to justify the increased xpense. In the experience of the writer, cotton planted in 3-foot ows and spaced to one plant every 2 feet, or 3 by 2 feet, has invarialy produced an excess more than sufficient to pay for the greater xpense of planting and cultivating in comparison with cotton planted by 1½ feet, or 5 by 1.2 feet, or 6 by 1 foot, the area to each plant eing 6 square feet in each case.

W. D. Hunter, in Farmers' Bulletin No. 189, however, strongly irges the importance of placing the "rows as far apart as experience with the land indicates is feasible, and thinning out the plants in the rows thoroughly." How far the Texas cotton grower should widen his rows and thin out the plants in the rows, as a means of lessening the prospective or next year's crop of boll weevils by permitting a freer access of sunlight and heat at the cost of a certain loss in the present year's crop of cotton, the writer is not prepared (nor is he called upon) to determine. It should be settled by those who are on the "firing line."

Number of plants to the acre.—The number of plants to the acre is a very vital detail in planning to secure a large and certain early yield of crop, and is itself an independent question. At the Georgia Experiment Station it has been shown by repeated field experiments that on the soils of the station farm, which are capable of producing, with liberal fertilizing, 1 to 1½ bales per acre, when spaced 4 by 1 foot the yield per acre at the first and second pickings has almost invariably exceeded the yields when spaced 4 by 2 feet, and without exception when spaced 4 by 3 and 4 by 4 feet, these spacings requiring, respectively, 10,890, 5,442, 3,630, and 2,722 plants per acre.

For the purpose of more clearly illustrating the proposition, the results in detail of two of these experiments out of a number that might be cited are given in Table 2. The first experiment was made in 1891, and covered 1 acre of land. It so happened that the gathering season was prolonged to a later date than usual, involving six pickings in order to harvest the entire crop. The second experiment was made in 1892, also covering 1 acre of land, and the crop was harvested in four pickings. In each experiment there were four series of four plats, each plat consisting of four 4-foot rows. The table gives the mean or average results of the four plats in each of the four series.

TABLE 2.—*Two experiments in spacing cotton.*

FIRST EXPERIMENT—1891.

How plants were spaced and number per acre.	Actual number plants maintained per acre.	Yields in pounds of seed cotton per acre at each picking and average yield per plant.													
		First picking, Sept. 8.	Yield per plant.	Second picking, Sept. 22.	Yield per plant.	Third picking, Oct. 1.	Yield per plant.	Fourth picking, Oct. 16.	Yield per plant.	Fifth picking, Nov. 4.	Yield per plant.	Sixth picking, Dec. 2.	Yield per plant.	Total yield per acre.	Average yield per plant.
4 by 1 .... 10,890	9,250	93	0.010	611	0.066	609	0.065	342	0.037	212	0.023	76	0.008	1,94[illegible]	[illegible]
4 by 2 .... 5,442	5,005	22	.004	401	.080	637	.127	444	.089	383	.076	140	.028	2,02[illegible]	[illegible]
4 by 3 .... 3,630	3,549	25	.007	324	.090	585	.165	461	.130	452	.127	160	.045	2,00[illegible]	[illegible]
4 by 4 .... 2,722	2,665	13	.005	243	.090	485	.182	444	.166	505	.190	143	.053	1,8[illegible]	[illegible]

SECOND EXPERIMENT—1892 (FOUR PICKINGS ONLY).

How plants were spaced and number per acre.	Actual number plants maintained per acre.	Yields in pounds of seed cotton per acre at each picking and average yield per plant.								
		First picking, Sept. 16.	Yield per plant.	Second picking, Sept. 29.	Yield per plant.	Third picking, Oct. 17.	Yield per plant.	Fourth picking, Nov. 21.	Yield per plant.	Total yield per acre.	Average yield per plant.
4 by 1 .... 10,890	9,559	593	0.062	554	0.058	384	0.040	85	0.009	1,616	[illegible]
4 by 2 .... 5,442	5,278	449	.085	556	.105	398	.074	113	.021	1,516	[illegible]
4 by 3 .... 3,630	3,545	323	.091	514	.145	472	.133	192	.054	1,501	[illegible]
4 by 4 .... 2,722	2,652	221	.083	432	.163	487	.183	299	.113	1,439	[illegible]

A careful examination will quite conclusively show that in both periments the closer planting resulted in much larger yields of seed tton. Read the numbers in columns 3 and 5, which represent the elds per acre at the first and second pickings, respectively, and note w regularly (with two exceptions) these numbers decrease from the p to the bottom of each half of the table. Note, also, in column 4 at the yield per plant of 9,250 plants, 4 feet by 1 foot, is exactly vice the yield per plant of 2,665 plants in the 4 by 4 foot series. his abnormal tendency, however, does not appear in the same column f the second experiment, in which all the progressions, ascending and escending, are remarkably regular.

It requires but a moment to discover that the yields per acre of the loser-spaced series, up to and including the second pickings, were ery much ahead of the yields of the wider-spaced series. At the ame time the 4 by 2 foot series in the first experiment, and the 4 by foot series in the second experiment lead the others very decidedly n the total yield, as shown in column 15.

As already intimated, the results of these two experiments are fully ustained by those of a number of similar experiments in following ears, and it seems impossible to avoid the conclusion that on soils of he character represented by those of the Georgia station close spacing—r, as farmers express it, "crowding" the plants—within the limits ested results in a larger early harvest and also in a greater total ield.

There are limitations and modifications in the practical application of the teachings of these experiments. It is not to be supposed for a moment that such close planting as 4 feet by 1 foot, or even 4 by 2 feet, would be effective or expedient on the moist, rich, alluvial soils of the Mississippi Delta or the Brazos River, or on any soils on which the cotton plants reach a height of 6 to 8 feet with a corresponding horizontal development.[a]

But the principle involved is doubtless applicable everywhere and on all soils. It remains for those who cultivate a particular soil, or who manage the experiment station of a State in which such soils abound, to find out by direct field experiments the "best distance" for cotton. It will probably be found, as a rule, that too great distance is given, this being especially true on old, worn uplands, and that the practice results every year in the loss of many hundreds of thousands of bales of possible production in the South as a whole.

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[a] The writer may be permitted to suggest that such soils are not ideal cotton soils, but should rather be devoted to corn, oats, sugar cane, meadow, etc.

CULTIVATING THE CROP.

Cultivation should commence as soon as the plants "are up," and it is often expedient to run a smoothing harrow over the field even before the plants have commenced to appear. This is especially indicated when a heavy shower of rain falls on the land after planting, the object being twofold—to stir the top soil and prevent the formation of a "crust" and to destroy the germinating weeds before they appear. Incidentally such stirring conserves moisture by retarding the ascent and evaporation of water from beneath the surface of the soil. Indeed, the frequent stirring of the surface of the field to the depth of from 1 to 2 or 3 inches is practically all that is meant by "cultivating the crop," so far as it may be accomplished by horsepower and expanding implements.

If the surface be not stirred as suggested immediately before the plants come up, it should be done as soon as possible thereafter, and the operation may often be repeated to advantage two or three times at intervals of a week or ten days.

The best implement for horsepower tillage is one that will "clean out" a row, i. e., stir the surface soil from row to row, as nearly as possible at one time. On the rolling lands of the older cotton States a good expanding one-horse cultivator, capable of sweeping out a 3-to 4 foot row at one time, is much in favor. On larger areas, level lands, and heavier soil a two-horse cultivator is to be preferred.

Hand cultivation.—So soon as the cotton plants have commenced to show the third leaf and are in healthy condition the hand hoe should be put to work. The rows of plants should be "blocked out" at a rapid gait, using a new hoe of such width of blade that one or two strokes will leave a bunch of two to four plants at the predetermined distance at which the final plants shall stand. The hands engaged in this work should go in a half walk, not striking twice in the same place. On smooth, clean land and with a good stand an active man may with ease block out 2 acres a day in 3-foot rows, and more in proportion if the rows are wider.

The object in view in going over the crop so rapidly is to destroy the surplus plants, and incidentally some grass, as rapidly as possible. The immediate object should be to individualize the plants that are to remain at as early a date as possible, to throw upon them—so to speak—the responsibilities of the position at once, that they may adapt themselves to the surroundings and develop rapidly and vigorously. On comparatively level, well-prepared land of high productive quality, on which the spacing should not be less than 2 or 3 feet between the plants, there is no reason why this preliminary blocking out may not be done by cross-plowing the rows with a flat sweep or other suitable plowshare. It would seem also practicable to use a planting machine at will drop a number of seeds at proper intervals instead of depositg them in a continuous row, as almost universally practiced. Such anters are in use to a limited extent in some sections.

To sum up this first stage of cultivation: The cotton plants should thinned to the final stand as quickly as possible, and all efforts ould tend to that end. After the plants have been thinned to such al stand cultivation should be mainly shallow and often repeated, e immediate object being to prevent evaporation of soil moisture by eping the surface as nearly as possible always broken and mellow. Once a week and once to the row," with a good horse cultivator, is 1 excellent rule.

Cultivation after flowers appear.—This rapid cultivation encourages a igorous and healthy growth of the plants, and should be continued p to about the time the blossoms begin to appear freely and the lants shall have commenced to put on "fruit." These early blooms—hose that appear during the third month after planting—are to produce he early bolls and yield the early pickings of cotton. If the soil be tirred at all during the early period of rapid blooming, the work hould be done very carefully, the cultivators running very shallow. Vhat is now wanted is rapid blooming, not fast growing, and the ceraiu retention and development of the bolls. Injudicious cultivation t this period, especially if at all deep, tends to encourage "weed" levelopment and loss of young fruit ("shedding"). Late cultivation ends to large growth of "weed" and a late crop of cotton, and may be n order when the main object is to secure the largest possible total ield, regardless of earliness.

Shedding.—Every farmer has noticed the great increase in shedding which often occurs within a few days after a heavy rain in July folowed by hot, sunny weather. Many careless observers think the "forms" thus thrown off have not yet quite reached the bloom. In this notion they are in error, since it is a fact that a very great majority of the supposed forms that have been dropped are young bolls only a few days from the bloom. Many such young bolls doubtless drop because of a failure of pollination due to constant rain or damp weather. But such shedding of young bolls is often noticeable immediately following a rather deep cultivation, even when weather conditions are entirely favorable to pollination. Indeed, deep cultivation in July is sometimes resorted to by skillful farmers in order to encourage a further and larger development of the plant. The removal of every boll and form from selected plants as late as July 4 has been known to result in an immediate resumption of growth and a larger yield of cotton from the plants thus treated than from adjacent plants that were not so treated. So, it seems, a loss of forms and immature bolls by actual manual removal may induce and promote renewed growth of the plant; and, conversely, the renewed growth when induced by abundant rainfall and sunshine, or by deep cultivation, causes the shedding of undeveloped fruit.

Results of cultivation.—It may be consistently stated, as a general rule, that early, frequent, and shallow cultivation tends to produce and mature a crop of early bolls; deeper and later continued cultivation tends rather to delay and hinder the development of the early bolls, but may increase the final and total yield of the crop in sections where the weevil does not occur.

CLEARING AWAY THE PLANTS IN THE AUTUMN.

The authority already quoted recommends the total uprooting and destruction by burning of the entire plants at an early date in the fall, with the view of destroying as many as possible of the weevils then existing in the several stages of development. Reference has already been made to the use of a two-horse "middle-burster," of which several kinds are manufactured. This implement will lift out the stalks entire, including the main root and large surface laterals. After a few days' sunning the plants may be gathered by means of a horse rake into large heaps or into windrows and destroyed by burning. The use of cheap petroleum sprayed over the piles of stalks greatly assists in destroying them, rendering it unnecessary to wait until they become sufficiently dry to burn alone.

SUMMARY.

(1) Prepare the soil thoroughly and early, beginning with fall plowing.

(2) Fertilize liberally and judiciously, carefully avoiding an excess of nitrogen. On rich, dark, alluvial, and freshly cleared soils, phosphoric acid alone, in the form of acid phosphate, may be applied.

(3) Apply fertilizers in the drill and bed on them. Broadcasting is rarely, if ever, expedient.

(4) Choose an early maturing and productive variety of cotton, and plant on the beds, and as early as possible. Apply in the seed furrow 40 to 75 pounds per acre of quickly available fertilizer, preferably 20 to 40 pounds of nitrate of soda.

(5) Reduce to a final stand as quickly as possible.

(6) Let cultivation be frequent and shallow.

(7) Narrow rows with wide spacing of plants in the rows will result in a greater early yield than will wide rows with close spacing.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 218.

THE

CHOOL GARDEN.

BY

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF.
Washington, D. C., February 25, 190[illegible].

SIR: I have the honor to transmit herewith a paper on The School Garden, prepared by Prof. L. C. Corbett, Horticulturist of this Bureau, and to recommend that it be issued as a Farmers' Bulletin.

Respectfully,

B. T. GALLOWAY.
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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ILLUSTRATIONS.

THE SCHOOL GARDEN.

INTRODUCTION.

Those who are charged with the direct presentation of school gar-n work to children will recognize that the point of view for city ildren must be different from that for country children. As a rule, ildren in rural districts are familiar with the fundamental opera-›ns of the garden—preparation of the soil, planting the seed, and the ltivation and harvesting of the ordinary garden and farm crops. o attempt, therefore, to maintain the ordinary type of individual ›getable and flower garden upon the grounds of rural schools would ıdoubtedly be an unwise expenditure of time and energy.

For city children, however, to whom the growth of the plant is like ıe discovery of a new world, the application of the simple operations ıvolved in the maintenance of the individual garden containing owers and vegetables is altogether a different matter. The plan of rocedure, therefore, for teachers in rural districts, should be quite ifferent from that followed by those in urban communities. The ›achers of the rural schools will find a most fruitful field along the ne of laboratory experiments, which will demonstrate the principles f plant growth and of plant nutrition, methods of propagation, etc. n this connection we have therefore outlined two classes of work ›hich will encroach more or less upon each other, but the discriminat-ng teacher will have no difficulty in selecting that which is best uited to the conditions by which he or she is surrounded.

In rural communities, instead of conducting miniature vegetable or lower gardens, it might be better to secure different varieties of rains or grasses for test upon home plats, encouraging the students o undertake small experiments which shall have for their chief end he development of the faculties of observation. Different methods ›f tillage and fundamental principles of this character will be in-volved in these experimental or demonstration areas, the results of which will emphasize the importance of certain lines of work.

In some localities it will be possible to bring together upon the school grounds groups of shrubs and trees arranged in an artistic manner, so that the finished work will present an attractive p... and will furnish material of great value for purposes of instructi... The habits and uses of various plants can be brought out and ... child led to appreciate the value of such decorative plantings in co... nection with the home. Such work, however, will not involve ... very considerable expenditure of time or energy, neither will it requ... systematic attention to garden work on the part of the child. It w... however, have a broader and less exacting influence, and will, perha... be of greater importance in rural communities than would ... attention to the maintenance of the individual garden.

VALUE OF SCHOOL GARDEN WORK.

In any phase of educational work, the first question which pre... itself is, What is the effect of the exercise or the study upon the pup... Those who have had most experience in the school garden moveme... are emphatic in their statements regarding the educational value ... this work. It is claimed that quick discrimination is one of the pr... nounced qualities resulting from it. Skill with the hands is nec... sarily an outcome. The handling of small seeds and of various to... naturally develops skill and agility. Systematic methods also follo... from the natural order in which the operations conducted in th... garden must be taken up. This not only develops a very importa... faculty, but at the same time teaches the young mind a logical ... quence based upon the natural order of things. Industry is not ... unimportant result which comes from school garden work. The i... of ownership and the rights of ownership, which come from th... possession of a garden, induce the pupil to exercise his ability to ma... his possession as good or better than that of his neighbor. Th... natural result of this is industry. Business experience is an impo... tant result of harvesting and accounting for the products which ar... grown. The right of ownership and a respect for property rights ar... more largely developed from the possession of individual garde... than in community gardens. The idea that "what's mine is my own" becomes very strongly developed, with the natural sequence that s... possessions must be properly protected and all rights concern... respected. On the other hand, a party interest in a community gar... den does not so emphatically develop the idea of individual respon... bility, and each one has a tendency to care less for the plants whi... another has shared in producing, with the result that responsibility ... shirked, and there is lack of interest, with a consequent lack of indu... try. For this reason, in our work from the very inception the indi... vidual garden idea has been emphasized and strictly adhered to.

The individual garden has the advantage of allowing each on... possessing a garden to perform each and every operation connect...

with the preparation, planting, and care of the plants grown in that garden. This, as before stated, not only develops system, but it furnishes a basis of very valuable knowledge, if the operations connected with these crops are properly conducted. If the requirements of the different crops in regard to preparation of soil, depth of planting, date of planting, and manner of harvesting and training are all carefully observed, the young mind has indelibly fixed upon it impressions which will be retained throughout life. The cultivation and management of these crops in future years will be looked upon as a sort of instinct, the time and manner of acquiring this knowledge having, perhaps, long ago been forgotten. The skill and ability resulting from the use of various implements connected with the cultivation of crops are of no mean significance.

In connection with these operations, the teacher can illustrate the good and evil effects from certain methods of cultivation, of working soil when in good and bad condition, with the consequent effects upon growing crops; can demonstrate the value of deep and shallow tillage, together with the importance of maintaining a loose soil mulch for the conservation of moisture. In fact, the school garden should be looked upon as a laboratory in which the different steps in the life of the plant are to be illustrated and demonstrated. The nature of soil, the importance of fertilization, and the conditions essential to germination, as well as the conditions conducive to growth, can all be illustrated in a logical and impressive manner in the school garden.

Field excursions may be an ideal way for conducting nature study with reasoning minds that have been trained to a logical system and in a consecutive, systematic fashion, but school gardens offer facilities not to be approached in field excursions. Field excursions give disconnected fragments of the history of natural objects, while the school garden furnishes opportunities for observing plants from seedtime to harvest. In addition to the actual operations in the school garden, a number of schoolroom studies and experiments may be conducted, which will be of decided interest and value.

THE INDIVIDUAL SCHOOL GARDEN.

TYPE OF PLANTS FOR THE GARDEN.

The limited area usually available for school garden work makes it imperative that for individual gardens, at least, which we believe to be best adapted for logical, systematic instruction, plants with a compact bush form or habit of growth are to be preferred. Tall-growing, broad-leaved, as well as climbing plants, must be excluded, except from community gardens or in general decorative plantings. The seed collections which have been assembled by the United States

Department of Agriculture for the individual garden have, therefore, been chosen to meet these requirements.

A VEGETABLE GARDEN.

The following plans are offered as suggestions for teachers:

Plan No. 1 (fig. 1) represents a vegetable garden 5 feet wide by 16 feet long. The rows, except the tomatoes, are located a foot apart. The distance between the individual plants in the row is indicated after the name of each sort. The tomatoes, it will be noted, are planted 18 by 20 inches apart, thus giving more room for the plants to spread than could otherwise be secured.

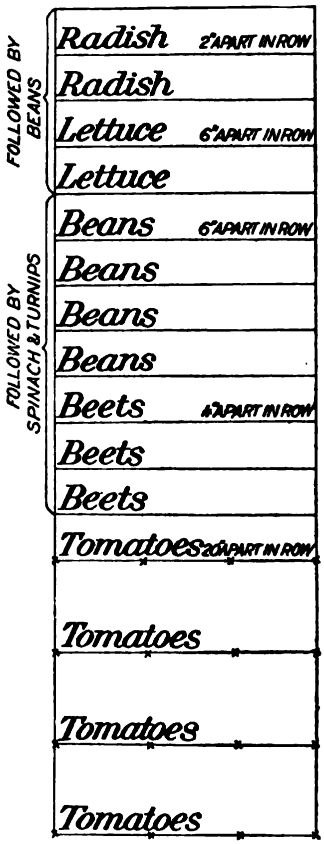

FIG. 1.—Plan of vegetable garden.

ROTATION OF CROPS.

The economical use of the area at one's disposal forms quite as important a part of the value of the instruction to be derived from the school garden as the successful growing of the plants. It will be noted that the quick-maturing crops are planted in groups, which afford a considerable area for replanting as soon as the crops mature. In the accompanying illustrations a bracket incloses the names of such crops, and the sorts which are to follow them are indicated by names outside the brackets. The rotation provides for a continuous use of the land and the growing of more than a single crop—the first lesson to be learned in intensive horticulture.

COMBINATION VEGETABLE AND FLOWER GARDEN.

Figure 2 illustrates a garden of the same area as the vegetable garden illustrated in figure 1, i. e., 5 by 16½ feet. The rows in this case are all 1 foot apart, with the exception of the radishes, which are 6 inches apart. The plants are grouped according to height of growth, so as to place the tall-growing plants in the center of the garden, with low-growing and decumbent plants at the ends. In this case it will be noted that tomatoes are used only as a succession or rotation crop following the radishes and lettuce.

CULTURAL SUGGESTIONS.

If practicable, the children should be allowed to do all the work of eparing the land as well as planting the seed and caring for the ants. The preparation of the soil can be converted into a lesson in il physics, the teacher explaining the nature of the soil as a source plant food, as a mechanical support to the plant, and as a store-use and conveyer of water and air. The influence of fining the il on the liberation of plant food and ater content, the importance of hoeing cultivating to eliminate competition the destruction of weeds and to con-rve moisture by the maintenance of a il mulch, and the necessity of thinning e plants in the row in order to reduce mpetition and increase the feeding area the individual plant, should be clearly resented. The influence of pruning on matoes to lessen competition among the ranches and increase the food supply the fruits retained should be brought ut. The plants themselves offer mate-ial to use as a basis for discussing their fe processes, including germination, rowth, the functions of leaves, stems, oots, and flowers, and, finally, the stor-ng of material in the finished product the seed) to carry the plant over that rying period when its natural function nust be suspended.

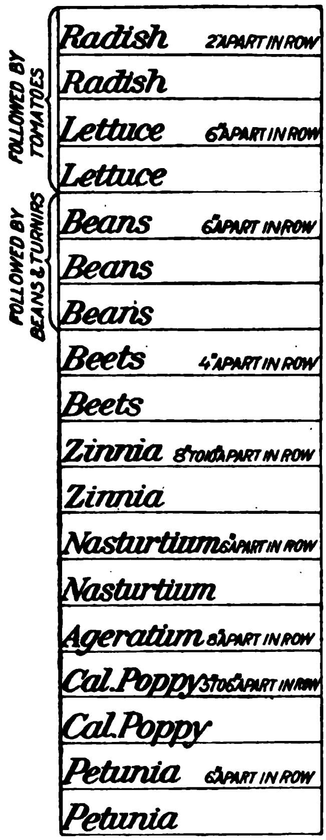

FIG. 2.—Plan of combination vegetable and flower garden.

VEGETABLES.

Radishes.—Radishes are hardy plants and thrive best during the cool weather of early spring and late autumn. In the South they can best be grown during the winter and early spring months. The seeds should be sown in drills, in rich. well-prepared soil, placed about half an inch apart and buried not deeper than 1 inch nor less than one-half inch. When the plants are showing the second set of true leaves they should be thinned to stand from 2 to 3 inches apart in the row.

Lettu —Lettuce is a hardy plant and thrives best during early spring and late autumn. The seeds should be sown in drills in the open or in boxes in the window. If in the open, the seeds should be scattered about one-half inch apart along the row, and covered not more than one-half inch with earth. Firm the earth well over the seeds, so as to bring the moist soil in contact with them. When the plants are well up, thin to 6 inches apart in the row. If the seeds were sown in a window box, hotbed, frame, or greenhouse, transplant the young plants to stand 2 by 2 inches apart as soon as the seed leaves are well expanded, and when they begin to crowd transfer them to their permanent places in the open, if the weather will permit. In the field, they should stand at least 6 inches apart each way.

Beans.—Beans are tender plants. They can not endure frost and will not stand transplanting well. It is best to wait and plant the seeds of this plant in the open where the plants are to grow, delaying the work until severe frosts are past. Plant in rows 1 foot apart, placing the seeds about 2 inches deep at intervals of 6 inches. Keep the soil loose and free from weeds.

Beets.—Beets, while they are hardy and can be planted at the same time as radishes and lettuce, are placed as indicated in the planting plan because they require a longer season for maturing than lettuce, radishes, and beans. The seeds should be planted in rows 1 foot apart, placed an inch apart in the row and covered 1 inch deep. When the plants are well up (2 inches high), thin to 4 inches apart in the row. Keep the soil well tilled at all times.

Tomatoes.—The tomato is the most exacting of all the plants included in the collection. From Washington southward the seeds may be planted in the open at the same time as beans, but to the north of this point the seeds should be sown in boxes, hotbeds, or greenhouses from the first to the middle of March, the young plants being transplanted to stand 2 by 2 inches apart as soon as the first true leaves appear. When they begin to crowd in their new positions, shift them to 4-inch pots or to cans such as are used by canners of tomatoes, and keep them growing slowly until about May 20 to June 1, when it will be safe to place them in their permanent locations in the garden. Set the plants in rows 18 inches apart and place the plants about 20 inches apart in the rows, as indicated by crosses on the diagram, figure 1. Each plant as it grows should have all side branches removed and the main stem tied to a stout stake, about 5 feet tall and at least an inch square, driven firmly in the ground.

FLOWERING PLANTS.

Ageratum.—Ageratums grow well upon almost all soils and through a wide range of climate. For that reason many combinations with them are possible. The plants are neat, bushy, and erect nd produce a profusion of brush-like flowers throughout the season. 'he dwarf blue sorts make fine borders and are much used where con·asting color effects are desired. For early bloom the seed should be ɔwn in cold frames or in boxes in the house early in the season March), but for summer and fall bloom the seeds may be sown in ʟpril or early in May in well-prepared beds in the open. Seeds sown ı August will produce good plants for winter flowering.

Nasturtium.—The large seeds of the nasturtium require to be ·lanted much deeper than the fine seeds of the petunia. Sow them n rows where the plants are to grow, placing the seeds about 6 inches part in the row and cover them about an inch deep. When all ·lants are up, thin so that they stand a foot apart if the soil is rich; f rather thin, it will be as well to allow them to stand at the plantng distance. The plants should be given clean cultivation to induce 'apid growth. If planted in the open at the same time that beans ıre planted, very satisfactory results will follow. For earlier bloom ɔlant in advance of this date in hotbeds, cold frames, or window ›oxes.

Petunia.—While the petunia grows readily and rapidly from seeds sown in the open about corn-planting time, earlier bloom can be secured by sowing the seed in window boxes or hotbeds and transplanting the plants once before placing them in the open. For localities north of New York the most satisfactory method of handling these plants will be to start the seeds in window boxes about April 1, and to transfer the young plants to the open when the weather permits—about the middle of May. The seeds are very small and should not be covered with earth in the ordinary way. They should be sown on the surface and brought in contact with the earth by firming it with a board.

California poppy (Eschscholtzia).—The eschscholtzia is an annual of striking character both as regards the form and color of its flowers, which are bright and rich in their tints of yellow and orange. The plants average about a foot in height, have attractive silvery foliage, and produce their large poppy-like flowers quite lavishly from early spring until frost. The seeds of eschscholtzia may be sown in window boxes or in a hotbed in March, or in the open where the plants are to bloom as soon as the soil is in fit condition, in April or May in the latitude of New York. In latitudes south of New York the seeds may be sown in the autumn for early bloom. The plants enjoy a rich loam and should be allowed about 5 or 6 inches of space in the row. When used in beds they may be sown broadcast.

Zinnia.—The zinnia is easily grown from seed sown in the open ground. When sown in April the plants will bloom abundantly and continuously through the entire season. During the month of August zinnias are at their best. To secure large flowers and a profusion of bloom the plants must be given ample room for full development, as well as an abundant supply of food. Strong, rich soils suit the zinnia. If the seeds are sown in a dwelling house or in a hotbed in March and the young plants are pricked out once or twice before being placed in their permanent situations, more satisfactory results will be secured than from outdoor-sown seeds unless equal care in thinning or transplanting is given. In addition to their use in the school garden, zinnias can be used for groups, beds, borders, garden lines, and summer hedges. Their average height is 1½ feet.

LABORATORY EXERCISES

STUDIES OF SOIL.

In the first place, the student may be told something about the origin of soil. It can be explained that all soil is the result of the breaking down of rock or of the decomposition of living matter. The character of soil which is formed in any particular case is determined by the kind of rock which was broken in its formation. For instance, the breaking up of sandstone results in the formation of a sandy or gravelly soil.

When the soil is the result of the blending of several materials it is called a loam, and the relative proportion of sand or clay produces what is known either as sandy loam or clay loam, depending upon the predominance of sand or clay. If a large quantity of decomposing vegetable or animal matter is to be found in the soils, such matter is called humus. When humus in large proportions is mixed with sand or clay and is well decomposed it forms a class of soil called muck.

The Relation of Soil to Plants.

The relations which soils bear to plants are interesting and can be illustrated by the objects seen in nature.

In the first place the soil acts as a mechanical support for plants, forming a matrix or mass in which the roots become embedded.

Its second function is a physiological one, acting (1) as a storehouse for water, (2) as a storehouse for food, and (3) as a place to contain air in order to provide congeniial conditions for the action of the roots.

Soil as a Storehouse for Water.

As a storehouse for water the soil fulfills one of its most important functions, and from the standpoint of the gardener or farmer the quantity of moisture which is held by the soil determines its fitness or s unfitness for agricultural operations. Soils which are too wet are ot congenial to the germination of seeds or the growth of plants.

Exercise 1.—The effect of water upon soil can easily be illustrated by placg a quantity of soil which is rather stiff and retentive in nature in a pot. lant a few seeds of beans or corn in it to a depth of three-fourths of an inch id make the soil thoroughly wet, keeping it constantly moist by the addition ' water. Under these conditions it will be found that the seeds germinate owly if at all, and if the soil is placed in a cool rather than in a warm room will be likely that germination will not occur. Too much water, therefore, as bad as too little. In comparison with this experiment use similar soil, lant the seed as before indicated, but do not apply water in excess, and note ie effect.

Exercise 2.—In order to show the movement of water in soils, arrange a series f glass tubes or straight lamp chimneys, such as are used with Argand burners, s shown in figure 3, and in each one place a different character of soil: in one, pure sand; in another mixture of sand and lay; in another, a sandy oam, and in still another, some well-decomposed leaf mold. Tie a piece of thin cloth (muslin) over the small ends of the chimneys and place soil in them to a uniform height, preferably up to the bulge.

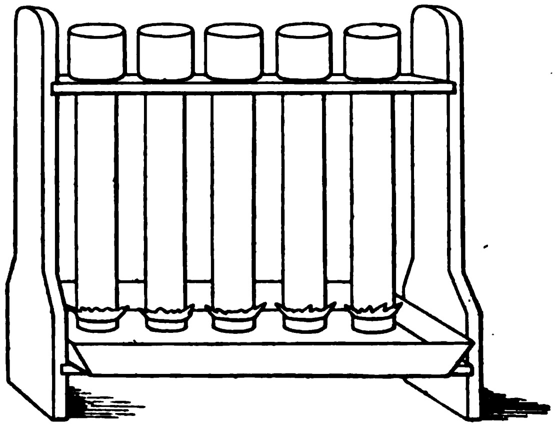

FIG. 3.—Device showing the movement of water in soil.

Place a pan under the small end of each one of these receptacles, and fill the pan with water. Note the time and the distance to which the water rises in each of the chimneys through the different soils. This rise of water through the soil is called its capillarity, and forms one of the most important functions, if not the most important function, of the soil in relation to the growth of agricultural crops. The rate at which the water rises in the soil and the quantity of water which each soil is capable of holding can be determined by weighing the chimneys prior to placing the water in the pan and at intervals up to the time the soil has absorbed all that it will take up. The difference in weight is the amount of water taken up, and gives an index of the water-holding capacity of the various soils. This will give an index to the power of the soil to withstand drought during the growing season.

Plant Foods in Solution.

It is a well-known fact that plants take their food in solution; that is, in order to get food which comes from the soil, the soil must contain more or less water, so as to extract from the soil particles the food necessary for the use of the plant. In very dry times the water supply is reduced, and naturally there is a reduction in the food ava-able to the plant.

Exercise 3.—To prove that plants take up food in solution by their roots, it is only necessary to place a rooted cutting in a bottle containing water, and another one in a bottle containing no water. The one which has its roots immersed in water will keep green and present no unusual appearance, while the one whose roots are suspended in the air will immediately wilt and die. This is sufficient to prove that the roots have the ability to take up water and keep the plant in an apparently normal condition. If, however, the plant were to be continued for an indefinite period with its roots suspended in water only, not only would there be little or no growth, but it would finally die. On the other hand, if the water were supplied with the proper ingredients of plant food to form a so-called water culture the plant could be grown and matured without ever coming in contact with the soil.

Exercise 4.—To prove that roots actually absorb water and the materials contained in it, it will only be necessary to place some coloring matter, eosin or red ink, in the water in which the roots of the plants are suspended. In a short time the coloring matter will enter the roots and be carried to the leaf tissue, changing its color slightly. A rooted cutting of Golden Bedder coleus is a good plant for this test.

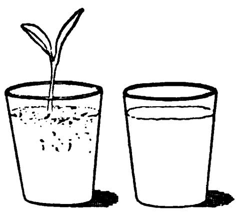

FIG. 4.—Method of demonstrating the effect of too much water in soil.

Air Essential to Growth.

Air is necessary in the soil in order to make it a congenial place for the growth of plants.

Exercise 5.—The necessity for air can be demonstrated very nicely by taking some ordinary garden soil which is rather retentive in nature—that is, contains a considerable percentage of clay—and placing an equal quantity in each of two tumblers, as shown in figure 4. In one, plant seeds of beans or peas in the usual fashion, and in the other plant the same kind of seeds in the same way, but keep the soil constantly saturated with water, so that there is a thin stratum of moisture over the surface of the soil. The seeds in the first tumbler will undoubtedly germinate in a short time, while the seeds in the other tumbler will require a longer time to germinate, and if the temperature of the room in which the two glasses are kept is low the seeds will rot. The tumbler which contains an excessive amount of moisture prevents the access of air that is necessary to the germination of the seed, while the one which is kept only moderately moist allows a sufficient amount of air to come in contact with the seeds to insure germination.

Soil and Water Supply.

In natural soil there are two classes of water. One class is water which is held in close contact with the soil particles, which is merely a film of water surrounding each soil particle. That such a film exists may be shown by dipping a pebble into a dish of water and allowing the water to drain off. The pebble will remain moist for a considerable length of time, and if placed in a closed receptacle it a similar manner to the conditions in which the soil particles exist when packed closely together the film of moisture will remain upon the pebble for a long time. This film of moisture which covers the individual particles of soil is known as capillary water, and forms the great storehouse of moisture upon which growing plants depend. The water-holding power of the soil is in direct proportion to the size of the soil particles. This can be demonstrated by the different grades of soil, ranging from gravel and sandy loam to a clay or muck, which can be placed in the lamp chimney arrangement shown in figure 3. By placing these soils separately in the individual chimneys and pouring water upon them until they become thoroughly saturated, the length of time required for each one to dry out will give an idea of the water-holding power or the retention of moisture by these different qualities of earth. These same soils and the same apparatus can be used to show the rate of movement of water in soils, as has already been suggested.

Besides the class of water just described, which is known as capillary water, there is in all arable soils free water, which constitutes the basis of supply for springs, wells, and streams. This water is not usually found close to the surface of the ground, except in depressions soon after a heavy rainfall. Each soil, however, possesses a natural level or height for water of this character, determined in each locality by the depth to which it is necessary to dig in order to secure a satisfactory well.

STUDIES OF PLANTS.

The observations which have been made up to this point have had for their object the illustration of different functions in connection with soil moisture or plant food. Attention will now be directed to the consideration of some of the simple, yet interesting, features connected with plants themselves.

Seeds.

The seed may be considered as the unit of plant structure and the starting point in the cycle of plant life. Seeds are interesting objects, because they have many different designs. Some are so made that they can take short aerial journeys—that is, they are provided with wings or parachutes which carry them from place to place. The seeds of the maple are provided with wings, and when they become detached from the parent tree a gentle breeze will carry them a considerable distance from the branch to which they were attached. There are many forms and modifications of the winged seed, as illustrated by the linden, the hornbeam, the elm, and the pine. These are all common trees from which seeds for illustrative purposes can be secured.

Some seeds are also provided with parachutes or umbrellas, not for protection from rain and storm, but for purposes of locomotion. The seeds of the thistle, the milkweed, and the dandelion—in fact, the seeds of all plants which have a cottony growth—are provided for these aerial journeys.

Besides these, some seeds are provided with hooked appendages by which they can attach themselves to the clothing of men or to the hair of animals, so that they become transported from place to place. Other seeds have hard seed coats, or shells, which are covered in many cases by edible fruit. The fruits are eaten by birds, but the seeds are not digested, and in this way become distributed from place to place. The groves of cedars which are characteristic of the landscape in many sections of the country, it will be noted are chiefly placed along the lines of fences or fence rows. The fruit of the cedar is an edible one, but the seed is not digestible, and in this way the existence of these hedge rows of cedars is explained. Cherries, grapes, and other fruits are to a considerable extent disseminated in like manner.

The hard nuts of our nut-bearing trees are not used as food by birds or large animals, but are usually sought by squirrels and small rodents, which are in the habit of gathering and burying them in various places or storing them in large quantities for winter use. The result is that a considerable percentage of those which are buried in this manner are never rediscovered by those hiding them, and in time nature causes the hard shell to crack open, and the warmth and moisture of the soil brings the germ contained in the kernel into life and a tree springs into existence. It will be noted that the nuts which were buried by the squirrels did not germinate immediately after being buried, but waited until the warm weather of the spring came before they put forth their tender shoots. This is not because they willed it, but because the hard outer walls of the shell would not admit the air and water to the germ, so as to stimulate its growth. It was necessary that the shell be frozen and broken by the action of the frosts and the weather before moisture could gain an entrance to cause the swelling of the germ. This peculiarity, when taken advantage of commercially, is called stratification. Seeds with hard shells, such as cherries, peaches, plums, and the like, have to be stratified—that is, they must be planted in the fall where the plants are to grow or they must be packed away in boxes of sand in a position where they will freeze and remain frozen during the winter, in order that they may germinate the following spring. If seeds of this character are stored and kept dry during the winter they will not germinate if planted in the spring. Seeds with thin seed coats, how-

'er, like peas, beans, etc., if treated in like manner, will be destroyed / the action of the cold, and no plants will result from planting iem in the autumn. Such seeds must, from the nature of the case, retained in a dry and comparatively warm place during the winter ason, in order that their vitality may not be destroyed.

Seed Planting.

The method of planting has much to do with the results. Seeds hich are small and fine must not be deeply covered with earth, for, they are, the weak germ which they contain will not be strong nough to reach the light and air. Large seeds, however, which con-

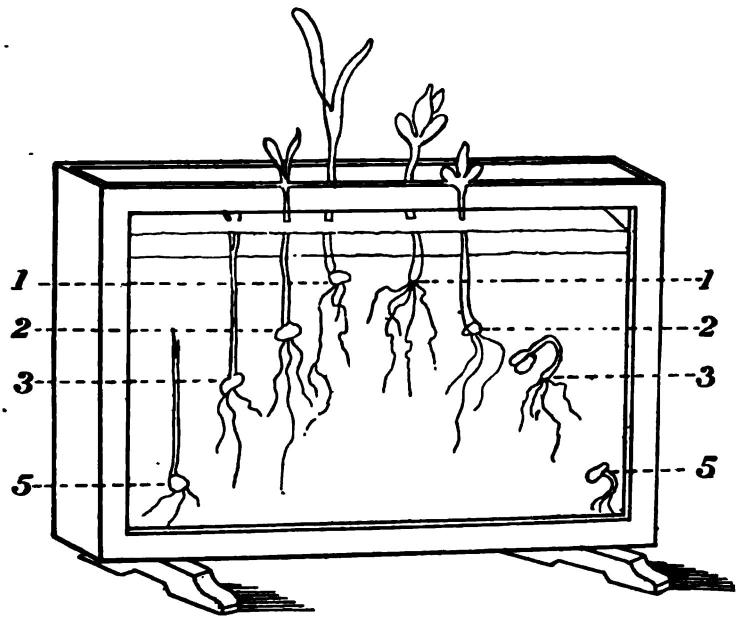

FIG. 5.—Device showing proper depth to plant seeds.

tain a considerable quantity of stored material, as in the case of peas and beans, may be planted quite deeply. In fact peas, which do not force the seed leaves out of the ground should, for best results, be planted from 3 to 5 inches in depth, while beans, which have a different method of germination, forcing their seed leaves out of the ground, should not be planted so deeply, for, as in the case of soils which are clayey and compact in nature, there will not be sufficient power in the growing stem of the bean to force the seed leaf from the soil and out into the light. The depth of planting, therefore, must be regulated by the habit of growth of the plant.

Exercise 6.—The proper depth of planting can be nicely illustrated by the device shown in figure 5, which consists of two panes of glass placed about one-half inch apart and held in this position by a wooden frame, the space between the two panes being filled with earth into which the seeds are dropped and held against the glass. Beginning at a distance of 5 inches from the top of the glass, place a kernel of corn, on top of this place a layer of earth and continue at intervals of 1 inch until a series of seeds rest against the glass from 5 inches below to within one-half inch of the surface. Try seeds of beans and peas in like manner and note the ability of the different seeds to reach the surface of the soil when proper moisture and temperature conditions are maintained. This apparatus will give an idea of the rate of germination at different depths of soil, and of the power of the different plants to force their way to the light.

The panes of glass of which the device is constructed should, except in times of observation, be kept covered with dark-colored blotting paper or by sheets of tin or other light-proof material to keep the growing seeds constantly in the dark.

Conditions Essential to Germination.

From what has been said in connection with soil conditions and the germination of seeds it will be evident that three factors are absolutely essential to the germination of seeds: (1) Moisture, not in excess but in moderate quantities; (2) heat of a given degree, for even if seeds have a proper amount of moisture, if the temperature in which they are placed is too low no growth will take place, and (3) plants and seeds must have air otherwise they will not germinate.

FIG. 6.—Method of showing conditions essential to germination.

This has been illustrated by the seeds planted in a closely packed wet soil, which was mentioned on page 14.

Exercise 7.—The conditions essential to germination can be shown by putting a quantity of seeds in a bottle, as suggested in figure 6, covering them with an inch or more of water, and then tightly corking the bottle. Seeds under these conditions will be deprived of air and will germinate, if at all, only in a weak, unsatisfactory manner. The skillful farmer or gardener, in preparing the soil, attempts to approach as closely as possible the ideal conditions for the germination of the seed. He selects a time when the soil is dry, warm and friable.

Seed Testing.

The exercise in seed testing can be made to serve two purposes: (1) The selection or separation of mixed and impure seeds, and (2) the determination of the number as well as the time required for the germination of various kinds of seeds. The percentage of live seeds can thus be learned.

Exercise 8.—Select several sorts of seeds of large size which are distinctive in character, such as corn, beans, peas, beets, radishes, and tomatoes, and put these all together; then allow the pupils to separate them. After they have separated the mixture into its several parts give them labeled samples put up in vials or packets for purposes of identification.

Exercise 9.—Take 10 or 20 seeds of the sort to be tested and place them between moist blotters or folds of canton flannel, as shown in figure 7. Place the device in a warm situation and see that it does not lack moisture, although it must not be kept too wet, otherwise the seed may rot. Observe the condition of the seeds every twenty-four hours. When all viable seeds have germinated, take account of the whole, and determine the percentage of those which have grown.

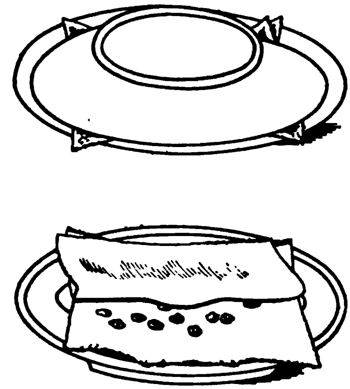

FIG. 7.—Device for seed testing.

Exercise 10.—Make sketches of the seeds of beans, peas, and squashes twenty-four hours after placing them in the germinator, and similarly after the lapse of forty-eight, sixty-four, and seventy-two hours.

STUDIES OF ROOTS.

The roots of plants subserve two important offices: (1) They act as a mechanical anchorage to the plant, holding it firmly in the soil, and (2) as a mouth through which the crude plant foods of the soil are taken up by the plant. That the roots of plants serve as a mechanical anchorage is evident from the ability of trees with tall trunks and broad spreading branches to withstand heavy winds.

That roots act as a means for gathering food can only be shown in an indirect way.

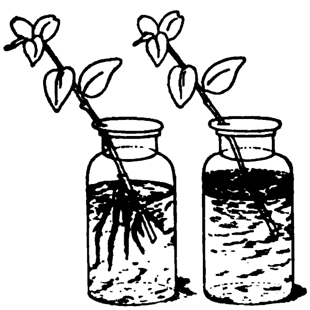

FIG. 8.—Arrangement for showing the effect of the exclusion of air on plant growth.

Exercise 11.—To prove that roots take up substances in solution, take two bottles, and place in each a rooted cutting or a branch of some plant, such as tradescantia, which will quickly throw out roots. In one of the bottles place a few grains of saltpeter, and in the other a few grains of common salt, and note the effect on the plants.

Exercise 12.—The necessity for air for the development of roots can be demonstrated by using two bottles similar to those shown in figure 8. After filling them two-thirds full of water, place a cutting of coleus, geranium, or tradescantia in the receptacles, as indicated, but over the surface of the water in one bottle pour a thin layer of oil—castor oil or sweet oil—and observe the behavior of the cuttings.

Exercise 13.—To show that roots increase in length, and to see where the growth occurs, place some kernels of corn or other large seeds between the folds of a piece of wet cloth. Keep the cloth wet till the seeds have sprouted and the young plants have roots 2 or 3 inches long. Have at hand two panes of glass about 5 by 8 inches, a piece of cloth a little longer than the width of the glass and about 3 inches wide, a spool of dark-colored thread, and a shallow pan or dish. Lay one pane of glass in the pan, letting one end rest on the bottom and the other on the opposite edge of the pan (fig. 9). Wet the cloth and spread it on the glass. Take one of the sprouted seeds, lay it on the cloth, tie pieces of thread around the roots at intervals of one-fourth inch (tie carefully so that the roots will not be injured); place the second pane of glass over the roots, slipping in a sliver of wood to prevent crushing them, and letting the upper edge of this glass come just below the seed. Fold the corners of the cloth about the seed, put half an inch of water in the pan, and leave for development. A day or two will show conclusively that the lengthening takes place at the tip only. Has this fact any bearing on the relation of soil texture to root development? The soft, tender root tips will force their way through a mellow soil with greater ease and rapidity than through a hard soil, and the more rapid the root growth the more rapid the development of the plant. Here is the lesson of deep plowing and thorough breaking and pulverizing of the soil before the crop is planted.

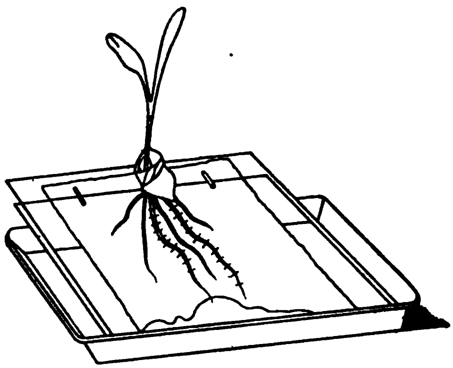

Fig 9.—Device for measuring root growth.

STUDIES OF STEMS.

The stems of plants are of interest in several respects. The stems of large trees are of value commercially, because they are the source from which material for construction is derived. The stems of certain plants, together with their leaves, form a part of the food for many domestic animals. The stems of tall-growing plants, such as trees, form the main framework of the plants. The outer portion of the stems of our broad-leaved trees, together with the inner layer of the bark, forms passages or canals through which the food of the plant is passed from the roots to the leaves or from the leaves to the various organs of the plant.

Exercise 14.—That the roots pump up moisture from the soil and force it up through the stem can be demonstrated by severing the stem of a geranium 3 or 4 inches from the surface of the soil, placing over the cut end of the stem a short section of soft rubber hose and in the other end inserting a small-bore glass tube several inches long, and keeping the root of the plant normal by supplying it with water. Note what happens inside the glass tube, making observations every few hours.

21

STUDIES OF LEAVES.

The leaves are the workshop of the plant. In them, under the ›rmal conditions of nature, wonderful transformations take place. he materials supplied by the root are here combined with materials ken from the air, under the influence of sunshine, into materials hich give the tints to the flowers, the flavor to the fruit, and the veetness to sugar. These intricate and complex operations can not demonstrated in a simple way, but that sunlight is a factor in the fe of the plant can easily be demonstrated.

Exercise 15.—Plant two pots with corn. Place one in a window where it may ake a normal growth. Give the other the same temperature and the same :tention as regards watering, but place it under a paper cone or box through hich light can not penetrate. Contrast the appearance of the two sets of plants rown under these conditions. After the plants nder the cone or box have attained a height of or 3 inches, remove the covering and note hat takes place when the pot is placed in full inshine.

The leaves of the plant throw off the excess moisire supplied by the roots.

Exercise 16.—That moisture is thrown off by ie leaves of growing plants can easily be demontrated, as indicated in figure 10, by placing cardboard around the stem of a thrifty nasturium, bean, or corn plant, and confining the leaves f the plant under an inverted glass. A tumbler ill answer for small plants and a fruit jar for irger ones.

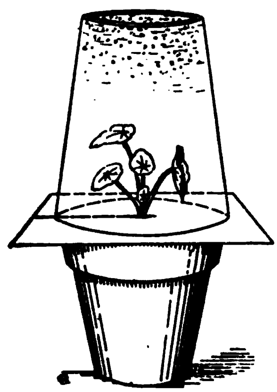

Fig. 10.—Tumblers and cardboard showing that moisture is thrown off by the leaves of plants.

STUDIES OF CUTTINGS.

Plants increase normally by seeds, stolons, ›r root sprouts. These natural processes ubserve the necessities of nature in providing a succession of vegeation upon the earth. For man's uses, however, it is desirable 'or many purposes that there be large numbers of plants which are imilar in the character of their growth or which produce fruits ›r flowers that are alike. Plants in nature conform to these requirenents in part only. It therefore becomes necessary to use methods 'or increasing certain plants which will insure uniformity. The 'eproduction of plants by cuttings is one of the methods employed to iccomplish this result.

A cutting is a detached portion of a plant inserted in soil or water for the purpose of reproducing a plant with characters like :hat from which the cutting was taken. There are several types of

cuttings, such as herbaceous cuttings, those made from the soft gro-
ing wood, and hard-wood cuttings, made from the growth of the se-
son after the growing period is past and the wood has bee
matured. Grapes, currants, privet, and plants of that character
readily increased from hard-wood cuttings of this nature. Lea-
of plants, such as the begonia and hoya (wax plant), are largely u-
to increase their kind.

Hard-wood Cuttings.

Simple cuttings.—The most common form of hardwood cuttings
that usually employed in propagating the grape and currant
11, *a*). Such a cutting consists of a straight portion of a shoot

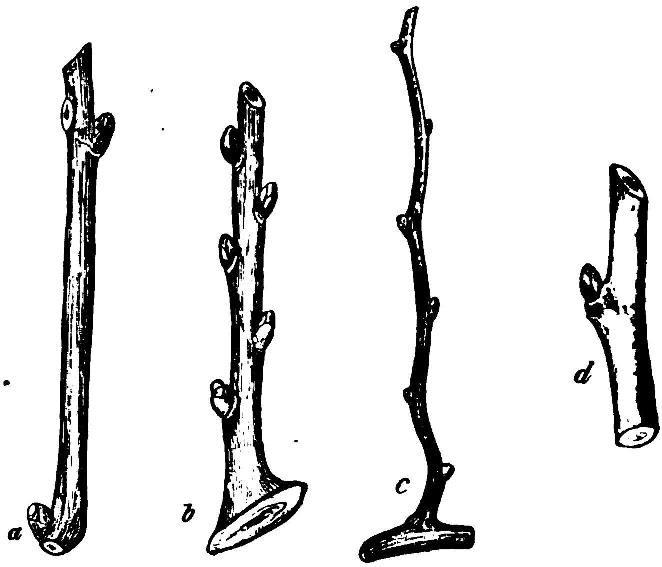

FIG. 11.—Cuttings: *a*, simple cutting; *b*, heel cutting; *c*, mallet cutting; *d*, single-
cutting.

cane, nearly uniform in size throughout, and containing two or mo-
buds. At the lower end it is usually cut off just below a bud, beca-
roots develop most readily from the joints. At the top the cut is
usually made at some distance above the highest bud.

Exercise 17.—Make simple cuttings.

Heel cuttings.—A cutting of the heel form (fig. 11, *b*) consists of the
lower portion of a branch containing two or more buds, cut from the
parent branch in such a manner as to carry with it a small portion of
that branch, forming the so-called "heel."

Exercise 18.—Make heel cuttings.

Mallet cuttings.—A cutting of mallet form is produced by severing the parent branch above and below a shoot, so as to leave a section of it on the base of the cutting (fig. 11, *c*).

Exercise 19.—Make mallet cuttings.

The principal advantage in the use of heel cuttings and mallet cuttings lies in the greater certainty of developing roots. The principal drawback is that only one cutting can be made from each lateral branch.

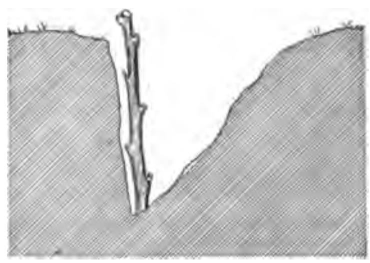

FIG. 12.—Cutting set in trench.

Single-eye cuttings.—When it is desired to make the largest possible number of cuttings from a limited supply of wood, cuttings are made containing but one bud each (fig. 11, *d*). Such cuttings are commonly started under glass with bottom heat, either in greenhouse or hotbed. They may be set either in horizontal position, with the bud on the upper side, or perpendicularly. In either case the bud is placed about an inch below the surface, preferably in clean sand, which should be kept uniformly moist.

FIG. 13.—Leaf cutting—part of leaf.

Treatment of hard-wood cuttings.—Cuttings are usually made with two or more buds. The cuttings are made while the wood is dormant during the autumn or early winter. As fast as made, the cuttings are tied in bundles of 25 or 50, with butts all one way, and are buried bottom end up in a trench, being covered to a depth of 2 to 6 inches with sand or mellow soil. This protects the top buds from freezing and gives the butts the benefit of the warmth of the sun in the spring, thus stimulating root development. Cuttings may also be kept over winter in a cool cellar, buried in sand, sawdust, or moss.

The following spring the bundles are taken up and the cuttings set about 3 inches apart, with only the topmost bud or buds above the surface of the ground (fig. 12). The soil is then replaced and thoroughly packed. In planting, the cuttings should be exposed to light and air as little as possible.

Herbaceous or Soft-wood Cuttings.

This class of cuttings is exemplified in the "slips" used to increase the numbers of house plants. Many greenhouse plants, including roses, carnations, geraniums, chrysanthemums, fuchsias, begonias, and

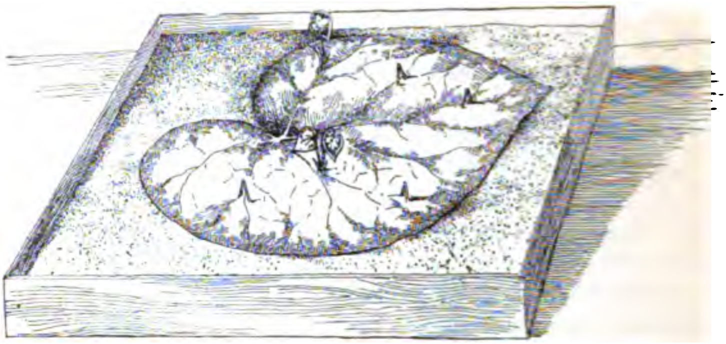

FIG. 14.—Leaf cutting—whole leaf.

the like, are propagated by soft-wood cuttings. One of the chief advantages of this method of propagation is that it can be employed in the winter under glass.

Herbaceous cuttings may be made from the leaf or stem.

Leaf cuttings.—These are commonly employed in multiplying hoyas (wax plants), begonias, and other plants having thick fleshy leaves containing a large quantity of plant food either in the body of the leaf or its larger ribs. Such cuttings may be made from parts of a leaf (fig. 13), or a whole leaf may be employed (fig. 14). In either case a leaf which has reached its full development and is in a vigorous, healthy condition is essential.

FIG. 15.—Stem cutting or "slip."

Stem cuttings.—A stem cutting, or "slip," is a portion of a branch containing two or more nodes, with leaves attached (fig. 15). Stem cuttings of coleus, geranium, and allied plants strike root very freely. As a general rule, in preparing slips the leaf area should be reduced a minimum in order to lessen evaporation of the moisture contained the cutting, and thus prevent wilting.

Tuber Cuttings and Root Cuttings.

Tuber cuttings.—Tubers (fig. 16) are thickened portions of either ›ots or stems in which starch is stored. Irish and sweet potatoes ·e familiar illustrations of tubers. Roots › not commonly arise from the tubers ıemselves, but from the bases of young ıoots or sprouts. When these sprouts ıve developed roots, they may be removed ·om the tuber cutting and planted inde- endently, when the cutting will then send ıt new sprouts. This practice is some- mes employed with new varieties of Irish potatoes in order to secure maximum yield from a small stock of seed potatoes.

FIG. 16.—A tuber—Irish potato.

In cutting Irish potatoes, there should be at least one eye on each iece; but in cutting such roots as sweet potatoes and dahlias, which ave no eyes, it is only necessary that each piece should have upon it portion of the skin or epidermis from which adventitious buds ıay develop.

Tuber cuttings may be planted in hotbeds for the production of prouts or sets, which are then removed to be set in the field or garden, or, as is customary with Irish potatoes, the cuttings may be planted in furrows in the field or plot which is to produce the crop.

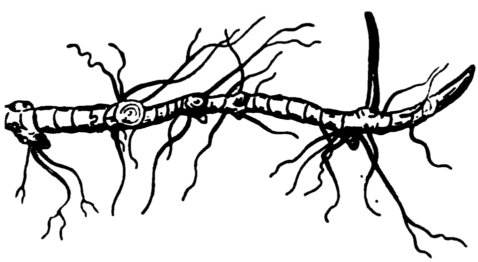

FIG. 17.—A rootstock.

Exercise 20.—Make and plant tuber cuttings of Irish potatoes.

Root cuttings.—Short cuttings of the roots may be ısed in the propagation of many plants, especially those which show natural tendency to sucker. Rootstocks (fig. 17) of Johnson grass, Bermuda grass, and some other grasses can be cut into short pieces ınd used in setting fields to grass. With root cuttings of many plants ›ottom heat is useful, but root cuttings of the blackberry do well with ›rdinary outdoor treatment.

Horse-radish is almost universally propagated by root cuttings. The small lateral roots may be cut into pieces 3 inches in length and planted. Care should be taken to place them in the ground ei… horizontally or right end up. In order to avoid mistakes in pla… the roots in the ground, cuttings may be made with a slanting cut … the base and a square cut at the top.

Facilities for Rooting Cuttings.

In order to successfully root cuttings of coleus, geraniums, fuch… roses, and begonias in the schoolroom it will be an advantag… have a broad window box constructed somewhat as follows: M… a frame about 15 inches wide, 6 inches high at one side and … inches high at the other, and as long as the width of the w… dow in which it is to be used. Place a tight bottom in t… frame, thus making a box similar to that shown in figure … Provide 3 or 4 holes one-half inch in diameter in the bottom of t… box to allow the escap… any excess moisture. Pl… about one inch of bro… pots, coarse gravel, or cli… ers in the bottom of the b… and on top of these pl… a layer of clean sand fr… from clay or decaying … ganic matter, about 2½ to … inches thick. Over the t… place panes of glass, … to make a close but w… lighted chamber within t… frame. Place the soft cu… tings in this frame. B… using care in watering a… providing ventilation … the partial removal of t… glass as necessity requir… under such treatment, f… results should follow. Some experience will be necessary to succ… fully root plants even with this device, but much better results may b… expected than without it.

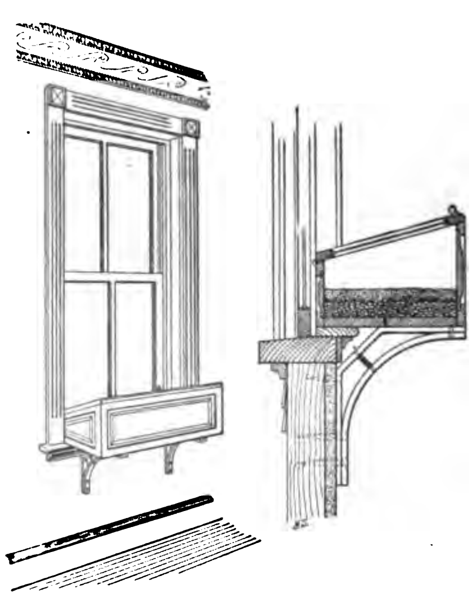

FIG. 18.—Frame for rooting cuttings.

STUDIES OF GRAFTS.

Were all forms of the art of grafting and budding to be taken fr… the horticulturists to-day, commercial fruit growing in its high st… of perfection would decay with the orchards now standing.

Scion.

A scion is a portion cut from a plant to be inserted upon anoth… (or the same) plant, with the intention that it shall grow. Ex…

or herbaceous grafting, the wood for scions should be taken while ı a dormant or resting condition. The time usually considered ·est is after the leaves have allen, but before severe freezng begins. The scions are tied n bunches and buried in moist and, where they will not freeze ·nd yet will be kept cold enough o prevent growth. Good reults often follow cutting scions n the spring just before or at he time the grafting is to be lone. If cleft grafting is the tyle to be employed, this practice requently gives good results, but he cutting of scions for whip

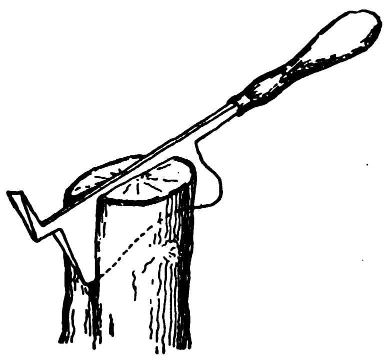

FIG. 19.—Grafting tool.

grafting is not desirable at this season, as not enough time is given for a proper union to take place before planting time in the spring.

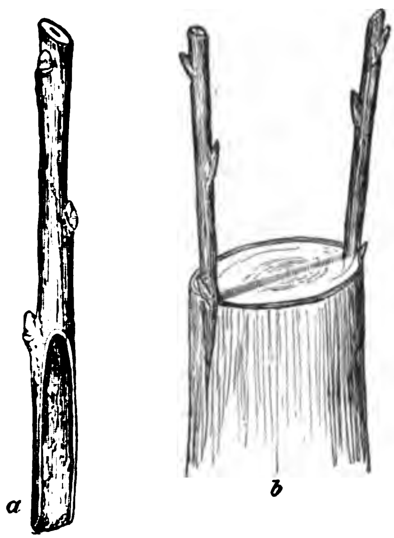

FIG. 20.—Cleft grafting. *a*, scion; *b*, scions inserted in cleft.

Stock.

The stock is the plant or part of a plant upon which or into which the bud or scion is inserted. For best results in grafting it is essential that the stock be in an active condition, or so that active growth can be quickly brought about.

Cleft Grafting.

The cleft style of graft is particularly adapted to large trees when for any reason it becomes necessary to change the variety. Branches too large to be worked by other methods can be cleft grafted.

Exercise 21.—To make a cleft graft select a branch 1 or 1½ inches in diameter and sever it with a saw. Care should be taken that the bark be not loosened from any portion of the stub. Split the exposed end with a broad thin chisel or grafting tool (fig. 19). Then with a wedge or the wedge-shaped prong at the end of the grafting tool spread the cleft so that the scion (fig. 20, *a*) may be inserted (fig. 20, *b*).

The scion should consist of a portion of the previous season's growth and should be long enough to have two or three buds. The lower end of the scion, which is to be inserted into the cleft, should be cut into the shape of a wedge having the outer edge thicker than the other (fig. 21). In general it is a good plan to cut the scion so that the lowest bud will come just at the top of this wedge (fig. 20, *a*) in order that it will be near the top of the stock. The advantage of cutting the wedge thicker on one side is illustrated in figure 21, which shows how the pressure of the stock is brought upon the outer growing parts of both scion and stock, whereas were the scion thicker on the inner side the conditions would be reversed and the death of the scion would follow.

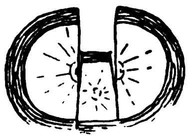

Fig. 21.—Cross section of stock and scion.

The importance of having an intimate connection between the growing tissues of both scion and stock can not be too strongly emphasized, for upon this alone the success of grafting depends. To make this contact of the growing portions doubly certain, the scion is often set at a slight angle with the stock into which it is inserted in order to cause the growing portions of the two to cross.

After the scions have been set, the operation of cleft grafting is completed by covering all cut surfaces with a layer of grafting wax.

Whip Grafting.

The style known as whip grafting is the one almost universally used in root grafting. It has the advantage of being well adapted to small plants only 1 or 2 years of age, as well as the other important consideration that it can be done indoors during the comparative leisure of winter.

Fig. 22.—Whip grafting: *a*, the stock; *b*, the scion; *c*, stock and scion united.

Exercise 22.—To make a whip graft, cut the stock off diagonally—one long smooth cut with a sharp knife, leaving about three-fourths of an inch of cut surface, as shown in figure 22, *a*. Place the knife about one-third of the distance from the end of the cut surface, at right angles to the cut, and split the stock in the direction of its long axis. Cut the lower end of the scion in like manner (fig. 22, *a* and *b*), and when the two parts are forced together, as shown in figure 22, *c*, the cut surfaces will fit neatly, and one will nearly cover the other if the scion and stock are of the same size. A difference in diameter of the two parts to be united may be disregarded unless it be too great. After the scion and stock have been locked together they should be wrapped with five or six turns of waxed cotton to hold the parts firmly.

While top grafting may be done in this way, it is in root grafting that the whip graft finds its distinctive field. When the roots are cut o lengths of from 2 to 5 or 6 inches to be used as stocks, the opera-n is known as piece-root grafting. Sometimes the entire root is ed.

The roots are dug and the scions are cut in the autumn and stored. e work of grafting may be done during the winter months. When operation has been completed the grafts are packed away in moss, wdust, or sand, in a cool cellar, to remain until spring. It is impor-nt that the place of storage be cool, else the grafts may start into owth and be ruined, or heating and rotting may occur. If the tem-rature is kept low—not above 40° F.—there will be no growth cept callousing and the knitting together of stock and scion.

In ordinary propagation by means of whip grafts, the scion is cut ith about three buds, the stock being nearly as long as the scion. he grafted plant is so set as to bring the union of stock and scion low the surface of the ground.

When whip grafting is employed above ground the wound must be rotected, as in cleft grafting, either with a mass of grafting wax or bandage of waxed muslin.

Grafting Wax.

A good grafting wax may be made of the following ingredients: Resin, 4 parts; beeswax, 2 parts; tallow or linseed oil, 1 part—by weight. If a harder wax is needed, 5 parts of resin and 2½ of bees-wax may be used with 1 part of tallow.

The resin and beeswax should be broken up fine and melted together with the tallow. When thoroughly melted the liquid should be poured into a vessel of cold water. As soon as it becomes hard enough to handle it should be taken out and pulled and worked until t becomes tough and has the color of very light-colored manila paper. If the wax is applied by hand, the hands should be well greased, tal-low being the best material for this purpose. The wax may be applied hot with a brush, but care is necessary in order to avoid injury.

The wax should be spread carefully over all cut or exposed surfaces and pressed closely, so that upon cooling it will form a sleek coating impenetrable to air or moisture.

Waxed string may be prepared by putting a ball of No. 18 knitting cotton into a kettle of melted grafting wax. In five minutes it will be thoroughly saturated, after which it will remain in condition for use indefinitely.

STUDIES OF BUDDING.

There are numerous styles of budding, but only the one in most common use will be described here. Budding is one of the most economical forms of artificial reproduction, and each year witnesses its more general use. Some nurserymen go so far as to use it as a substitute for all modes of grafting save whip grafting in the propagation of the dwarf pear. Budding is economical in the amount of wood used from which to take buds. In this method a single bud does the work of the three or more upon the scion used in grafting. But while it is economical of wood, it is expensive in the use of stocks, a seedling being required for each tree, while, with the piece-root system of grafting, two, three, or more stocks can be made from a single seedling.

FIG. 23.—A bud stick.

The operation of budding is simple, and can be done with great speed by expert budders. The expense of the operation is, therefore, not more than that of whip grafting, although the work has usually to be done in July, August, or early September. The usual plan is for a man to set the buds and a boy to follow closely and do the tying.

The Bud.

The bud should be taken from wood of the present season's growth. Since the work of budding is done during the season of active growth, the bud sticks are prepared so that the petiole or stem of each leaf is left attached to serve as a handle to aid in pushing the bud home when inserting it beneath the bark of the stock. This is what is usually called a shield bud, and is cut so that a small portion of the woody tissue of the branch is removed with the bud. A bud stick is shown in figure 23. The operation of cutting the bud is illustrated in figure 24.

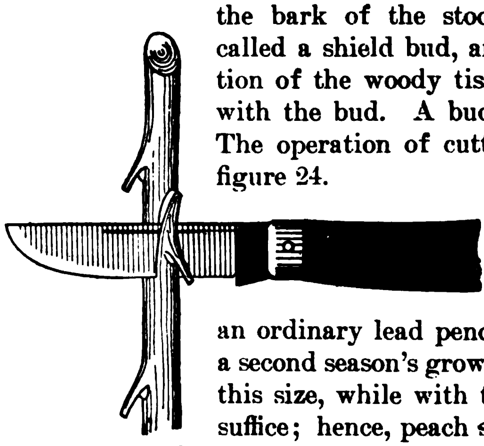

FIG. 24.—Cutting the bud.

The Stock.

The stock for budding should be at least as thick as an ordinary lead pencil. With the apple and pear a second season's growth will be necessary to develop this size, while with the peach a single season will suffice; hence, peach stocks can be budded the same season the pits are planted. Consequently the peach is left until as late in the season as is practical in order to obtain stocks of suitable size. The height at which buds are inserted varies with the operator. In general, the nearer the ground the better.

Exercise 23.—To bud a plant, make a cut for the reception of the bud in the shape of a letter T (fig. 25, *a*). Usually the crosscut is not quite at right angles with the body of the tree, and the stem to the T starts at the crosscut and extends toward the root for an inch or more. Loosen the flaps of bark caused by the intersection of the two cuts (fig. 25, *b*) with the ivory heel of the budding knife, grasp the bud by the leaf stem as a handle, insert it under the flaps and push it firmly in place until its cut surface is entirely in contact with the peeled body of the stock (fig. 26, *a*). Tie a ligature tightly about it, above and below the bud, to hold it in place until a union shall be formed (fig. 26, *b*). Bands of raffia or wrapping cotton, about 10 to 12 inches long, make a most convenient tying material. As soon as the buds have united with the stock the ligature should be cut in order to prevent girdling the stock. This done, the operation is complete until the following spring, when all the trees in which the buds have "taken" should have the top cut off just above the bud (fig. 26, *c*).

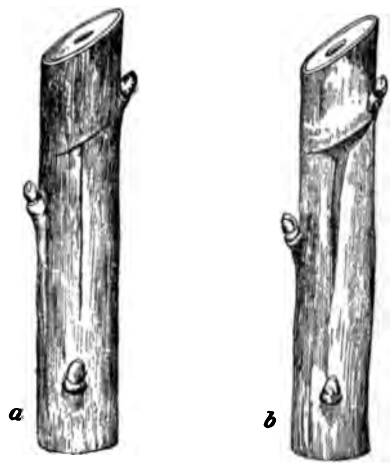

FIG. 25.—Budding: Preparing the stock.

WINDOW BOXES FOR SCHOOLROOMS.

Because of the conditions which prevail in a schoolroom, window boxes must be made comparatively deep and must contain a larger quantity of soil than is commonly necessary for the growth of plants in greenhouses in order that the adverse conditions may in part be counteracted. Boxes intended for window gardens should therefore be made at least 6 to 8 inches in depth, should be rather broad, and of a length to conform to the window opening. The soil should be rich garden loam or a compost consisting of rotted sods and stable manure thoroughly mixed together and screened through a screen with at least a half-inch mesh.

Before filling the box a layer of broken pots, or coarse gravel, or clinkers from the ash heap should be placed over the bottom of the box to the depth of 1 inch. If the box is made air-tight, holes should be provided in the bottom, in order that any excess of moisture which comes from watering the plants may escape from the bottom. After placing this drainage material in the bottom of the box fill it to within 1 inch of the top with the soil above described. Window boxes which are to be used for propagating plants from cuttings need not be more than 6 inches deep, and should have the drainage material above mentioned, with about 3 inches of clean sand placed over the clinkers.

The cuttings may then be prepared as suggested and planted in rows about 3 inches apart, with the ends of the cuttings inserted about

1 inch deep in the sand. Thoroughly moisten the sand after placing the cuttings in position, and cover the box for twenty-four hours with an old newspaper. After that time replace the newspaper by panes of glass, which should themselves be shaded by a single sheet of newspaper when the sun is too intense. Remove the shade when the sun does not shine directly on the plants, and if moisture condenses to any considerable extent upon the glass, lift or partly remove the glass so as to give ventilation, but do not allow the cuttings or the sand to become dry.

Plants to be used in window boxes can be grown from seeds sown in 4-inch pots, prepared somewhat as follows: Place a layer of broken pots, gravel, or clinkers in the bottom of the pot, and on top of this fill the pot to within about an inch of the surface with a compost similar to that suggested for filling window boxes. If the seeds to be sown are small and fine like the begonia, sprinkle a thin layer of sand over the surface of the soil in the pot and sow the seeds in the sand. Moisten the earth by setting the pot for a minute in a receptacle which contains water of sufficient depth to bring it to within an inch of the surface of the soil in the pot. Lift the pot from the water as soon as the soil is moistened; place it in a warm, sunny situation, and cover it with a piece of glass. As soon as the seeds begin to germinate, remove the glass to a slight extent by placing under one edge a match, or by slipping it partly off the surface of the pot. Judgment must be used in regard to the amount of air to be given to prevent the plants from becoming drawn and yet keep them from being injured by becoming too dry.

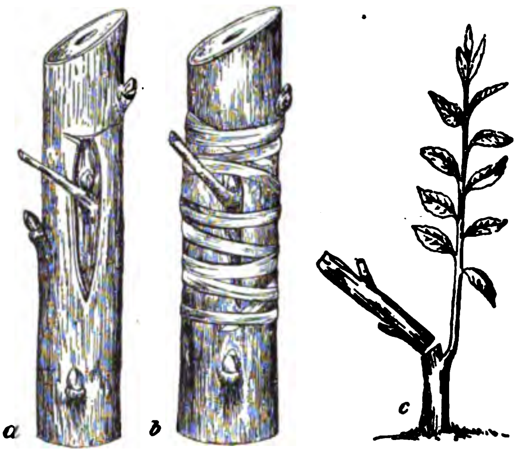

FIG. 26: Budding: *a*, inserting the bud; *b*, tying; *c*, cutting off the top.

Large seeds, like seeds of the nasturtium, should be planted about an inch deep in the soil of the pots, prepared as above described, but no layer of sand need be used with plants of this character.

The character of plants to be used in a box will be determined by the preferences of the cultivator, but in general they should be small and compact in habit of growth, or those which can be trained readily on strings. The following list will serve as a guide in their selection.

PLANTS SUITABLE FOR WINDOW BOXES.

Plants which can be grown from seed.—Ageratum, petunia, sweet alyssum, mignonette, *Lobelia erinus*, portulaca, *Bellis perennis*, *Primula obconica*, coleus, nasturtium (dwarf), dianthus, stock.

Other plants.—Geranium, fuchsia, calla, begonia, lantana, abutilon, German ivy, tradescantia, vinca.

SPECIMEN PLANTS FOR SCHOOLROOMS.

The conditions obtained in the living room or schoolroom are as a general rule very trying to plants. Light, heat, and ventilation are very uncertain in schoolrooms, particularly during the interim between Friday afternoon and Monday morning. The plants which are capable of enduring such adverse conditions as usually obtain during this period are few. The following, however, may be mentioned as among those possessing most merit for schoolroom use: *Aspidistra lurida; Aspidistra elatior* var. *variegata;* lantana; geranium; begonia; cactus; umbrella plant; amaryllis; sword fern; Jerusalem cherry; *Ficus elastica;* abutilon; oleander; screw pine (Pandanus); oxalis; *Primula obconica;* German ivy; *Asparagus sprengeri;* peperomia; *Sansevieria zeylanica.*

THE DECORATION OF SCHOOL GROUNDS.

Two primary objects should be kept in view in the decoration of school grounds: (1) Instruction; (2) beauty and utility.

The primary object of the school is instruction. The work of beautifying the school grounds should also carry with it an element of instruction. The grounds should serve as an object lesson for the residents of the community in which the school is located. They should be laid out on sound principles of landscape gardening, and be so well executed as to induce residents of the vicinity to copy the general idea of the plan and possibly the details of the shrubbery groups. The idea of beauty can be emphasized in the proper grouping of trees and shrubs in relation to walks, drives, and vistas, and utility can be subserved by so placing the heavy plantings as to serve as a shield from the wind or sun. Shrubbery groups can be arranged so as to separate one portion of the grounds from another and yet not to interfere with large open spaces which can be used as playgrounds, such as ball fields, tennis courts, etc.

THE PLAN.

The first essential for the work of beautifying the grounds will be a plan, as suggested in figure 27. The beginning of this plan may be

a rough sketch of the area on which the school building stands, w.
directions and distances marked upon it. Next, locate the perma-
objects, such as trees and buildings. Determine next the main l-
of travel leading to the schoolhouse and use these as a basis for t-
permanent walks, unless there is some good reason for changing t-
main paths. The walks and drives should be straight, if dista-
are less than 100 feet, and gently curved if longer, so as to admit
the use of trees and shrubs along the border. The outlook from e-
door and window should be carefully inspected before determin-
which objects in the landscape should be retained in view and wh-
hidden or concealed by the use of trees and shrubs.

Trees and shrubs should be confined chiefly to the borders of t-
place, an open and unbroken lawn being preserved in front and -

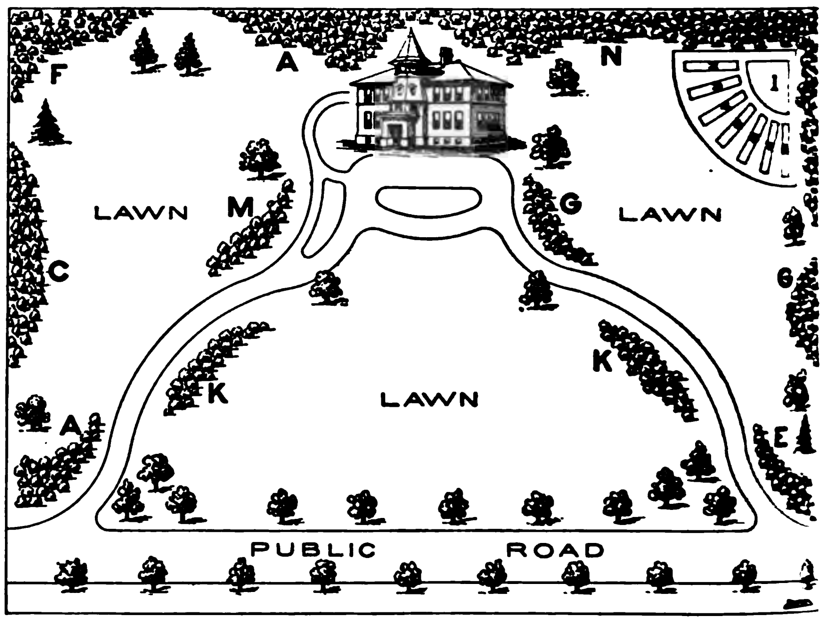

FIG. 27.—Planting plan for school grounds.

the sides or rear where playgrounds are to be maintained. The diff-
ence between indiscriminate planting and conformity to this plan -
well exemplified in figures 28 and 29. In rural districts the tr-
should be so located as to give protection from storms in winter a-
from the sun in summer, and at the same time to produce a plea-
effect. Shrubs may be employed to advantage in screening unsight-
objects, as suggested in figures 30 and 31. The plans of the grou-
will serve both as an exercise in geography and in arithmetic, and -
the pupils are encouraged to make such designs their interest in th-
work will be assured and a practical application of the principle
taught in the schoolroom will be a result of no little value.

WALKS.

The walks leading to and from the school should be direct, but where space will permit they should have gentle and pleasing curves

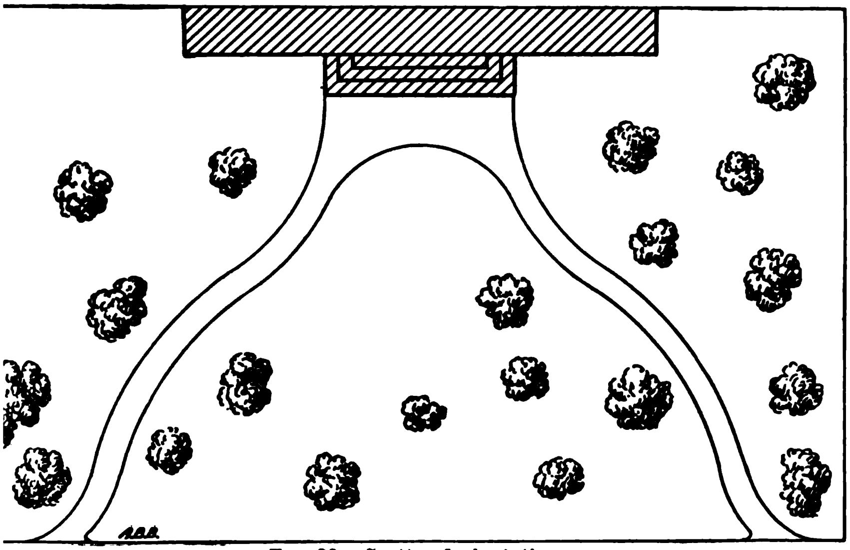

FIG. 28.—Scattered plantations.

which conform to the contour of the ground. Upon level areas it is well to allow an artistic use of shrubs in groups in the bays, which

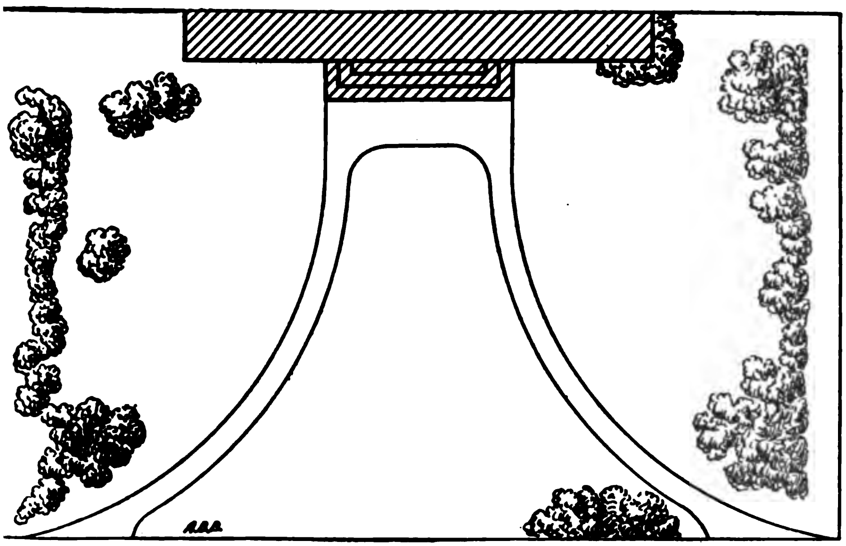

FIG. 29.—Group planting.

shall serve to break the monotony and obtrusiveness of an unscreened straight walk across an open lawn.

The material used in the construction of walks will be determined by circumstances and by the locality in which the work is to be done.

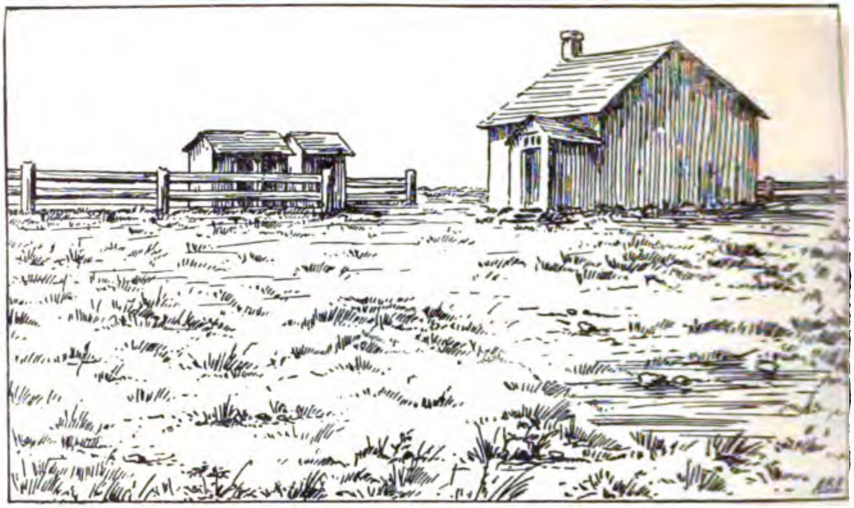

FIG. 30.—Unadorned school grounds.

When the walks are to be made permanent, nothing fills the requirements better than cement or artificial stone. When gravel or cement

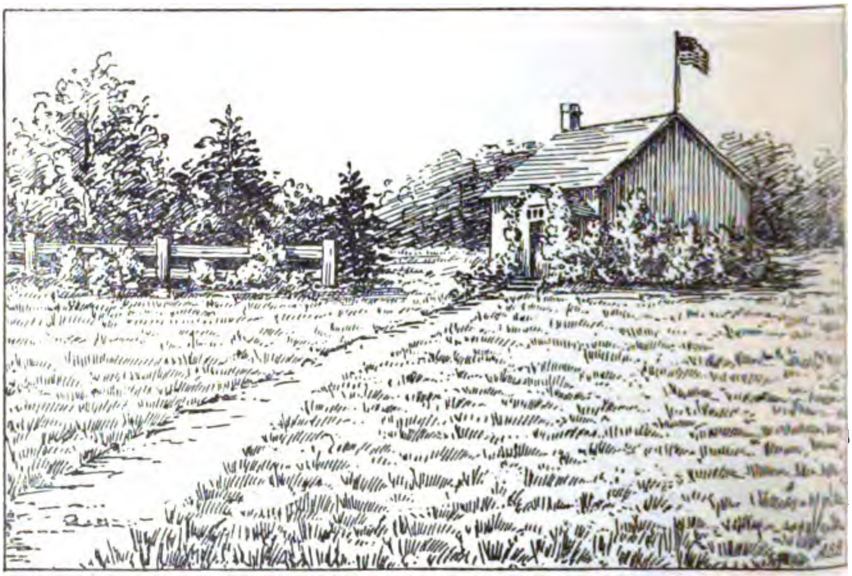

FIG. 31.—The school grounds shown in figure 30 softened by trees and shrubs.

is used the walks should be made slightly crowning, and the highest point in its surface should be at least 2 inches below the general level of the greensward. No coping or borders should be allowed, and the grass should be brought up to the edge of the gravel or cement. A slightly sunken walk makes the care of the lawn easier, besides hiding it very effectively from view when looking across the lawn, thus giving the grassplot an unbroken appearance and having the effect of enlarging its extent.

LAWNS.

Lawns are the foundation of all decorative planting. A good, well-kept lawn contributes more to the beauty of grounds than any other single factor. For this reason special attention should be given to the grading, cultivation, and enriching of the area to be devoted to the lawn. After good preparation come good seed and care.

The variety of soils which will be encountered and the special treatments which they need render it possible to make only the broadest generalizations here. For localities north of St. Louis, Mo., and Richmond, Va., lawns can be formed chiefly of bluegrass, redtop, and white clover. South of this point Bermuda grass and St. Augustine grass will have to be relied upon chiefly, although it is said that in some places alfalfa has been employed with good results.

The letters on the plan, figure 27, have reference to the groups of shrubbery indicated in detail in figure 32. The details of the arrangement of the groups, as well as names of the plants composing them, are suggested, but must of necessity be varied in different parts of the United States to allow the use of plants adapted to the region, a brief list of which can be found on page 40 of this publication.

For more detailed planting plans the reader is referred to Farmers' Bulletin No. 185.

ANNUAL PLANTS.

Annual flowering plants, such as those mentioned in the following list, may be used to give immediate effects in place of the more permanent trees and shrubs. Even after the trees and shrubs have been planted the annual plants can, with good effect, be used among them. The list is self-explanatory, and the plants can be so placed as to produce a variety in color or a contrast in height and general effect.

Annual Plants Suitable for School Grounds.

Tall foliage plants.—Castor bean, caladium, canna.

Tall flowering plants.—Cosmos, scarlet sage, sunflowers.

Border plants.—Alternanthera, alyssum, ageratum, coleus.

Medium-tall annual flowering plants.—Geranium, California poppy (Eschscholtzia), zinnia, marigold, aster, petunia, cockscomb, larkspur, nasturtium.

Climbing annuals.—Cobæa scandens, moonflower, Japanese morning glory.

For a more comprehensive list of annual flowering plants [illegible] Farmers' Bulletin No. 195.

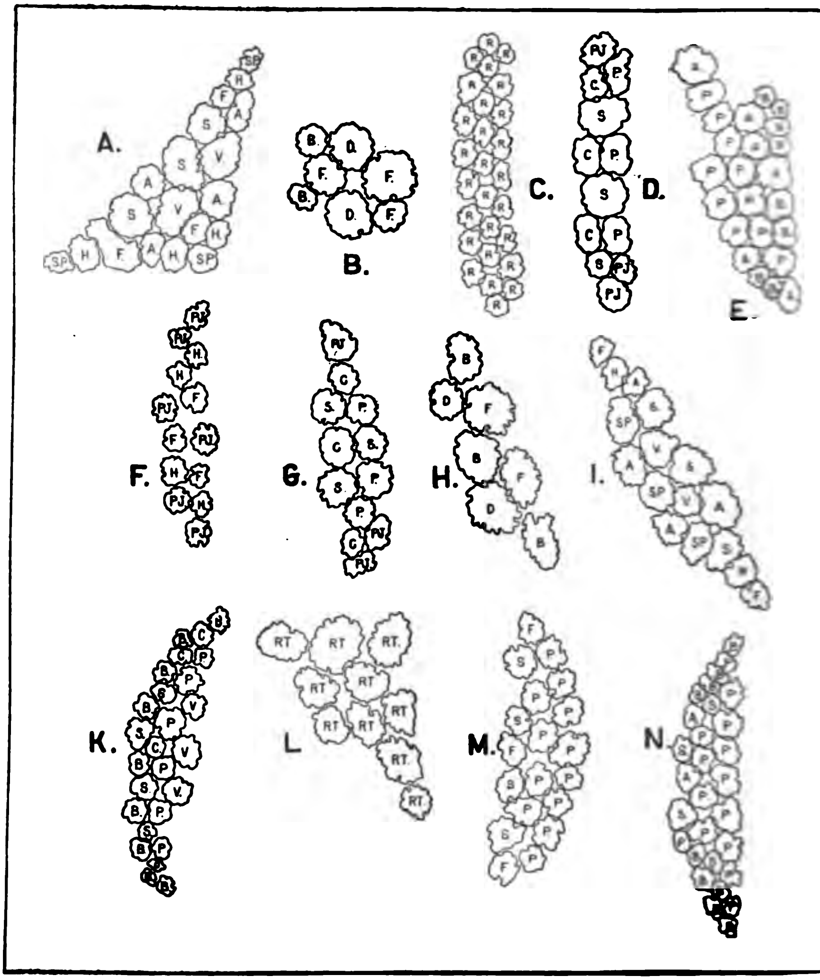

FIG. 32.—Detail of shrubbery groups shown in figure 27. GROUP A.—F, 3 Forsyt[illegible] (May); S, 3 Syringa (May); V, 2 Viburnum (June); SP, 3 Spiræa (July); A, 4 Al[illegible] (August and September); H, 4 Hydrangea (August and September). GROUP B.—[illegible] Deutzia crenata (June); F, 3 Forsythia; B, 2 Berberis. GROUP C.—R, 27 Ro[illegible] variety. GROUP D.—C, 3 Calycanthus; P, 3 Philadelphus; S, 3 Syringa (white[illegible] 3 Pyrus japonica. GROUP E.—A, 6 Althea; B, 8 Berberis; P, 10 Privet. GROUP [illegible] F, 3 Forsythia; H, 4 Hydrangea; PJ, 6 Pyrus japonica. GROUP G.—C, 3 Calycanth[illegible] P, 3 Philadelphus; S, 3 Syringa (white); PJ, 3 Pyrus japonica. GROUP H.—[illegible]zia crenata (June); F, 2 Forsythia; B, 3 Berberis. GROUP I.—F, 2 Forsythia (Ma[illegible] S, 3 Syringa (May); V, 2 Viburnum (June); SP, 3 Spiræa (July); A, 4 [illegible] (August and September); H, 2 Hydrangea (August and September). GROUP K.—[illegible] Viburnum plicatum; S, 4 Syringa (white and purple); C, 4 Calycanthus; B, [illegible]beris; P, 6 Privet. GROUP L.—RT, 10 Rhus typhina (sumac). GROUP M.—[illegible] Privet; S, 4 Syringa; F, 3 Forsythia. GROUP N.—P, 14 Privet; S, 4 Syringa; A[illegible] Althea; B, 9 Berberis.

TREES AND SHRUBS.

The cultural directions here given are not ideal by any means, but are offered in the way of suggestion and should be so considered.

Cultural Directions.

The beauty of a shade tree depends upon its normal and symmetrical growth. In order to insure this, before planting cut off the ends of all broken or mutilated roots; remove all side branches save upon evergreens, so that a straight whip-like stalk alone remains. Dig holes at least 2 feet in diameter and 1 foot deep in good soil, and make them 4 feet across in poor soil. The sides of holes should be perpendicular and the bottom flat. Break up soil in the bottom of the hole to the depth of the length of a spade blade. Place 2 or 3 inches of fine top soil, free from sods or other decomposing organic matter, in the bottom of the hole. On top of this place the roots of the tree, spread them as evenly as possible over the bottom of

FIG. 33.—Map of the United States showing districts suited to the growth of various trees.

the hole, and cover with 2 or 3 inches of fine top soil as before. Tramp firmly with the feet and fill the hole with good earth, leaving the surface loose and a little higher than the surface of the surrounding soil. When the work of planting is completed, the tree should stand about 2 inches deeper than it stood in the nursery.

In order to insure symmetry of growth, trees must be allowed unrestricted area for development. At least 40 feet should be allowed between trees intended to occupy the ground permanently. Quick-growing nurse or temporary trees may be planted between the long-lived ones to produce immediate results, but these should be removed as soon as they interfere with the development of the permanent plantations.

The lists of trees and shrubs contained in this publication are merely suggestive, but in all cases they include such sorts well adapted to the particular locality for which they are rec- mended. Because of the great differences existing in the soil a climatic conditions of the several parts of the United States · country has been partitioned into five sections, and a list of tre- shrubs suitable for school grounds or for home adornment is enu- ated for each section. The section in which any particular scho located can be determined by a glance at the map (fig. 33). and ref- ence to the list of trees and shrubs will assist in selecting suit decorative material for the grounds.

Trees and Shrubs Suitable for School Grounds.

District 1.

Deciduous trees.—Sugar maple, Norway maple, silver maple, green ash, wh ash, American white elm, red oak, white oak, pin oak, American linden.

Evergreen trees.—Norway spruce, white spruce, Colorado blue spruce, wh pine. Scotch pine, balsam fir.

Shrubs.—Lilac, golden bell, exochorda, snowball, mock orange, hydra- Japan quince, flowering currant, calycanthus, cornus, deutzia, spiræa, weigel.

District 2.

Deciduous trees.—Tulip, sycamore, pin oak, white oak, black oak, live oak, oak, white ash, bald cypress, Norway maple, silver maple, red elm, Americ white elm, Kentucky coffee, American linden, catalpa, liquidambar, Caro poplar, hackberry, sour gum.

Evergreen trees.—White pine, long-leaf pine, magnolia, live oak, cedar Lebanon.

Shrubs.—Golden bell, hydrangea, lilac, *Elæagnus longipes*, loniceras, hib hardy roses, Japan quince, calycanthus, smoke tree.

South of Charleston, S. C.—Camellia japonica.

Southern Florida and Texas.—Oleander, privet.

District 3.

Deciduous trees.—Bur oak, linden, silver maple, Norway maple, cottonw green ash, box elder, wild cherry, larch, American elm, *Catalpa speciosa*, bl walnut, hackberry.

Evergreen trees.—Scotch pine, Austrian pine, white pine, Norway spruce, Co rado blue spruce, white spruce, red cedar, arbor vitæ.

Shrubs.—Lilac, barberry, cornus, *Tamarix amurensis*, Japan quince, *Ro rugosa*, cratægus, *Elæagnus hortensis*, snowdrop, *Shepherdia argentea*.

District 4.

Deciduous trees.—Valley cottonwood (*Populus fremontii wislizenia*), mount cottonwood (*Populus angustifolia*), mountain ash (*Fraxinus velutina*), b elder (*Acer negundo*).

Evergreen trees.—Arbor vitæ, *Cedrus deodara*, box, euonymus.

Shrubs.—Althea, snowball, mock orange, wild rose, crape myrtle, spiræa flowering currant, elder, lilac.

District 5.

Deciduous trees (Coast region).—Large-leaved maple, tulip tree, mountain European linden, sycamore, weeping willow.

Shrubs (Coast region).—Roses, weigela, European holly, lilac, laburn deutzia, *Hydrangea paniculata*, mock orange, Japan quince.

Trees (Columbia Basin).—Scotch elm, American elm, Norway maple, Eur- pean linden, sycamore, green ash, silver poplar, Russian poplar, white willo

Shrubs (Columbia Basin).—Lilac, hardy roses, Philadelphus, *Elæagnus h tensis*, laburnum, spiræa, *Tamarix amurensis*, *Rosa rugosa*, barberry.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 219.

LESSONS FROM THE GRAIN-RUST EPIDEMIC OF 1904.

BY

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Cerealist in Charge of Cereal Investigations, Vegetable Pathological and Physiological Investigations, Bureau of Plant Industry.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1905.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., February 25, 1

SIR: I have the honor to transmit herewith the manuscript of article entitled "Lessons from the Grain-Rust Epidemic of 1 and recommend that it be published as a Farmers' Bulletin.

This paper was written by Mr. Mark Alfred Carleton, Cerealist this Bureau, and was submitted by Mr. A. F. Woods, Pathologist Physiologist, with a view to publication.

Respectfully,

B. T. GALLOWAY,
Chief of Bur

Hon. JAMES WILSON,
Secretary of Agriculture.

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ILLUSTRATIONS.

:SSONS FROM THE GRAIN-RUST EPIDEMIC OF 1904.[a]

INTRODUCTION.

In respect to grain production, the season of 1904 was characterized ' one unusual feature, particularly in the hard spring wheat region. :obably the most severe attack of rust ever known in that region, rtainly the most severe in the last twenty or twenty-five years, curred during that season. While the results appear to be most seri- is in the States of North Dakota, South Dakota, and Minnesota, uch damage was also caused farther north in the neighboring dis- icts in Canada and in portions of the adjacent States of Wisconsin, wa, Nebraska, and Kansas. The season was noted for a considerable nount of rust in almost all portions of the United States. Generally, ıly wheat and oats were badly affected, wheat suffering most of all. here was little or no damage to barley as a rule, but in some places ye appears to have been injured considerably.

While the farmers, grain dealers, and especially millers, have gen- rally lamented the occurrence of such unusual havoc to the grain rops, nevertheless it is probably true that this disaster, like a number f others of national importance that might be mentioned, will be fol- owed by such improvements in grain cultivation resulting from the essons learned at this time as will counterbalance several times over he actual loss sustained in the deficiency of grain production this one eason.

It is the purpose of this bulletin to call attention to some of the les- sons that may be learned from this rust epidemic, or, rather, in some ases simply to emphasize the importance of these lessons, since farmers generally have no doubt already noted that very different results would have been obtained by them if certain different methods

[a] Many of the results forming the basis of discussion in this bulletin were obtained in cooperative experiments with the South Dakota Agricultural Experiment Station, the North Dakota Agricultural Experiment Station, and the Office of Seed and Plant Introduction of the Bureau of Plant Industry.—A. F. Woods, *Chief Pathologist and Physiologist.*

had been practiced. Good results are already seen in the un... attention being given to the subject of seed selection by grain de... and millers in cooperation with the farmers throughout the Northw... There is nothing more promising for better things in agriculture th... the special attention at present given by commercial men to the se... tion and improvement of seed grain.

THE NATURE OF THE RUST DOING THE DAMAGE.

It is a fact not generally known, and yet of much importance f... our actual knowledge of conditions, that there are several differ... kinds of rusts that attack grains and that the existence of any one... these has no relation whatever to the occurrence of any of the other... except in the mere coincidence that they all thrive and propaga... much more rapidly in wet weather than in dry weather.

Each of the cereals, wheat and oats, is affected by two distinct rust... One of these is found chiefly on the leaves and causes very slig... damage, if any. On wheat it is called the "orange leaf" rust and o... the oat plant it is called the "crown" rust, because of the fact th... the spores at their upper portions have the form of a crown. T... other kind of rust on each of these cereals is called "black ste... rust, which, in seasons of great severity, is found in much abunda... on the stems. In the season of 1904, as well as in all other sea... when rust has done any great amount of damage, it was this bla... stem rust that caused the injury. It always appears a little later th... the leaf rust, and until it does occur no particular injury to the pla... can be noticed. Many varieties of grain that ripen early, therefor... often escape damage by being able to mature just before the bla... stem rust appears in any considerable quantity.

A very erroneous idea of general prevalence should here be pointe... out. It is not true that one of these rusts is entirely a black rust a... the other entirely a red rust. Each kind has two stages—the red-r... stage, appearing first, followed by the black-rust stage. The kind o... rust generally called by farmers the "red" rust, and which we na... here the orange leaf rust, has, therefore, a black stage just the sa... as any other rust, but as the red or orange stage is so much mo... abundant than the other and occurs on the leaf, it is called the oran... leaf rust. On the other hand, the black stem rust has a red or brow... ish-red stage, which, however, is much less important than the bla... stage that occurs on the stem, and this kind is therefore called t... black stem rust. The occurrence of the various stages of these di... ferent rusts among each other on the same plants makes it difficult to distinguish them.

REASONS FOR UNUSUAL ABUNDANCE OF RUST IN 1904.

'aturally there has been some discussion of the question why there uld have been such an unusual prevalence of rust in 1904, and the)rrectness of certain theories should be pointed out. In the first ·e, it is not true that the rust is more abundant on exhausted soils that there is any increase in rust from year to year simply because soils are becoming "worn out." Neither is it true in principle that weaker plants are more rusted than others. This seems to be true the case of some other plant diseases, but in all attacks of rust it is, the contrary, a fact that the healthiest plants are as a rule the worst ted, and for the very natural reason that whatever conditions are best the plant are also favorable for the rust. It is no doubt partly for s reason that some believe that the fertility of the soil is concerned, of course, if the plants grow more rankly in a more fertile soil, ıer things being equal, they will have more rust. It is not, hower, because of any particular element in the fertile soil that the rust specially abundant, but chiefly because of the greater quantity of ter and therefore softer tissue in the growing plant.

The simple reasons for the unusual abundance of rust in 1904 are) the fact that there was an unusual quantity of moisture just at the oper time for the rust to do the most damage to the crop and (2) the usual delay in the ripening of the grain. The season was generally et and besides was preceded by wet seasons. There being a considable quantity of rust in the two previous wet seasons, it finally ached the climax of abundance in the third wet season of 1904, and pecially at the critical period. This period, when the greatest nount of damage is done, is always between the date of blossoming d the date of ripening, when the head is "filling out."[a] How the ıst is carried over from one season to another is not yet thoroughly nderstood in the case of the black stem rust, but it is possible that ny unusual quantity of rust one season will make it more likely for amage to occur to a crop the following season if the disease should ccur the second year at just the right time for doing the damage.

In this connection the question may be asked, Is rust increasing or ecreasing from year to year? The writer does not believe that this uestion can be answered accurately, although it is generally supposed hat as conditions throughout the country are becoming more and nore complicated with respect to both animal and vegetable life there s a tendency toward the increase of all kinds of diseases. This may)e true of grain rust. On the other hand, our knowledge of means of

[a]This period of "filling" of the grain was apparently delayed in 1904 in South Dakota, Nebraska, and southern North Dakota until just about the time of the occurrence of the rust in greatest abundance.

resisting or avoiding these diseases is also increasing, so that it is doubtful whether the actual damage to the crops from any particular disease is actually increasing. It has been stated that attacks of grain rust are much more common and serious now than years ago, when the land was first cultivated. On the other hand, in certain localities the worst cases of rust that the writer ever saw were only two or three years after the settlement of the country, the rust never having been so prevalent in those localities since that time. The prevalence of the disease is largely a question of the humidity of the atmosphere.

There is a rather common and erroneous belief among many farmers that rust is caused by the bursting of the stem or leaf of the plant by too much accumulation of "sap" within, this sap acquiring a reddish color on coming to the surface. It should be thoroughly understood that rust is a plant, just as an oak tree or a sunflower is a plant, although it propagates by means of spores instead of seeds. These spores are carried by the wind and grow only when they alight upon a living plant. After germinating and passing through the epidermis to the inside of the plant new spores are produced and multiply in such numbers that they burst the plant and emerge on the outer surface in long reddish or black lines.

PLANTING SEED DAMAGED BY RUST.

The seed from a crop injured by rust is in practically the same condition as seed that is shriveled from any other cause, such as drought or immaturity, at the time of harvesting. It is generally well known that seed that is merely shriveled from any of these other causes, unless to an extreme degree, is all right for planting. Seed that is much shriveled, however, from any cause should not be used, as it will not have the vigorous growth that it should develop after germination, not having a sufficient amount of stored-up material in the seed to give it a good start. The only important fact for the farmer to understand is that seed from rusted grain will not carry the rust into the next crop—at least so far as the grain rusts of our own country are concerned.

THE USE OF RUSTED STRAW IN STOCK FEEDING.

If straw is extremely rusted, it is of course likely to be of very little value for feeding, simply because a large part of the nutritive material has been consumed by the rust parasite. In such cases the straw becomes actually rotten and looks somewhat similar to straw that is decayed from any other cause. It is not known, however, that there is any particular poisonous action of such straw on the stock, so that while it may be a waste to feed straw badly rusted it is not likely to produce any injury. Many cases are known of feeding very large uantities of rusted straw and smutted corn and cornstalks to cattle ithout any injury whatever.

In harvesting badly rusted grain, the spores flying thickly in the ir sometimes cause considerable irritation in the nostrils and throats f the men who are at work. This is, however, merely a mechanical rritation, occurring only when there is a great abundance of the rust. Beyond this, no other bad effects on animal life due to the occurrence of rust are known.

VARIETIES OF CEREALS RESISTANT TO RUST.

By far the most important thing to be learned from the results of the general rust attack of 1904 is the fact, now well demonstrated, that there are a number of kinds of wheat and other grains sufficiently resistant to rust to give at least a good average yield when the disease occurs in the greatest abundance. It was not until the past season that the opportunity of thoroughly demonstrating the fact of this complete rust resistance of certain varieties was presented, and this demonstration alone may yet be found to be of sufficient value to much more than counterbalance all the losses sustained during the season. It can now be seen very plainly what varieties can be depended upon to withstand rust, and if such varieties are grown no considerable loss by this fungus need ever again be sustained. The many experiments carried on by the Department of Agriculture and the State experiment stations for several years have led to the belief that a number of varieties of wheat can offer considerable resistance to rust, but in no one locality where these experiments have been conducted was the rust ever sufficiently severe to test this question thoroughly until 1904. On analyzing the results of many experiments for the season of 1904 it is found that these varieties have withstood the attacks of rust, as would have been expected, but the degree of resistance has been very much greater than would have been predicted.

RESISTANCE OF DURUM WHEATS.

The writer has for several years called attention to the fact that durum wheats resist rust very much more than the common varieties, and that this ought to be a fact of considerable importance favorable to their use. However, this quality has not been emphasized as much as it might be, for the reason that durum varieties are particularly adapted to the drier regions where rust does not often occur. It is now seen from the results of the crop season of 1904 that rather severe rust attacks are likely even in the driest portions of the grain region, and that in about one year out of ten this quality of rust resistance becomes of the greatest importance. The results of the season have also emphasized two other facts, attention to which has been called before. While the wheats of the durum group are more resistant than common varieties, there is, however, great variation in this respect among the durum varieties themselves and also among the common varieties. All durum varieties do not resist rust to an equal degree, and, on the other hand, a few of the common varieties are immune to a slight extent even in a bad rust season.

The extreme effect of a severe rust attack is clearly shown in the accompanying illustrations, in which are represented the seed that was sown of the spring wheat known as Crawford's Hybrid (fig. 1), and the seed of the rusted crop (fig. 2).

The samples which furnished this illustration came from the South Dakota Experiment Station farm, Brookings, S. Dak., and were taken from experimental plats grown in coöperation with the Department of Agriculture. The grain of a crop rusted to the extent shown in figure 2 has reached the limit of acceptance at the elevators, and in many cases throughout the Northwest grain rusted to this degree or worse was entirely rejected by the grain buyers. The yield of grain per acre in this case was 4 bushels. If, now, a wheat can be grown on the same quarter section of land the same season and under exactly similar conditions otherwise which will yield 20 to 25 bushels per acre, it is exceedingly important to know this fact; and this information has been obtained as the result of the cooperative experiments at the South Dakota Agricultural Experiment Station during 1904. The varieties that resisted the rust so far as to give the maximum yields mentioned were all of the durum group.

FIG. 1.—Original seed of Crawford's Hybrid spring wheat sown in the spring of 1904 in South Dakota.

A very interesting feature of the experiments as to rust resistance, which have been carried on by this Department for ten years in coöperation with State experiment stations, is that the variety Iumillo (Cereal Investigation No. 1736), which showed the most complete resistance the past season, is the same one that has been more resistant than any other in all of the experiments for the last three years or more. During the previous years the rust was not sufficiently severe to make much difference whether any of these varieties were resistant or not, but nevertheless it was still an interesting fact that this one

·ty was always marked 100 in the scale of rust resistance, while ther variety reached that grade, or, if so, at least only rarely. this fact becomes much more significant and of the greatest omical importance after a season of extreme injury through rust. a while the fact was overlooked that this is a durum variety, it ; referred to always as belonging in the common group.

the accompanying illustration (fig. 3) is shown the grain of this ·ty for the crop of 1904 in comparison with that of three other ·ties. In the order from A to D, which is also the order of the ·ee of injury from rust, the varieties represented are as follows: No. 1736, Iumillo; B, No. 2228, Saragolla; C, No. 1517, Ghirka ng, and D, a pedigree Blue ı. The yields of these varieties acre were, respectively: Iumillo, bushels; Saragolla, 12⅘ bushels; rka Spring, 6⅘ bushels, and the gree Blue Stem 5⅘ bushels. first two are durum wheats and last two ordinary wheats.

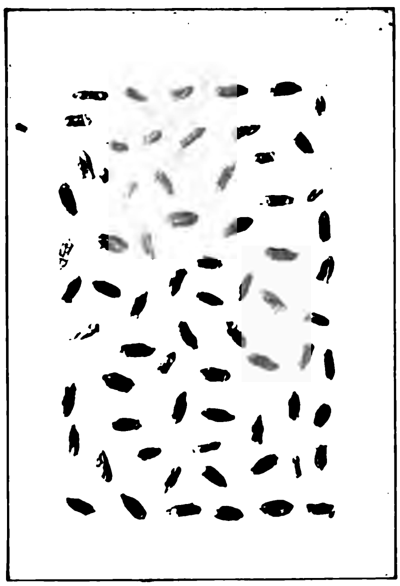

FIG. 2.—Condition of resulting crop from seed shown in figure 1 after the severe rust attack of 1904.

rom all results so far obtained oughout the country, it appears the variety Velvet Don stands t to Iumillo in rust resistance, therefore takes second rank in respect. This is shown in an urate manner by experiments at subexperiment station at Edge-, N. Dak., carried on in coopera- ı with the North Dakota Agri- tural Experiment Station.

Six varieties of durum wheat and common wheats grown at this tion stand in the following order in rust resistance, the yields per e and weights per bushel also being given:

'elvet Don (durum) 35.2 bushels, weight 57 pounds per bushel.
rnautka (durum) 31.3 bushels, weight 56 pounds per bushel.
iharnovka (durum) 30.8 bushels, weight 55 pounds per bushel.
'ererodka (durum) 25 bushels, weight 50 pounds per bushel.
Kubanka (durum) 21.5 bushels, weight 48 pounds per bushel.
Nicaragua (durum) 11.2 bushels, weight 42 pounds per bushel.
Hayne's Blue Stem (common) 11.9 bushels, weight 39 pounds per bushel.
Rysting's Fife (common) 11.6 bushels, weight 42 pounds per bushel.

It is seen that at this station the variety Kubanka, which in all other spects appears so far to be the best durum wheat yet imported to this country, stands rather low in rust resistance. Both the yield and weight per bushel of Nicaragua are extremely low as compared with other durum varieties. This is in accord with numerous other observations and experiments with this variety. The Nicaragua wheat has long been grown in Texas, and has reached a considerable degree of deterioration, and it is no longer a first-class variety of durum wheat.

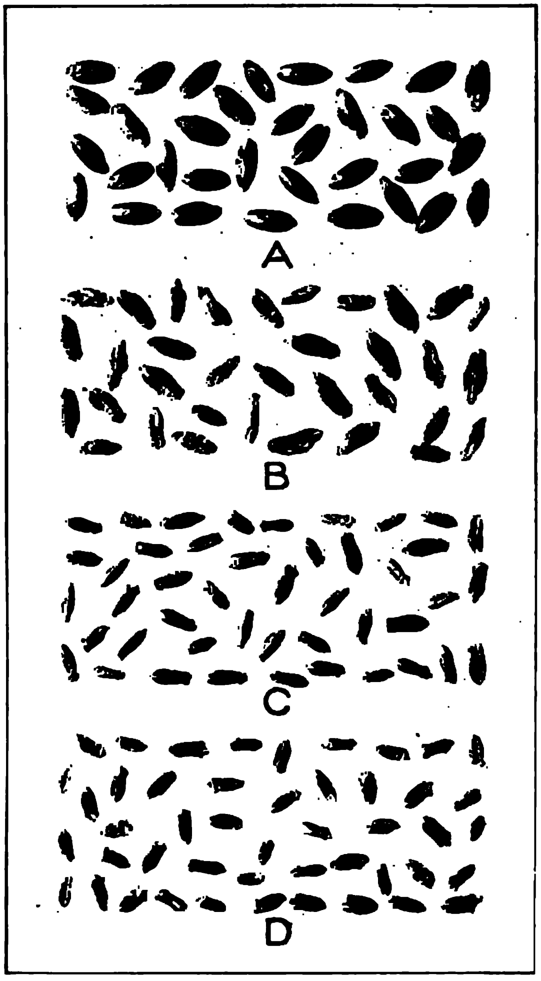

FIG. 3.—Comparison of rust resistance of four different wheats. A.—Iumillo durum, No. 1736; B.—Saragolla durum, No. 2228; C.—Ghirka Spring, No. 1517; D.—A pedigree Blue Stem.

Of course, rust resistance is not necessarily indicated by the yield per acre, although within certain groups the yield is likely to be better in the more resistant varieties during a season of an abundance of rust. At the North Dakota Experiment Station durum wheats did not do as well as usual, it being a rather wet season, but they maintained well their reputation for rust resistance. Two of the varieties of Blue Stem at the same place resisted rust to some degree, one of these being a pedigree variety, but the resistance was small compared with that of the durum varieties.

In experiments at other points similar results were obtained, the durum wheats always resisting rust much more than the ordinary varieties, although at some points the rust was not nearly so severe as in North Dakota and South Dakota.

Among the reports received from farmers are many statements of the great damage inflicted on the ordinary varieties, while the durum wheats, whenever grown on the same farm or in the vicinity, resisted ıe rust to a great degree and in some cases almost entirely escaped ıjury. A careful digest of numerous reports received by the Depart-ıent of Agriculture from farmers in the Northwest, compared with ıublished reports received elsewhere, would indicate that the loss to he wheat crop by rust amounted to as much as 50 or 60 per cent over arge areas in North Dakota, South Dakota, and Minnesota, while in ıll cases the loss to durum wheat through the same source seldom reached more than 10 per cent, being usually 3 to 5 per cent, and some-imes nothing. Conservative estimates have given the decrease in the entire production of wheat in the three States mentioned at from 25,000,000 to 40,000,000 bushels, or a loss in the farm value of the wheat of at least $25,000,000. There is little doubt that if all wheat grown in these three States during 1904 had been durum wheat this loss would have been entirely avoided,[a] as the little damage that occurred to the durum wheat would be much more than counterbalanced by the ordinary increase in yield of the durum wheats over that of the com-mon wheat when no rust occurs. It is not to be assumed from this statement, however, that durum wheat should be grown throughout the wheat-growing area of those States; it is only adapted to the drier portions. The quality of drought resistance of this wheat is of even more importance than that of rust resistance.

The following statements from farmers are given to show the actual comparison on the farm of durum wheats with other kinds in rust resistance. The yields given, as already stated, do not accurately indicate the relation of rust resistance between different varieties, but on an average they will give an approximate idea of the differences:

Mr. S. Glover, owner of a large ranch at Glover, N. Dak., who grows 6,000 or more acres of wheat each year, writes that the Fife and Blue Stem varieties yielded on an average about 5 bushels per acre and in a number of instances were unfit to cut because of the effect of rust. The durum wheat was also damaged somewhat, but to a much less degree and yielded on an average 12 bushels per acre, grading generally No. 2. At the Glover ranch it was found that the Kubanka was hurt more by rust than the Arnautka durum wheat.

Mr. Joseph Keller, at Glenullin, N. Dak., grew the Black Don durum wheat, obtaining an average yield of 14 bushels per acre by measure, which greatly exceeded the standard weight. Ordinary wheat from the same farm yielded 9 bushels to the acre and was very light in weight.

[a] At the same time it is now definitely and thoroughly demonstrated, through the experience of many millers and bakers, as well as by numerous family bakings, that the former contention that this wheat is not good for bread is entirely erroneous. (See Bul. No. 70 of the Bureau of Plant Industry, The Commercial Status of Durum Wheat.)

A correspondent at Arapahoe, Nebr., writes as follows:

I do not think that there is a bushel of spring wheat in this precinct excepting durum wheat. The rust struck the wheat and it blasted, but durum stood the rust all right and made about 35 bushels per acre.

Mr. David Lloyd, of Lamoure, N. Dak., reports as follows:

The crop of 1904 of the durum wheat averages 60 to 85 per cent over Fife, 50 per cent of the difference being due to rust. The probable increase in acreage of durum wheat the coming spring will be fully 50 per cent over 1904. The condition of the wheat crop in this part of the State was better than any year for over twenty years had it not been for the black rust, said rust reducing the yield of Fife wheat about 50 to 65 per cent and the quality about 25 to 40 per cent.

An interesting feature of the reports from farmers shows that usually where the Pelissier durum wheat was grown it has been more resistant to rust than Kubanka wheat grown at the same place. Mr. C. W. Askew, of Utica, Kans., writes that the Pelissier wheat grown by him resisted rust very strongly, but that Turkey wheat, white Russian wheat, oats, and barley were completely ruined by the rust, and that the Kubanka wheat was badly affected. He adds: "I have never seen such rust as we had on small grain this year."

Mr. M. G. Blackman, of Hoxie, Kans., thrashed 350 bushels of Kubanka wheat which yielded 15 bushels per acre. The ordinary winter wheat in the same locality was an entire failure. He obtained his seed from Prof. J. H. Shepard, of Brookings, S. Dak. The yield of the same wheat in 1903 was about 10 bushels per acre, the kernel being larger and of better quality than the original seed, while this year both yield and quality were still better.

Mr. M. Schievelbein, of Arapahoe, Nebr., obtained 20 bushels per acre of durum wheat, while ordinary wheat on the same farm was not considered worth harvesting because of the destruction by rust.

Mr. K. K. Lee, of Elbow Lake, Minn., reports a yield of 15 bushels to the acre of Bachir durum wheat, while ordinary wheat was a failure because of black rust.

Mr. Henry E. Schultz, of Erwin, S. Dak., after reporting on his crop of Kahla durum wheat, remarks: "The rest of my wheat, Blue Stem, averaged about 7 bushels per acre by the side of this Kahla, No. 7581, which yielded 20 bushels per acre." The inference from his report is that the difference in yield was caused chiefly by rust.

Mr. N. L. Carpenter, of Barton, N. Dak., grew Kubanka wheat in 1904 with a yield of 26 bushels per acre, ordinary wheat in the same locality yielding about 13 bushels per acre, the difference being due chiefly to rust.

HARD WINTER WHEATS.

In a season of severe attack no kinds of wheat will withstand the ravages of rust except the durum varieties and einkorn and certain varieties of the spelts and emmers. During ordinary seasons, however, even n the rust may be in considerable abundance, the hard-grained sian winter wheats are found to be considerably more resistant to than the ordinary varieties, and the increase in yield of these eties over others in the hard winter wheat region is often, no ot, to a large degree due to the difference in resistance to rust.

the experiments carried on by this Department at Halstead and Pherson, Kans., in cooperation with the Kansas Agricultural Experiment Station for three successive years, it has been shown conively that the hardiest and hardest-grained Russian winter wheats st rust considerably more than other varieties. There is also a dency among these hardy winter wheats to ripen just a little earlier n most other varieties, which is also a point in their favor in pect to rust attacks. Even among the Russian winter wheats the iety Kharkof and the recently imported Crimean variety seem a le more resistant than the common Turkey wheat generally grown Kansas, which originally came from the Crimea. There is especially onsiderable difference in rust resistance between Russian varieties hard winter wheats and the Hungarian varieties, the difference ing in favor of the former.

EMMER AND EINKORN.

For several years the writer has called attention in publications and herwise to the rust resistance of emmer and einkorn, the latter being kind of grain resembling emmer, but having much smaller heads d only a single grain in each spikelet. Recently it has been deterined that only certain varieties of emmer are particularly resistant, ere being other varieties that are rather susceptible to rust. To the rmers, therefore, who are growing emmer it is suggested that they ep close watch of the crop in the field and of the different varieties this grain that are handled in the markets, use seed of those varies which resist rust best, and select from their own fields the most ist-resistant plants for seed. It will probably be found that the rustesistant varieties are also the most drought resistant.

Among the varieties of emmer grown in cooperation with the South akota Experiment Station during 1904 it was found that three [illegible] howed great differences in rust resistance, one of the three [illegible] uch damaged by rust. The variety worst affected (Cereal Investigaon No. 1522) gave a yield of 2[illegible] bushels per acre, [illegible] esistant variety (Cereal Investigation No. [illegible] [illegible] er acre. The former variety was graded [illegible] per cent [illegible] nce to black stem rust, while the latter variety, so far as any [illegible] ion could disclose, showed [illegible] per cent of resistance.

Einkorn appears to [illegible] ary orange leaf rust, a[illegible] n no instance known to [illegible] to einkorn from rust in the very worst rust seasons during all time that this grain has been under trial in this country. It is very drought resistant and completely winter hardy for all latitu at least as far as the northern boundary of Nebraska. It is of growth, but ought to furnish a considerable amount of winter past age and still produce a good yield of grain at harvest time.

RUST-RESISTANT OATS.

There has not yet been found the degree of rust resistance in varieties that exists in certain wheat varieties. It is true, howev that in ordinary seasons certain kinds of oats in some localities are affected by rust when other varieties are considerably damaged. W are known as rustproof oats, under the names of Texas Rustpro Texas Red, Georgia Rustproof, etc., are generally supposed to be only kinds that can be grown at all in the extreme South with promise of success, because of the great abundance of rust wh often nearly or entirely destroys ordinary varieties. Of course th so-called rustproof oats are not actually rustproof; there is alwa considerable amount of rust on the plants, but in the extreme S they certainly resist rust to a considerable degree. It is a lit peculiar that these same oats when planted in middle latitudes or the North will resist the rust but little, if any, better than the or nary varieties adapted to such places, and they appear in some ca to be even more affected than other varieties. There is no do however, that the rustproof oats, when not affected by the winter, the safest for general purposes in the South. On the other hand is an important fact that these oats, though often sown in late autu or early winter, are not winter oats, and therefore are often wint killed even in the far South. There is therefore a demand in South for a true winter variety that is at the same time able to w stand the rust as well as or better than the rustproof oats.

EARLY VARIETIES OF GRAIN THAT ESCAPE RUST.

A number of varieties of grain good in other respects will often free of rust, not because they are resistant, but because they ripen early as to escape the disease at its worst period. Some varieties so very early in ripening that even though their yield is not as g as that of others and their quality not so good, they become ve important in certain localities, simply because of their ability escape rust and the attacks of other fungous as well as insect pe By this means they are able to produce a very good average yi although their yield in any one favorable season may be less by large per cent than that of other kinds.

EARLY OATS.

As already stated, oats do not resist rust to as considerable a degree do a number of durum wheats, and therefore a very early variety oats has special value. At the present time two of the most valua- varieties in the United States, probably the most valuable in this spect, are the Sixty Day and Early Burt oats, the former having en introduced in recent years from southwestern Russia by the partment of Agriculture. The advantage that the Sixty Day riety has over others in the matter of earliness has been particularly own during the last season in the Northwest in the entire freedom om rust that has been its characteristic almost everywhere that it s been grown whenever seeded in good time. In many instances here other oats met with entire destruction through rust the Sixty ay oat was harvested in bright condition, with but very little, if any, mage from rust. In such seasons, therefore, it is not a question hether the Sixty Day oat and others of its class are good yielders, but hether such varieties are not the only ones that will yield *anything.* ne Sixty Day variety also seems to stand up well. It is of short owth, and, not having a very heavy panicle, does not usually lodge. does not have a plump grain, and is not so good in quality as the wedish Select and some other kinds, but it makes up for these defi- encies in the certainty of producing a crop in unfavorable seasons.

In the cooperative experiments at the South Dakota Experiment tation, already referred to, the varieties of oats in most cases were dly rusted. A portion of the report from that station on rust of ts is as follows:

The spores of the red stage were so plentiful that at times the ground was colored d. About the time the black rust appeared the straw crinkled so badly that it as necessary to cut green, so little can be told by quantitative results in the case of ts. In the fields shown in Photo. G the Sixty Day oat, at the right hand, stood up ell and was free of rust, giving a yield of 84.5 bushels per acre testing 35 pounds r bushel. The Swedish Select field, at the left, made a much larger growth of raw, which lodged and rusted, and only thrashed out 51.7 bushels per acre with a st of 23 pounds per bushel, but for reasons given above they were cut while quite een. In the series of plats shown in Photo. H, where the Sixty Day oat is the first at and the Swedish Select the sixth, the yields were 69 and 70 bushels per acre, spectively.

As the Swedish Select will commonly yield much more than the ixty Day oat and nearly always greatly outweighs it, it is evident at the difference in weight per bushel in the first of these instances nd the average difference in yield in favor of the Sixty Day oat is ue simply to the fact that the latter variety ripened sufficiently early escape the rust.

In all plat experiments of the Department of Agriculture the Sixty Day and Early Burt varieties have maintained the quality of escaping rust and other diseases by early maturity. The difference in tii maturing between these and the average of other varieties runs fr week to ten days, or occasionally even two weeks. This, of cour time for great changes to occur in the abundance and rate of in of rust and other parasites, as well as for great changes in the wea By the same means the Sixty Day variety often escapes the dr that begins about harvest time in many localities. The Kher another very early variety—in fact, similar in many respects to Sixty Day oat—now grown to a considerable extent in Nebraska also introduced from Russia, is becoming important; but being ap ently more adapted to the drier districts where rust seldom occurs ability to escape the rust is not of so much advantage.

JAPANESE AND CHINESE WHEATS.

In most respects Japanese wheats, which all belong to the com group, are not particularly good. They are inferior in milling qu to the varieties generally grown in this country, although really than the white, starchy wheats of the Pacific coast. A number Japanese wheats, however, have the important quality of great ea ness, and for this reason alone are of value for certain portions of country, particularly where there is much rust. Several of the well as some Chinese sorts, have been under experiment by Department of Agriculture for a number of years, and a few have given some striking results in the matter of earliness. T varieties Yemide and Onigara are particularly early, and, if sown good time, will nearly always escape any bad attack of rust. T are, however, very inferior in the quality of their grain and are adapted for use in the Northern States or the States of the Gr Plains. On the other hand, the Pootung, an early Chinese vari appears to have a very high proteid content, although its quality bread making has not yet been determined.

The statements just made apply also to some early varieties of bar although the investigation of different varieties obtained from n quarters has not yet gone so far as in the case of wheat and oats is known already that there are a few varieties of importance fr the standpoint of earliness.

THE IMPORTANCE OF GROWING HARD WINTER WHEATS.

It has now been determined by actual trials that it is possible by t use of the hardiest varieties to grow winter wheat all over Nebra and Iowa, in the greater part of South Dakota, and even in porti of Wisconsin, Minnesota, and North Dakota. In previous publ tions of the Department of Agriculture attention has been called sever times to the fact that winter wheat, when it can survive the winter, w always produce a much better crop on the same farm than spr wheat. At the same time, if the proper varieties are used the quality of the grain will be just as good on an average as the hard spring wheats. It has been stated with particular emphasis that winter wheat, by having a stronger root growth and starting out more vigorously in the spring and ripening much earlier, is able to escape to a great extent the disastrous effect of a rust epidemic, as well as the attacks of other fungi and of insects. It will often also escape the effects of drought, which usually sets in about harvest time or a little earlier.

The ability of winter wheat to escape rust has been shown very clearly the past season. In many instances this wheat has remained almost as free from rust as the durum varieties, but because of its earliness, while the durum wheats resisted the rust. Winter wheat, if ripening at the same time as spring wheat, would probably be as much affected by rust as the latter, although it would always have the general advantage of being a more vigorous plant, with stronger roots. In the season of 1904, in nearly all cases where winter wheats were grown in the spring-wheat States they were much less rusted than the spring varieties, although badly rusted in districts farther south. In the experimental plats at the South Dakota Experiment Station the winter varieties matured early enough to escape any damage, although the ordinary spring wheats, as already stated, suffered very severely last season.

It has been mentioned that the hardiest winter wheats resist rust a little more than other winter varieties, but it is also found that the earlier these varieties are the better, as of course in that case they have the advantage both of resistance and earliness in avoiding the rust. As these hardy and hard-grained winter wheats have such an advantage in respect to rust, besides being superior in other ways, there is probably nothing of more importance than the further extension of their range northward in the spring-wheat region. In this connection one of the most interesting facts now shown is that winter wheat can be grown at least as far north as Lisbon, N. Dak. This gives confidence to the prediction that the results of further experiments will show that the range can be extended to the Canadian boundary.

Mr. C. A. Waterman, of Hay Springs, Nebr., who grew Kharkof winter wheat, the hardiest of the introduced Russian varieties, states that, as a rule, wheat rusted very badly in his section in 1904, but that Kharkof rusted very little. His principal field of Kharkof, however, gave a small yield, because of a very severe hailstorm. This variety seemed to stand the dry weather much better than the ordinary spring wheat. The spring wheat in the locality averaged 10 bushels per acre, while the Kharkof gave indications of producing more than 20 bushels per acre before the fall of hail.

The most interesting trial of winter wheat in the spring-wheat region has been made by Mr. T. N. Oium, of Lisbon, N. Dak. Mr. Oium has grown the Kharkof winter wheat very successfully for tw... sons, obtaining in 1904, 375 bushels, with a yield of 21 bushel... acre. This yield was much better than that of the common sp... wheat of the locality, although not nearly so good as the durum w... which latter yielded 35 bushels per acre. A particularly inter... fact in connection with this test is that the success in safely wint... the wheat was apparently due to the method of seeding it di... into ordinary wheat stubble without plowing the ground, which g... the opportunity of much protection to the wheat from the snow ... was caught and held by the old stubble. This is a method that ... be strongly recommended for a time until the wheat become... ciently acclimated to be sown and treated in the ordinary way. It ... probable that a harrowing or even a light disking might be give... the stubble ground, which would increase the chances for a good ... and at the same time not interfere materially with the prote... offered by the stubble. The quality of the grain obtained by M... Oium in 1904 was excellent, and would easily grade No. 2, and p... sibly No. 1. The weight test was 59 pounds per bushel. A por... of the seed was sown on ordinary plowed land and some in short ... let stubble, in both cases with the result that these seedings w... entirely winterkilled about the middle of March.

A number of other reports have been received, showing com... success with winter wheat at other points in South Dakota, Iowa, ... southern Minnesota. The accompanying picture (fig. 4) is as good ... illustration as could well be produced of the differences in injury f... rust in winter wheat and spring wheat near Sioux Falls, in so... eastern South Dakota.

The winter wheat used, the Kharkof variety from the original ... received from central Russia, is represented on the right of the p... ture. The spring wheat represented on the left is the common B... Stem, having a velvet chaff. In both cases the straw, the heads, a... the grain are shown. The difference in the quantity of rust on t... stems can easily be seen, as well as also the more important differ... economically in the character of the grain, it being very much sh... eled in the case of the spring wheat. The two wheats had every co... dition the same, with the simple exception that one was sown in ... autumn and the other in the spring.

SEED SELECTION WITH REFERENCE TO RUST RESISTANCE

Constant and thorough selection of seed is always one of the m... important things on the farm, but the results of the past season ha... greatly emphasized this importance. One of the most interest... facts brought out in the experiments in cooperation with the Sta... experiment stations, as well as shown by observation in many ... on the farms, is the great variation in the effects of the rust on diff...

plants in the same field. This was often true even on different ts of the same variety, but of course in many other cases the difnce was due to the mixing of varieties in the same field.

IG. 4.—Comparative rustiness of spring and winter wheats in southeastern South Dakota in the season of 1904. A—Blue Stem spring wheat; grain much injured by rust. B.—Kharkof winter wheat; grain not injured.

Nearly all of the varieties of durum wheat recently imported from Russia and Algeria were handled in their native localities in so primiive and careless a manner that the seed when obtained here was in every case badly mixed, and much trouble has been caused to the

Department of Agriculture and to the experiment stations and others concerned to develop pure seed from these varieties. The fact of the mixture of the seed has been strikingly shown, as already stated, in the great variation in the effects of rust on different plants in the same field. In some instances certain plants have shown almost 100 per cent of rust resistance, while others, supposed to be of the same variety, were almost worthless because of the rust. There have been other equally interesting examples of mixtures of the common spring wheat with the durum wheat on many of the farms in the Northwest, it being perfectly easy always in going through a field to select the rusted plants from their habit of standing up straight and having a light head, with little or nothing within the chaff, while the durum wheat heads would hang over heavily and be full of fairly sound grains.

As a result of these conditions the farmers of the Northwest have an excellent opportunity this year of ridding themselves of mixtures of other grain in their crops because of the lightness of the rusted seed, and they will certainly not be alive to their own interests if they do not take advantage of it. In most instances the seed of the ordinary spring wheat, mixed with the durum wheat, is so very light that a good fanning will throw it all out, and the farmer therefore can readily obtain fairly pure durum wheat seed. It will be almost inexcusable, therefore, if next season in any of the fields of the Northwest there should be seen any considerable quantity of common spring wheat in the durum wheat, and at the same time the farmers who have clean fields will receive quite a premium in price for their wheat.

FIG. 5.—Sample of durum wheat grown at Berlin, N. Dak., in the season of 1904.

In the accompanying illustrations the very poor shriveled grains (fig. 6) shown were separated from a sample of durum wheat received from a farm in North Dakota. The seed of the durum wheat is shown in figure 5.

In this instance the rusted, shriveled seed, which was ordinary Fife wheat, made up from 6 to 10 per cent of the crop, a mixture that should never be allowed on any farm. It will be seen that the seed is so light that a large part at least, if not all, could be readily blown out with a fanning mill. The illustrations show the striking difference in the effects of the rust on the common wheat and on the durum grown in the same fields and under exactly the same conditions. e same time, the farmers may learn the lesson from this experi- of the importance of selecting sound, healthy plants from all in all cases. Even where they have no mixture of other varieties will always be great variation among the plants.

great advantage of making constant use of a regular seed plat ll shown by the season's experience. The method of making use is plat will be described briefly. The seed plat is simply a small of 1 acre or more (depending upon the acreage of grain that armer grows), in which only seed grain is grown, none of it being in the markets, but all being used for sowing the general crop of next year. To start the seed plat go through the large field just re harvesting and select all the best individual plants that can be kly obtained, keeping in mind stooling, large heads, and vig- s, healthy plants without rust nut. Continue selecting until a cient number of bundles of the its are obtained which, when ished, will give seed enough for ing an acre of ground, or more he farmer wishes a larger plat n an acre. This can be thrashed simply by a flail or by tramping beating inside of a bag; or, if the d selection should become a regu- custom, which it ought to be, the mer may be justified in buying mall 1 or 2 horsepower thrasher it can be run by a gasoline engine, a cost of about $200 for both the rasher and the engine, which will adily thrash any small-sized bun- es, as small even as a mere handful.

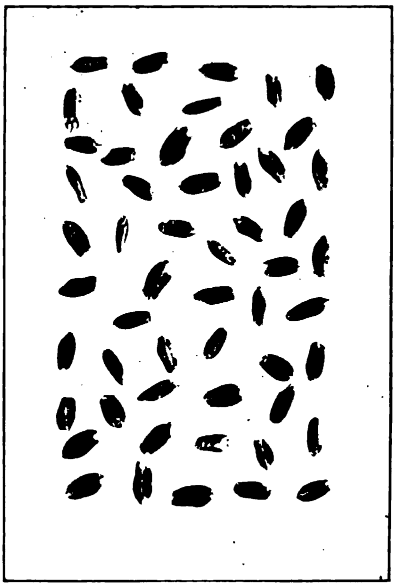

FIG. 6.—Sample of ordinary spring wheat mixed in the same field from which the sample shown in figure 5 was taken.

ne seed from these bundles is used for seeding the seed plat, which ould be set apart separate from any of the fields and kept thoroughly rotected, even fenced in if necessary. Just before harvesting this seed at, the very best plants should be selected from the plat in the man- er described, and the seed of these plants should be used for sowing is seed plat the next autumn or spring, and all the remainder of the ed from the seed plat will then be used for seeding the general crop. ontinue the same method from year to year, always obtaining the est seed from the seed plat for seeding itself and using the remainder f the seed harvested from this plat for seeding the general crop. In this way no seed is ever taken from the general crop, and yet it is p- duced on the same farm, is constantly improved, and is better th- seed imported.

DRAINAGE AND CLEAN CULTIVATION.

Probably in all cases where it is supposed that differences in composition of the soil have some relation to the occurrence of r- the real cause for variation in this respect is the relative quanti- water in the soil. A poor soil will nearly always be somewhat - vated and a rich soil low lying, as naturally the richer material of soil will be washed to lower elevations. At the same time and f- same reason there will be more water in lower, fertile soils tha- the poorer soils. The more succulent and watery the plant be- from the great quantity of water in the soil the more rapid- rust will grow in the plant, and this is, therefore, the reason why m- rust occurs in the fertile, lower lying soils. It is evident that in g- grown on water-logged soils there will be much more rust than - where, and that thorough drainage will tend to lessen the amou- rust.

On plants grown in heavily manured ground it is not directly - amount of nitrogenous material thus furnished to the plant that i- cause of more rust, but the fact that such plants are also thus en- to absorb more moisture and always are more rank in growth and - softer straw. It will also follow that plenty of sunlight will hav- effect of dissipating moisture, and therefore to some extent will p- vent the spread of the rust. Thorough and clean cultivation of soil, exterminating all weeds and drilling the wheat instead of b- casting, will admit much more sunlight, and should always be pra- for other reasons as well.

INFECTION FROM RUSTED GRASSES.

It has been proved by previous experiments of the Departme- Agriculture that the black stem rust of oats is the same as that w- occurs on the wild meadow oat grass and sometimes on orchard g- It probably occurs also on two or three other wild grasses. The stem rust of wheat is known to occur on several of the wild-w- grasses, or quack grasses, and on certain wild-rye grasses. It known, further, that the rusts from wild-wheat and wild-rye gr- will readily infect wheat. It is therefore of considerable importa- to the farmer to know whether these grasses on his farm are u- rusted; and if so, to try to avoid sowing the grain crops near them. is probable that further experiments will determine what other gra- if any, harbor these rusts, so that all the grasses that should be away from the grain fields may soon be definitely known, and thr- such knowledge the farmer may be enabled very largely to elimi- the chances for the occurrence of rust in his fields.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 220.

TOMATOES.

BY

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., March 7, 19[illegible].

SIR: I have the honor to transmit herewith a paper on Tomatoes, prepared by Prof. L. C. Corbett, Horticulturist of this Bureau, and recommend that it be published as a Farmers' Bulletin to supersede the publication on this subject (Farmers' Bulletin No. 76) issued in 1898.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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ILLUSTRATIONS.

TOMATOES.

INTRODUCTION.

'he tomato is one of the few garden vegetables of American origin ding high rank as a commercial crop which has come into general tivation within the last century. This plant, because of its rela- to the nightshade family, was for a long time held in disrepute gardeners and people generally. For at least a century after the nato was more or less familiar to botanists and gardeners it was y sparingly cultivated, and when grown at all was used chiefly as an namental plant. Its cultivation was, therefore, markedly delayed, l it was not until after the strong prejudice that the tomato was isonous was broken down that its cultivation began to attract atten- n and its use became general.

The cultivation of the tomato in England and the United States me much later than it did in the countries bordering the Mediter- nean. Climatic conditions undoubtedly had much to do with this. cause of the warm climate and otherwise congenial conditions exist- g in the Mediterranean countries the tomato flourished there. In gland, however, because of the comparatively short season and nall amount of heat during the growing period, the cultivation of is plant gained slowly. Even now the cultivation of the tomato in reat Britain is chiefly confined to house and protected walls. In the nited States, after the plant was once introduced and its poisonous fects were discredited, its cultivation grew rapidly, and now we find among the most generally cultivated of our garden vegetables.

As before stated, the tomato is of American origin. The exact cation from which the plants first carried to Europe were secured is ot definitely known, but historical evidence indicates that these plants ere taken from Peru.

TYPES OF TOMATOES.

There are now a number of distinct types of the tomato in cultiva- ion, three of which are worthy of mention, namely, the Currant type, he Cherry type, and the common commercial type, of which there are nany varieties.

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The Currant tomato is a weak-growing, small-leaved, small-fruited plant, bearing its fruit in large currant-like clusters, the individual fruits being about one-fourth inch in diameter, and usually red in color.

The Cherry tomato is somewhat similar in habit of growth, though more robust, with larger foliage and with fruits borne in large clusters and the individual fruits much larger in size, varying from one-half to five-eighths inch in diameter, and in some extreme cases fruits three-fourths inch in diameter have been obtained. The small spherical fruits of these two classes are usually two-celled and very regular in size and shape.

The plant of the commercial tomato is robust in habit of growth as compared with that of the Currant or Cherry type. The most characteristic and probably the normal habit of the plant is spreading, with large, open, compound leaves, and comparatively small, ordinarily flat, or somewhat rolled leaflets. It may, however, be upright in habit, with large, much-wrinkled leaves, giving the plant a very compact and sturdy appearance, as in the Dwarf Champion group. In another group, known as the Potato Leaf, the leaflets are large and flat, but quite pubescent, giving the plant a luxuriant appearance. The normal and most characteristic form of the tomato, however, has a decumbent habit of growth, open compound leaves, with comparatively small leaflets or subdivisions.

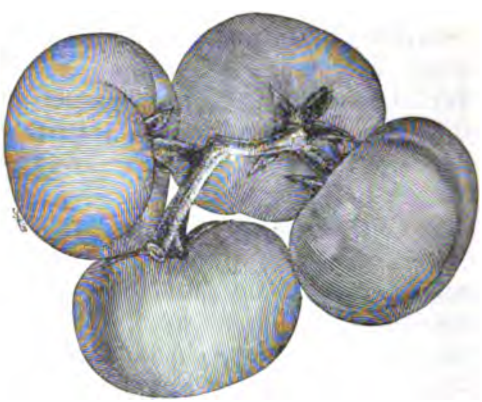

FIG. 1.—Globular, regularly formed fruits, such as occur in the Stone, Beauty, and Perfection varieties.

It is not necessary at this place to enter into a description of the botanical relations of these different types and forms. Enough has been said to show that there is more than one species and that the tomato is remarkably variable. This is also carried out in the form and color of the fruit, as well as in the habit of the plant and in the forms of the leaves. The fruits vary in size from that of the Currant to the large irregular forms of the Beefsteak variety. They vary in color from the deep red of the Cherry through various shades to the purple of the Beauty and the yellow of the Golden Queen. The form of the fruit also varies from the spherical type of the Currant and Cherry to periform and turbinated, and from the broad, flat forms of the Beefsteak to the globular, regularly formed fruits, such as occur in the Stone, Beauty, and Perfection varieties, as shown in figure 1.

LENGTHENING THE GROWING SEASON.

›cause of the tropical origin of the tomato it requires a long season ts growth and development, and on this account it is necessary ιe Northern States, in order to secure paying crops, to resort to ιods which lengthen the growing season. It is much easier for gardener to accomplish this while the plant is small than when it rge, and because early fruits are as a rule more valuable than late ; it is of advantage to the gardener to secure his crop as early in season as practicable. The season is, therefore, lengthened at the ınning rather than at the end. This is accomplished by sowing ls in hotbeds or greenhouses several weeks in advance of the time n they could be safely planted in the open.

ı the latitude of New York City it is the common practice to sow seeds of the tomato about March 15, while farther south it is cusιary to sow them somewhat earlier, from the 10th to the 15th of ›ruary, and as the more southern latitudes are approached even lier dates of planting are resorted to. In Florida and southern ιas plantings are made in November, so that the fruits come into the rket several weeks in advance of the earliest northern-grown fruits. is evident from what has been said that the tomato has no fixed ·iod of growth. In fact, in climates where its growth is not interpted by frosts it becomes a perennial plant, but in temperate regions ιere seasons are markedly distinct it is forced to acquire an annual bit and to be treated as an annual plant.

Since the prejudice in regard to the poisonous qualities of the fruit s been broken down and improved canning processes have come into e the tomato has become a very important commercial field and garn crop. It is a fruit which, as before stated, has no definite season. is relished at all periods of the year in a fresh state, and is equally elcome upon the table, when properly cooked or prepared, whether it ιs been freshly taken from the vines or has been preserved in cans. s a result of the extensive use of the tomato it is now cultivated both ı a field and as a forced crop, and in this publication we shall conder it under both heads.

THE TOMATO AS A FIELD CROP AT THE NORTH.

East of the Mississippi River and north of the latitude of Washingɔn, D. C., the tomato is handled as an annual, the seeds being sown ı hotbeds about the middle of March. The young plants, as soon as hey have developed their first true leaves, are transplanted to stand bout 2 inches apart each way and are allowed to develop in these uarters, until they have attained a height of from 4 to 6 inches and he leaves begin to crowd considerably. They are then transplanted

to pots, 3 or 4 inches in diameter, similar to those used by florists, o
if these are not available, they may be shifted to strawberry boxe
to tin rims formed by melting the top and bottom from an ordina
2-pound can used by canners in tinning vegetables. The heat w
is necessary to unsolder the top and bottom of these cans will be
ficient to unsolder the seam at the side, which will leave a rim of
about 5 inches in height and about 3 to 3½ or 4 inches in diame
By tying a string around each rim it can be filled with soil an
young plant placed in this receptacle. By slipping a shingle u
a can so prepared it may be shifted to the quarter where the pla
to grow until it attains the size desired for field planting.

With seed sown at the time mentioned it will frequently hap
that plants handled in the manner described will be in bloom or e
bearing small fruits the size of a marble before it is time to p
them in the field. With careful handling at the time of placing
plants in the field these blossoms and fruits can be saved and
come to maturity and produce a very early and profitable crop.

TRAINING PLANTS TO STAKES.

For earliest returns it is desirable to train forced plants to a sin
stem by tying them to a stake 4 or 5 feet in height. A good stake
this purpose is formed by small saplings
as are used for training beans, or from a
edge seven-eighths to 1 inch square. Th
stakes should be driven firmly into the gr
beside the plants and the plants carefully
to them to prevent whipping and to keep
fruits off the ground. All side shoots sho
be kept pinched out and only the central l
ing stem allowed to develop, as shown in fig
2. If the plants are to be trained in this
they can be set from 18 inches to 2 feet ap
in the row, and about 3½ to 4 feet between
rows.

FIG. 2.—Plant trained to a stake.

TRAINING PLANTS ON FRAMES.

Another plan sometimes followed in
training of tomatoes is illustrated in figur
A flaring frame, about 18 inches square at
base and 24 inches square at the top, is pla
over the plants before they begin to spre
The shoots as they become heavy with fr
fall over against the sides of the rack and are prevented from comi
in contact with the earth. For a kitchen garden where but few plant

wn this is a very satisfactory plan. The plants can be set some- oser than is the case where no supports are provided. For :cial plantations, however, the cost of the frames is prohibitive. nmon commercial practice is to place the plants about 4 feet ıch way in check rows so as to allow them to be cultivated in rections. Under intensive cultivation in a small garden, how- e first meth- t of tying ›s to stakes, found very tory.

FIG. 3.—Training plants by the use of frames.

SIVE CUL- 'ATION.

re tomatoes own on a scale and the product only a small er bushel, ve methods of handling and training can not be profitably fol- The common practice in growing tomatoes for the general and for canning purposes in localities north of New York City w the seed very thinly in a hotbed about March 15 and allow the to grow slowly without transplanting them until they can be he field about June 1. The plants, even with the most careful ›n, when grown under these conditions will become long and mmed, with a small tuft of leaves at the top.

SETTING THE PLANTS.

:s more than a foot high which have been grown under these con- should be treated somewhat as follows: Instead of attempting to plant deeply and maintain it in an upright position, remove all three or four of the topmost leaves about the growing point. Dig ›w trench along the row—a trench 3 or 4 inches deep—slightly from a deep point at one end to the surface of the ground at the Place the bare stem of the tomato and the root in this trench, ıe root in the deepest portion, cover the stem throughout its with fresh soil, and pack this firmly. Under these conditions the ill take root throughout the length of the buried stem, and in a me the added root system which is thus given the plant will force vigorous growth. Plants of this character which are to be on an extensive scale are never trained. They are allowed to t will, and the fruits are gathered as they ripen without special ›n to keep them off the ground or otherwise to care for them.

The construction of hotbeds for tomatoes is described in Farmers' Bulletin No. 195 of the Department of Agriculture, and for that reason is not repeated here.

SOIL AND YIELD.

The soil for the tomato varies as much as the localities in which it is grown. Judging from the extent of the tomato industry in Maryland and the fact that the greatest quantities of canned tomatoes are grown and packed in that State, one would naturally be led to the conclusion that the soil conditions there are ideal for the tomato. While it is undoubtedly true that the tomato can be more economically grown in Maryland than in any locality north of that point, it does not necessarily follow that the largest yield per acre is obtained in that State. The largest yields of tomatoes are undoubtedly obtained by careful handling of the plants and attention to fertilization and cultivation in latitudes north of Maryland. Accurately measured yields from areas of one-fourth acre and upward in Michigan have indicated a return of 1,200 bushels per acre, which is undoubtedly far in excess of the yields ordinarily obtained by even the best growers in localities where tomatoes are extensively produced for canning purposes.

LENGTH OF SEASON.

The season of fruit production is longer in the higher than in the lower latitudes. This is a rather interesting and unexpected condition. Normally one would expect to find that the tomato would begin maturing its fruit earlier and would continue bearing longer in the latitude of the city of Washington than it would in the latitude of Boston; but this is not the case. Tomatoes in the latitude of Washington and south of this point come into bearing, quickly produce a heavy flush of fruit, and then refuse to do more, and in order to have a continuous supply throughout the season it is necessary for market gardeners and truckers to plant seeds in succession so as to keep up a continuous supply. In fact, the common practice among truck growers is to make two sowings—an early sowing made about the 1st to the 10th of February, which will give fruits about July 15, and a second sowing from April 15 to May 1, plants of which placed in the field give a crop of fruit from September to November. In the latitude of Boston, however, plants from seed sown March 15 are usually transferred to the field about June 1, while upon the clay or gravelly loam soils of the terminal moraines these plants will grow continuously throughout the season. As soon as they begin ripening their fruit they will keep up a continuous supply until the vines are killed by frosts. For this reason the large yields previously mentioned become possible.

FERTILIZERS.

Since the tomato is grown exclusively for its fruit, those fertilizers which induce a large growth of plant and foliage are not desirable in the production of this crop. Soils vary greatly in regard to the quantity of available plant food they contain. The use of a fertilizer is determined largely by the character, mechanical condition, and composition of the soil. If a soil is deficient in all the essential elements of plant food—nitrogen, potash, and phosphoric acid—the application of any one or even two of them will not materially influence the yield of the crop. In such cases a complete fertilizer must be used. One containing a small percentage of nitrogen (1 or 2 per cent), with a high percentage of potash (4 to 6 per cent) and phosphoric acid (8 to 12 per cent), is considered more desirable than a higher grade fertilizer for the crop. On the other hand, on soils deficient only in potash or phosphoric acid, or both, little would be gained by adding nitrogen, which is already in excess, to the other element or elements to be applied. Economy of operation, as well as the general effect upon the soil, must also be considered. This may be influenced by the character of the season, but should be based on the increased yield and increased net receipts of the crop.

Tests of fertilizers.—The best and most economical fertilizers to be applied upon any given soil must be determined by the grower by actual test.

A very simple test of different fertilizers may be made by setting aside a section in one corner of the field or in some place where the soil is uniform and representative of the entire field. Use some good standard variety and divide the section into plats containing ten plants each, and treat somewhat as follows:

Plat 1. Nitrate of soda, one-half pound to 10 plants.
2. Muriate of potash, one-half pound to 10 plants.
3. Phosphate, 2 pounds to 10 plants.
4. Nitrate of soda, one-half pound; muriate of potash, one-half pound, to 10 plants.
5. Phosphate, 2 pounds; muriate of potash, one-half pound, to 10 plants.
6. Nitrate of soda, one-half pound; phosphate, 2 pounds, to 10 plants.
7. Nitrate of soda, one-half pound; phosphate, 2 pounds; muriate of potash, one-half pound, to 10 plants.
8. Barnyard manure, 1 shovelful per plant.
9. Unfertilized.

Keep a careful record of each plat separately, giving the date and quantity of each picking, including the green fruit that may be upon the plants when killed by frost. From such a record one can very easily determine the increased yield, as well as the influence upon the ripening period, if any, due to the application of each of the different fertilizers, and from this the economy of its application will appe· This test may be modified by increasing or decreasing the amount of the various ingredients and comparing the results.

If plants are placed 4 feet apart each way, 2,722 will be requir for an acre, and each plat will represent $\frac{1}{272}$ of an acre. Then, multiplying the amount of fertilizer applied and the yield returned 272, the corresponding quantity and yield per acre will be obtai

Qualities required in fertilizers.—As a general rule, readily solu "quick-acting" fertilizers which produce an early growth and ea ripening of the crop are most desirable. If nitrogen is nee nitrate of soda is perhaps the best form in which it can be appl It acts quickly but not through a long period, and for that reason very desirable where short-season crops are concerned. In man cases it is found an advantage to apply the nitrate at two peri rather than all at once. It is well to make one application when plants are set in the field and a second about the time the fruits be to color. Fertilizers containing nitrogen in a slowly available for such as cotton-seed meal or coarse, undecomposed stable man which do not stimulate an active growth until late in the season, not desirable for this crop. Such fertilizers are too slow for a sho season crop like the tomato, which needs something to stimulate it the very time it is transplanted to the field. Such fertilizers also t to stimulate late growth of vine at the expense of the maturity of fruit. Potash and phosphoric acid are more conducive to the dev opment of fruits than is nitrogen, except in the form of nitrat soda.

Heavy dressings of stable manure tend to produce too much vi and are seldom or never employed. If stable manure is used it is a moderate rate, usually not more than one or two shovelfuls to a pl This, if well decomposed and thoroughly incorporated with the soil very stimulating to the young plant and consequently very benefi

Any fertilizer used should be applied, in part at least, at the ti the plants are transplanted to the field.

CULTIVATING THE PLANTS.

As soon as the young seedling plants from the hotbed or greenho are transferred to the field they should be given clean cultivation w implements which stir the surface of the soil but do not produce ri or furrows. The spring-tooth cultivator or a horse hoe with narr teeth makes an ideal implement for cultivating this crop. When plants are set in check rows 4 feet apart each way it is possible in fi culture to keep the plantation almost free from weeds by the use horse hoes. If, however, the plants are set so that cultivation can carried on only in one direction, hand hoeing will be necessary to k wn weeds between the plants in the row. Where land is not expen-e, and where labor costs heavily, the cost of producing a crop of natoes can be decidedly lessened by planting in check rows and rying on the cultivation by horsepower. A man with a modern ltivator and a well-trained horse can easily do the work of three four men working with hand tools, and since the cost of production termines the percentage of profit, every legitimate means of reducing is item should be used.

The grower should bear in mind, however, that the object of culti-tion is not merely to kill weeds. The destruction of weeds is an nportant factor and in itself sufficient to justify clean culture, but the eservation of a soil mulch for the purpose of husbanding the mois-re of the soil during periods of drought is of even greater value. 'ith care in the choice of implements both results can be attained ith the same expenditure of labor.

HARVESTING AND MARKETING.

The fruits should be gathered two or three times a week if the omato is grown as a truck crop. When used for canning purposes the arvesting periods need not be quite o close, and when the fruits are o be shipped some distance they hould be gathered as soon as par-ially colored, instead of allowing hem to become colored on the ine. The fruit of the tomato is elvet green up to the time the ipening process begins, and at this tage, if the products are to be hipped long distances, the fruits hould be harvested. For home narkets, however, the fruits should be allowed to ripen upon the plant.

FIG. 4.—Six-basket carrier for shipping wrapped tomatoes.

In harvesting, none except sound fruits of a similar stage of matu-rity should be harvested and packed in any one receptacle. Leaky fruits and deformed fruits should be rejected. In packing tomatoes for the market, those that are symmetrical in form and uniform in size and of a like degree of ripeness should be selected for filling any one receptacle.

Where the fruits are to be shipped long distances and have been picked in an immature state, the individual fruits should be wrapped in thin, pliable, brown or white paper, similar in grade to what is known as tea paper. When so wrapped and packed in small recep-tacles they may be shipped several hundred miles and go upon the market in good condition. In packing for long-distance shipments it is the common practice to employ the six-basket carrier (fig. 4) now so universally used for the shipment of peaches. The wrapped fruits are carefully placed in the carrier baskets, and the baskets are then packed in a crate in the same manner as peaches. A flat box 18 to 20 inches square and about 5 inches deep, similar to the one shown in figure 5, which will carry two layers of wrapped fruit, is now extensively used in some sections of the country. The preference in packages, however, seems to be in favor of the six-basket peach carrier.

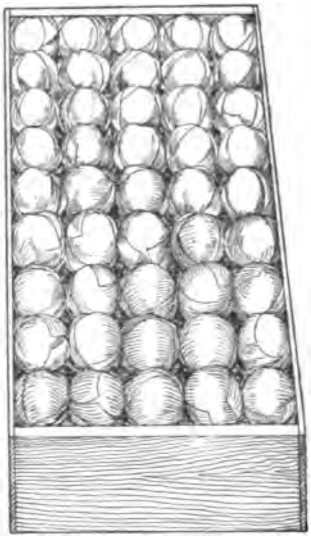

FIG. 5.—Flat box packed with wrapped fruits for shipment.

Formerly tomatoes which were grown and shipped less than 100 miles were packed in flat-handled baskets made after the fashion of the one shown in figure 6. A shallow basket made of splints with a folding handle or with one upright handle were employed. These baskets held something less than a half bushel. Fruits were gathered as soon as partially colored, carefully arranged in the baskets, and the baskets covered with mosquito bar. This style of shipment is not now very generally practiced except where the fruits are to be carried only short distances.

Fruits intended for the canning factory are allowed to mature upon the vines, are packed in short flat-handled baskets, as above described, or in bushel boxes, and are carried directly to the factory. The bushel box or slatted crate is undoubtedly more generally employed for this purpose than any other form of receptacle.

FIG. 6.—Basket for shipping tomatoes short distances.

VARIETIES FOR THE NORTH.

There are a large number of sorts of tomatoes, each one possessing some points of merit or difference which distinguish it from all others. These differences enable the intelligent cultivator to select sorts for special purposes, as well as for special soils and climates. The varying demands of the markets and the different soil and climatic conditions presented in the various sections of the United States where the tomato is grown can only be satisfied by a variety list as variable as are the aditions. It is fortunate that domesticated plants present so many ferent forms; otherwise the cultivation of many crops would be stricted to a few favored localities. Besides broadening the field to nich the tomato is adapted, varieties present other important differces manifested chiefly in the fruit.

Early ripening sorts are frequently irregular in shape, have comiratively thin walls, large seed cavities, and numerous seeds. The uit is apt to color and ripen unevenly, remaining green around the em, or to contain a hard green core. Later-ripening sorts, while not ll superior to the others, have as a rule thicker and firmer walls, maller seed cavities, and few seeds.

Desirable qualities.—The most highly developed varieties now make ew seeds and ripen evenly. These characteristics of the fruits are mportant factors in determining heir fitness for special purposes. Medium-sized, smooth, spherical fruits, which ripen evenly and have small seed cavities and thick walls, as shown in figure 7, are especially suited to long-distance shipment. These qualities should enter into every sort selected to the greatest possible degree consistent with earliness, lateness, heavy yield, or any other special quality which gives the variety a marked commercial advantage.

FIG. 7.—Cross section of tomato, showing the small seed cavities and thick walls of good shipping sorts.

The following list is made up of varieties possessing some markedly distinct character, such as earliness, great size, purple, red, or yellow color, dwarf habit, etc.:

Early ripening varieties.—Sparks' Earliana, Atlantic Prize, Early Freedom.

Large-fruited varieties.—Ponderosa, Beefsteak.

Purple-fruited varieties.—Beauty, Acme, Imperial.

Red-fruited varieties.—Favorite (late), Honor Bright, Matchless, Stone, Royal Red, New Jersey.

Yellow-fruited varieties.—Golden Queen, Lemon Blush.

Dwarf or tree types.—Dwarf Champion, Station Upright Tree, Aristocrat.

Potato-leaf types.—Livingston's Potato-Leaf, Mikado, Turner's Hybrid.

THE TOMATO AS A FIELD CROP AT THE SOUTH.

Commercial tomato growing in the Southern States is almost exclusively confined to the production of tomatoes at a season when they can not be grown at the North except in greenhouses. On this account the commercial production of this crop is restricted to areas where there is very little, if any, freezing during the winter months. Florida and Texas lead in the production of this crop.

TIME OF PLANTING.

At the extreme southern limit of the commercial cultivation of t… crop in Florida the plants are grown so as to be ready for sett… in the open about December 1. The date of seed sowing adva… as the cultivation of the crop progresses northward, so that … northern Florida the seeds are sown early in January and the … plants placed in the field in March. Where frost conditions d… form barriers against the production of seedling plants in the op… the seed beds for the young plants are prepared in some shelt… situation where partial shade can be given and where the seed … can be frequently watered. The young plants, as soon as t… have attained the proper size—that is, from 6 to 10 inches in heig… are transferred to the field in practically the same manner as are t… hotbed-grown plants produced for general field culture at the N… and except for a specially early crop they are not transplanted or pot… .

In the latitude of Savannah, Ga., the seed for a crop of tomato… usually sown in cold frames provided with glazed sash about Janu… 1 to 10. The young seedlings do best if transplanted to other fra… and placed about 3 or 4 inches apart each way by February 15, w… they may be allowed to remain until planted in the open about Ap… 1. Picking from such plantations will usually take place from J… 1 to 10, about one month earlier than fruits can be expected from … field in the latitude of Washington, D. C.

The young seedlings in the cold frame will require careful atten… in the way of watering and ventilation; otherwise many plants wil… lost by damping off or from sun-scorching during bright days unl… the sash are lifted or entirely removed.

FERTILIZING.

The plants are set from 3 to 4 feet apart in the row, with 4 t… feet between the rows. The ground is fertilized with commer… fertilizers containing from 1 to 2 per cent of nitrogen in the form… nitrate of soda, from 8 to 10 per cent of phosphoric acid, and from … to 6 and even 8 per cent of potash. A dressing of from 400 to … pounds to the acre is employed, and with clean cultivation the pla… make a quick return. The fertilizer is almost exclusively confined … a strip 1 or 2 feet wide along the course of the row instead of bei… sown broadcast over the area.

TRAINING THE PLANTS.

It is customary to train the plants grown in this latitude to stak… from 2 to 2½ feet in height. The stalks of the plants, which are usua… restricted to two or three in number, are tied to these stakes in ord…

to keep the fruits and the foliage off the ground and to expose the plants to the action of sun and air for the purpose of bringing the fruit to early maturity. A tomato plant as trained in this manner for this section is shown in figure 2.

YIELD OF FRUITS.

The yield of fruit in the South, under the conditions mentioned, is much less than it is in regions having the long growing periods characteristic of higher latitudes. Yields vary from 75 to 250 bushels to the acre, but the high price obtained for the fruits which are thus produced at a season when the sole competition comes from the products of northern greenhouses renders the crop, when well handled, very remunerative.

SOIL FOR THE CROP.

The soil which is preferred for the production of this crop is one which contains a comparatively high percentage of sand. In this region sandy loam or a sandy soil is preferred to bottom land for the cultivation of tomatoes. An area with a gentle slope to the south is considered more desirable than that with other exposure. If a windbreak can be secured along the north and west sides of the area very early crops can frequently be preserved through a wind storm when the temperature, while not low enough to freeze the plants, will, when accompanied by a high wind, chill and destroy them.

HARVESTING AND MARKETING.

Where tomatoes are extensively grown for shipment to the North, convenience, care, and judgment should enter into the preparation of the product for the market. It is always advisable and usually necessary to assort and grade the fruits as they come from the field before placing them in the shipping boxes. If this work can be done in a shed located on the railway over which the fruits are to be transported, so much the better, but if it is necessary to haul the tomatoes some distance for shipment then the packing shed should be located at the most convenient and accessible point for both harvesting and shipping. The same precautions in handling the fruits should be observed at the South as at the North.

Sorting and grading.—The fruits as they come from the vines should pass the scrutiny of experienced sorters and graders so that tomatoes of a certain size and degree of ripeness will reach the same shipping case. All leaky fruits should be excluded, and the stems, if any are found attached to the fruits, should be removed. Experience has shown that fruits are less likely to be broken and leaky upon arrival at their destination if all stems are removed than when this feature is neglected.

Packing.—The individual fruits are wrapped in a soft brown or white tea paper and packed in two-layer boxes or in the six-basket peach carrier already described (fig. 4). Fruits packed in this way and shipped by express are successfully carried from Miami, Fla., to New York, and from Corpus Christi, Tex., to Chicago.

Time of picking.—For the long shipments which are necessary in order to place the Florida and Texas grown tomatoes in the markets, the fruits are picked as soon as they have reached full development and show the slightest change in color. The stage of ripeness at which fruits should be picked and shipped should be regulated by the season as well as by the demands of the market for which they are intended. During cool weather the fruit should be riper when gathered than during the warm season. The most distant shipments should be filled from the least advanced fruits. These features would appear to be self evident, but they are worthy of enumeration, for they are important factors in gaining the highest success.

VARIETIES FOR THE SOUTH.

In the South, where the tomato is handled as a short-season crop, certain varieties are found to give best results in certain districts. Along the Atlantic seaboard the growers of tomatoes use such sorts as Beauty, Stone, Perfection, Aristocrat, and Paragon.

In the truck regions of eastern Texas the Dwarf Champion is perhaps more universally grown than any other variety, but in this same region the Success is found to be a more profitable late-season or [illegible] crop than the Champion.

SECOND OR LATE CROP TOMATOES.

At the present time the tomato growers of the South place their main dependence on the early crop, which comes in in advance of the tomatoes grown at the North and consequently finds competition only with the hothouse-grown product. There is, however, another very promising field for a limited number of truck growers in the Southern States in the production of a second or later crop of tomatoes which shall ripen during the months of September and October. The southern markets, which are each year becoming more and more important, are practically bare of tomatoes from early in July throughout the rest of the season, and some local growers who have taken advantage of this by growing a second or late crop are now reaping very satisfactory harvest from such plantations.

The question of varieties which are adapted to this purpose is not well understood and each locality engaging in this work will of necessity be compelled to work out its own variety list. When this [illegible] re been determined the question of producing a second or late crop tomatoes to supply the southern market will be much simplified, l a larger number of gardeners will find this a paying crop. At the sent time the Success seems to be the only variety which is pre-inently adapted to this purpose, particularly in the State of Texas.

FORCING TOMATOES.

In the forcing of plants, which means the growing of a plant out of natural season and in an artificial environment, the first requirement success is a properly constructed protective structure or green-use. Because of the tropical nature of the tomato more than ordi-ry provisions must be made in order to meet the demands of this p. In the forcing of most vegetables a lower temperature and nches without bottom heat are satisfactory, but with the tomato house must be piped so as to maintain a minimum temperature of - F., and the benches should be so constructed as to admit of apply-g bottom heat.

TYPE OF GREENHOUSE.

The type of house that is generally employed for the forcing of toma-es is the even-span or a three-fourths span house. If the even-span use is used it is preferable to have the ridge running north and south; the three-fourths span house is employed it is best to have the long le sloping toward the south. The tomato when grown in the forcing use, because of its long fruiting season and the fact that its clusters fruit are borne one above the other, requires a considerable amount head room. Low houses are therefore not desirable in the produc-on of this crop. The side walls of a house designed for the forcing tomatoes should be at least 4 feet in height, and the distance from e top of the middle bench to the ridge of the house should be at least feet.

SOIL.

The soil for the production of this crop should be well decomposed am, made, if possible, from sods from an old pasture, the soil of hich is a rather light clay loam or a heavy sandy loam. With this ould be incorporated about one-fourth its bulk of well-rotted stable anure, preferably cow manure. By composting these two materials r from four to six months before they are required for use a very tisfactory soil for the forcing of tomatoes will result. Care should e exercised to allow the soil that is used for forcing tomatoes to be ozen each year.

Depth of soil.—The depth of soil required for the successful growth of matoes is considerably more than that employed for roses, although

the temperature and other requirements are very similar to th-
demanded by the rose. While 4 or 5 inches of soil are adequat
produce a crop of roses, the soil for tomatoes should be at least 6
inches in depth; 8 inches is preferable.

Renewal of soil.—It is not well to allow the soil to remain in the gr
house longer than a single season. It becomes somewhat exhau
and is likely to become infested with injurious forms of life, parti
larly nematodes, which cause root-knots upon the tomato plants, t
defeating the work of the gardener. This trouble, however, ca
easily overcome by subjecting the soil to freezing.

Sterilizing the soil.—In localities where the winter temperatur
not admit of renovating the soil by freezing, steam may be us
accomplish the same end. Sterilization can be carried on in box
to 15 or 18 inches deep, in the bottom of which are steam pipe
perforations every 2 inches, the perforations being about one-sixte
of an inch in diameter and so placed that they are on the under
of the pipe. The pipes are arranged in coils and distributed far en
apart to allow the blade of a spade to be operated between them.
lid which is carefully fitted over the box should be provided, an
box should be made so as to hold 1 or 2 cartloads of compost. A
subjecting the soil to the action of the steam a sufficiently long t
to cook a potato buried in it the soil will have become thorou
sterilized.

If a more permanent structure than the box is desired for sterilizat
a brick pit, 18 to 20 inches in depth, can be arranged for the pur
Good drainage should be provided. The bottom of the pit shoul
paved or concreted, and the side walls should be at least 9 inches t
and coated with cement to make them as nearly air-tight as po
A tight-fitting lid will also be necessary for use in connection with
device. It is better, however, to make the pit shallow and bro
long, rather than deep, as the sterilization will be accomplished so
in a comparatively shallow layer of soil than in a very deep one.

TEMPERATURE.

After the soil has been sterilized or after the compost has
made, as first described, the soil should be spread upon ben
which should be constructed so as to admit of placing steam or
water pipes beneath them in order to produce the desired am
of bottom heat. In order to secure the greatest economy both in h
and in space, the heating pipes may be placed very close to the sur
of the ground and the bed in which the soil is to be placed should
constructed only a few inches above the heating pipes, thus makin
very small air chamber beneath the bed, not to exceed 10 or 12 inc

ˀ bottom of the bed and the top of the floor or ground. ın arrangement and with adequate openings along the sides hes the heat given off by the pipes beneath the bed will ıfficiently high atmospheric temperature for the tomato.

SEEDLING PLANTS.

s of plants are used for forcing purposes—seedling plants plants. The former are, of course, seedlings grown from .lly sown for the pur- ng plants to be grown ›use. It is customary de of New York and ːo sow the seed for a p of tomatoes in the .ugust, August 15 be- on date for this opera- oung seedling plants, they develop the first are then transplanted ed bed to small pots, }-inch pots. They are ply at this time and ɔwing rapidly but not to produce a soft, rowth. As soon as pots are filled with ›lants are shifted to , and when the plants ·d a height of 12 or 15 have developed their ıs, they are usually placed on the benches of the green- ·e they are to produce their crop. The plants are then 8 inches apart each way in a soil prepared as previously The plant represented in figure 8 is a good example of a ›le for use in a forcing house.

FIG. 8—Pot-grown plant, ready for transplanting to forcing house or field.

CUTTING PLANTS.

should be taken from strong, healthy, vigorous-growing he field, and placed in the cutting bed about the last of ere they will quickly take root. As soon as the roots have o a length of from one-half to 1 inch the young plants are or 4 inch pots, where they are allowed to develop until the ds are well formed or the blossoms have expanded, when be planted on the bench where they are to mature their e manner as noted for seedling plants.

Cutting plants are somewhat shorter jointed and come into blossom sooner than seedling plants, and for this reason they may be started somewhat later than the date mentioned for sowing seed.

TRAINING THE PLANTS.

Tomato plants in forcing houses are usually grown to a single stem, as shown in figures 9 and 10, or at most with two or three stems, as shown in figure 11. The houses are provided with wires running parallel to the rows and immediately over them, the wires being fastened by screw-eyes or staples to the sash bars, as indicated in figure 12, which gives a general view of a tomato forcing house. In many instances parallel wires are also fastened to the top of the bench and pass close to the rows of plants. Strings, preferably tarred, similar to the tarred strings used by farmers for tying corn fodder, are used between the two wires and to form a support to which the stems of the tomatoes can be tied.

FIG. 9.—Single-stem plant in forcing house, showing method of tying fruit cluster.

The tying of tomatoes should be carefully done. Raffia should be used for this purpose and should be passed around the supporting string two or three times to bind the raffia to the string, so that when a loop is passed under a fruit cluster or under a leaf, as shown in figure 9, the stem of the tomato will be held up to the string and still allow sufficient room for the growth and thickening of the stem of the plant. If the stalk of the plant is tightly tied to the supporting string or wire it is liable to be girdled. As the plants come into fruit and the fruit clusters develop it will be necessary to pass a band of raffia under one of the subdivisions of the fruit cluster and around the stem of the plant or around the supporting string in order to prevent the fruit cluster from being broken close to its point of origin by the weight of the fruit. When once broken the nourishment to the developing fruits is cut off and the development from that time on is unsatisfactory.

e field, where the tomato plants are exposed to the action of
ıd to the visits of insects, no special attention is necessary in
o secure the pollination of the flowers and the setting of the
 Under the conditions existing in a greenhouse, however, it is
ry to artificially pollinate the flowers of the tomato; other-
ly a very small percentage of fruits will set and the object of
k will be defeated. It is therefore necessary to allow the tem-
e of the house to become quite high in the middle of the day on
unshiny days while the plants are in bloom, and to pass through
se at this time with a little stick, 18 inches or 2 feet in length,
ıich to strike the supporting strings or wires and thus to set
ıts in motion and liberate the pollen and cause it to fertilize
'ers.

ore satisfac-
y, however,
ıse a watch
or 1½ inches
eter, embed-
putty, at the
handle com-
f a light ma-
preferably
pine, which
e 12 or 18
s long, as
in figure 13,
sp this spat-

FIG. 10.—Bench of single-stem plants.

ıe left hand and, with a light pine stick of equal length (fig. 13,
e right hand, pass through the house, tapping each open flower
with the wand, at the same time holding the watch glass under
ers to catch the pollen. Before removing the watch glass from
ition lift it sufficiently to cause the stigma of the flower to dip
pollen contained in the glass.

refully going through the house from day to day during the
ıg period nearly 90 per cent of the blossoms which develop can
ed to set. During dark, cloudy, stormy weather, however, a
percentage of plants will be fertilized than during bright,
atively dry weather. The conditions in the greenhouse can
modified so as to entirely overcome the adverse conditions
on the outside, although with care much can be done in this
n.

MANURING.

It is desirable to keep plants of the tomato which are designed forcing growing at a moderately rapid rate throughout the forcing period. Growth should be strong and robust at all time slow enough to produce close-jointed plants which bear their clusters at near intervals. There is considerable difference in vari of tomatoes in this respect, and those which naturally bear their clusters close together should be selected for forcing purposes. T manuring of the plants should, therefore, take a form which be conducive to this strong, ous growth, yet not suffici heavy to produce plants which to wood at the expense of bearing. If a nitrogenous fe lizer is to be used, nitrate of in solution is preferable to slower acting forms commonly ployed in greenhouse operat such as bone meal, cotton-seed and sheep manure. It is bett use an artificial fertilizer than manure for producing str growth in the plants during forcing period. Nitrate of sulphate of potash, and acid phate can be combined so give the desired proportion nitrogen, phosphoric acid, potash.

FIG. 11.—Plant trained to three stems.

INSECT ENEMIES.

Forced tomatoes are, as a not seriously infested by the mon insect enemies of the g house, with the exception of sp of mealy bug and white fly.

Mealy bugs can be destroyed by spraying the plants with a solu of a cheap neutral soap in water or by fumigation with hydroc acid gas. The white fly (*Aleyrodes* spp.) can be held in check by f gation with tobacco stems or with one of the modern tobacco smu now upon the market. For information in regard to remedies for greenhouse white fly, see Circular No. 57 of the Bureau of Entomol Department of Agriculture.

VENTILATING AND WATERING.

If careful attention is given to keeping the plants in a healthy con-tion by never allowing them to suffer from overwatering or from ecoming too dry, and if sufficient ventilation is given without allow-g draughts of cold air upon the plants, much can be done to prevent e development of mildew. If the plants are to be sprayed it should e done once a week or once in ten days, and then only in the morn-gs of bright days. Ordinarily, however, the atmosphere of the ouse should be kept dry rather than moist, as a very moist atmos-here is liable to produce a soft, succulent growth, which brings on a isease known to gardeners as œdema. This, however, is only a

FIG. 12.—House of tomatoes, showing wires and strings for training plants.

ysiological condition and can be prevented by care in keeping the use rather dry. The temperature of the house, too, should not be lowed to fluctuate through too wide a range. The night tempera-re for tomatoes should range between 65° and 68° F., while the day mperature should run from 70° to 80° F.

GATHERING THE FRUITS.

The individual tomatoes as they ripen should be cut from the cluster as not to interfere with or disturb the remaining fruits, and a por-n of the stem should be left adhering to the calyx. Fruits gathered this way present a more pleasing appearance and are less liable to leaky. For special markets close at hand it is not nec specially wrap the fruits, as they are usually sold by the pound. F· shipment, however, it is best to wrap the fruits in tea paper, eit· white or brown, and to pack them carefully in carrier baskets similar t· those used by growers for the shipment of peaches. The yield of a plant grown in the manner described should range between 4 an· pounds, the average being about 5 or 6 pounds.

VARIETIES FOR FORCING.

The comparatively limited use of tomatoes for forcing purpo· in this country has not resulted in the development of many sorts e·p· cially suited for this purpose. The Lorillard is the one Americ· sort which is now almost exclusively confined to this use, and it · perhaps more generally cultivated in forc·. houses than any other single variety.

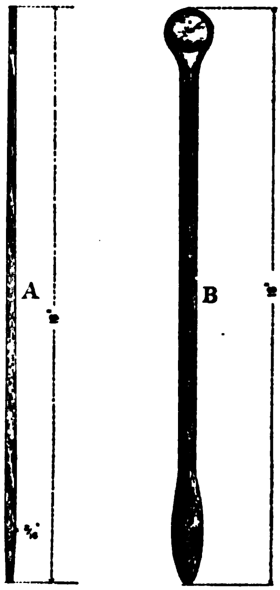

FIG. 13.—A, Wand used in pollinating flowers. B, Spatula used in pollinating flowers.

THE TOMATO AS A FIELD CROP FOR CANNERIES.

The tomato is so extensively grown a·. field crop that it may seem as though lit· could be added concerning the method· t· be observed in growing the crop for cann·. purposes. Success, however, requires d·· nite knowledge and careful practice al·. the four lines already emphasized: (1) T· selection of the variety; (2) the growing . the plants; (3) the selection and preparat· of the soil, and (4) the fertilizing and cult· vation of the land.

SELECTING THE VARIETY TO GROW.

Owing to the fact that in canned tomat· it is difficult for the average consumer to n·: any deficiencies in the appearance of the ori· inal fruit, many labor under the delusion th· any variety will answer for this purpose. This is a mistaken idea. · quality in canned goods is now an important factor, and it is quite a· necessary that a good quality of product should be used for cann·. as for growing for the early or general market, although from t· field side it is natural that tonnage should be a primary considerat·

In the matter of varieties, as in the case of early tomatoes, too m· dependence should not be placed upon the name or upon the fact th· a neighboring farmer secures good results from a given variet There are so many variations in the character of soils, even in t· same locality, which exert an influence upon the size and quality · crop that the best variety is usually one that is, in part at le·st

eloped by the individual grower. The main point is to select varie-
that produce large, smooth, solid fruits, which do not remain green
rack on the shaded side near the stem. Those which possess size
heir chief characteristic are frequently of poor quality, as they are
ly to possess large seed cavities and to ripen unevenly. The Stone,
agon, Ten Ton, Cumberland Red, and Livingston's Perfection are
varieties that have been grown with advantage. In fact, in many
alities the variety giving best returns has no trade name, neither is
place of origin known. Thus it assumes a local name, as, for ex-
ple, in New Jersey the "Jersey Red" is probably grown more
gely than any other sort, though it possesses very different charac-
istics in different localities, and is a development and improvement
some good variety introduced at an earlier period.

The conditions in some sections are such as to prevent the canners
m making as much distinction between good and poor varieties as
y would like. Canneries are in a measure obliged to receive all
t come, unless they can control absolutely the land upon which the
p is grown. The variation in the quality of the crops of different
rmers will make a difference of from 25 to 40 cans on a ton of fruit,
from 6 to 10 per cent—a very considerable item. In good seasons
d with good fruit 400 cans may be regarded as the maximum number
be derived from a ton, though late in the season, and with poor
rieties, as already stated, the pack from a ton is very much less.
e interests of the grower and the canner are really identical in
is regard. An improvement in the quality of the fruit will result
an improvement of the canned product and a consequent increase in
e price of both the raw and manufactured products.

GROWING THE PLANTS.

Less expense is involved in growing suitable plants for cannery pur-
ses than for other crops. This is due to the fact that earliness is not so
portant a factor as it is in the market garden crop. On this account the
ed bed for the cannery crop can be prepared without the use of sash or
ames. A sheltered situation where north and west winds are cut off
t with full exposure to the south will serve for this purpose in New
rsey, Maryland, and States to the south. The seeds should, however,
planted early in April and the plants be ready to go into the field
out the first of June. In localities where planting can not be safely
ne in the open at this date recourse should be had to cold frames.

The soil of the seed bed in the open should be a warm, well-drained
ndy loam, deeply spaded, carefully raked, and made smooth before
wing the seeds.

The seeds should be sown shallow, about one-half inch deep, the
rface compacted by use of a board, which may serve as a walk for
he workmen while sowing the seeds as well as a marker for laying off

the rows. The rows may be 3 or 4 inches apart and rather broad with the seed scattered thinly in a belt. In some cases it may prove an advantage to place a light mulch of coarse litter or cut straw over the seed bed immediately after planting. In all cases, however, the mulch should be removed before the seed breaks the ground; otherwise the plants will be drawn and valueless. When the plants are an inch high the soil should be stirred. This stirring should be repeated frequently, particularly after each rain, as it induces more rapid growth and more freely admits the warm air to the roots of the plants. Unless there is an abundance of rain, careful attention should also be given to watering, as the plants require a great abundance of water.

If all these precautions are carefully observed and the work properly carried out, good, strong, well-rooted plants should be ready for the field from the first to the middle of June—the time at which they are usually set in New Jersey or Maryland. In States farther south the planting of the seed would naturally be a little earlier, thus making the setting in the field proportionally earlier.

SELECTING AND PREPARING THE SOIL.

The tomato as a field crop is adapted to a wide variety of soils, though a medium clay loam is probably the best. In fact, any soil well adapted to potatoes will grow the tomato to good advantage. The previous treatment, however, has an influence on the best development of the crop, and a clover sod, or a soil upon which corn has been the preceding crop, is perhaps the best. In either case the land should be deeply cultivated, preferably in the autumn or early spring, in order to improve its physical character and to destroy injurious insects, which may be troublesome later. It is also desirable where it is the practice to use manure, particularly if it is coarse, to spread it during the winter, in order that the soluble portions may become thoroughly distributed in the soil. As soon as the land is ready to work in the spring it should again be plowed shallow and then deeply cultivated in order to thoroughly work up the soil and to incorporate in it the coarser portions of the manure.

FERTILIZING AND CULTIVATING THE SOIL.

In manuring and fertilizing, the character of the crop and the season of its growth should be remembered. Hence, recommendations that were made in these pages for an early crop do not apply in all cases, except perhaps on the poorer classes of soils. In the first place, the plants are not put in the soil until summer, when the conditions are most favorable for the rapid change of organic forms of nitrogen into nitrates, and thus, if the soil has been manured or is naturally rich in vegetable matter, the additional application of nitrogen in immediately available forms is not so important. In the second place, the object of the growth is not early maturity, but the largest yield of mature fruit.

It is more desirable to grow a larger plant than in the case of early tomatoes. The fertilizing should be, therefore, such as to furnish an abundance of all the elements of plant food.

Since the tomato belongs to the potash-consuming class of plants, the fertilizers used should be especially rich in potash. It is not to be understood, however, that it is not necessary to apply nitrogen, for frequently soils are used that are either not naturally well adapted to the plant or have not been previously well supplied with vegetable matter containing nitrogen. On such soils additional nitrogen is very important, and nitrate of soda is one of the best forms to use, as it is absorbed fully by the roots, thus encouraging an early and vigorous growth of plant and a normal development of fruit. Slow-acting organic forms of nitrogen, on the other hand, frequently begin to feed the plant and cause its rapid growth when the energies should be concentrated in the growth and maturity of the fruit.

Fertilizers that have proved excellent are those which contain a relatively smaller amount of nitrogen than is required for early tomatoes and larger quantities of phosphoric acid and potash.

Character of fertilizer.—On a good soil which would without manure produce 5 to 6 tons there should be added a sufficient excess of nitrogen, phosphoric acid, and potash to provide for a maximum crop, and the fertilizer should be relatively richer in nitrogen and potash than in phosphoric acid. A mixture of nitrate of soda 400 pounds, bone tankage 700 pounds, acid phosphate 400 pounds, and muriate of potash 500 pounds, would contain approximately 95 pounds of nitrogen, 144 pounds of phosphoric acid (48 pounds of which would be soluble and available), and 250 pounds of potash in each ton.

An application of 500 pounds of this mixture to the acre would furnish half as much nitrogen as is contained in 10 tons of crop, nearly as much immediately available phosphoric acid, and two-thirds as much potash. Hence, a dressing containing the quantities, kinds, and proportions of plant food here indicated would be regarded as very desirable, since one-half of the nitrogen is in the form of nitrate, which would contribute to the immediate growth of the plant. The quantity of soluble and available phosphoric acid is sufficient to satisfy the needs of the crop throughout its entire growth, and an abundance of potash is present to insure the maturity of both plant and fruit. Formulas of this character have been used with good success, though the large proportion of salts sometimes makes mixtures of this sort too moist to handle well, in which case a part of the potash, or even the nitrate, may be applied separately with advantage.

On poorer soils the artificial supply of plant food should be proportionately greater, or sufficient to provide for the entire needs of a fair-sized crop, since as a rule the relative power of the plant to acquire food is somewhat less on poor soils than on good soils, or, stated another way, the results from the use of fertilizers are proportionately better upon soils in good condition than upon those not well cared for. A good formula for use on these soils may consist of nitrate of soda 500 pounds, bone tankage 500 pounds, acid phosphate 400 pounds, and muriate of potash 600 pounds.

One ton of this mixture would furnish approximately 105 pounds of nitrogen, 120 pounds of phosphoric acid, and 300 pounds of potash. The application of 1,000 pounds of this mixture to the acre would furnish sufficient food in good proportions to meet the demands of a fair crop. The advantage of using so large a proportion of nitrogen in the form of nitrate is that in this form it is immediately available and induces the immediate and rapid growth of the plant, and thus prevents too late a growth by furnishing a minimum of organic nitrogen, which would become available late in the season.

The cost of the fertilizer suggested in these cases, though apparently rather large, should not exceed $15 per acre, and is no more than would be required for fertilizers to insure a maximum crop of corn or other field crop on the soils described. Besides, it must be remembered that the quality of the crop would be greatly improved. The necessity for so expensive a dressing could be materially lessened by reducing the need for nitrogen, and this could be accomplished by sowing crimson clover with or after the previous crop of, say, early corn or potatoes; in fact, if weather conditions are favorable, crimson clover may be seeded in the tomato fields in August after cultivation has ceased, at the last cultivation, and a crop of clover grown which will provide nitrogen for the next year's crop. This method is now practiced with advantage by many growers. The cost of manuring or fertilizing tomatoes on soils in good condition, and which have been well managed for previous crops in the rotation, should not exceed $8 per acre.

SETTING AND CULTIVATING THE PLANTS.

The plants should be set from 4 to 4½ feet apart each way and cultivation should begin immediately. The first cultivation should be deep, in order to conserve the moisture, and each subsequent cultivation shallower, in order not to destroy the roots, which will fill the soil as soon as the plants reach maturity. The crop in good seasons should begin to ripen in August, and picking will continue from that time until the last of September.

COST, YIELD, AND VALUE OF CROP.

The cost of production per acre is much less for fruit for canning than in the case of early tomatoes, the chief difference being in the production of the plants. The several items may be classified as follows:

Cost of growing an acre of tomatoes for canning.

Plants	$2
Manures and fertilizers	8
Preparation of land, setting plants, and cultivation	8
Picking and carting	10
Total	28

ıe yield, as in the case of the early tomatoes, varies widely, rang- from 5 to as high as 20 tons per acre, even 30 tons per acre having ι reported in exceptional cases, although the average for a series ears on average land will probably be under 8 tons. Where all litions are carefully observed, 20-ton yields are frequently obtained, at the prices received at the cannery, ranging from $5 to $7.50 ton, according to the locality, the crop is a fairly good one and the profits are quite as large as for other field crops.

CONTRACTS BETWEEN GROWERS AND CANNERS.

'he agreements made between the growers and canners differ some- ıt, though the main object on the part of the canner is to secure icient tonnage to maintain the factory during the ripening season. vould seem that the fairest form of contract would call for the ›duct of a certain number of acres rather than the delivery of a cer- ı number of tons. It is impossible for the farmer to anticipate the son, and therefore he can not safely contract to deliver a definite mber of tons. The following form of contract, which is generally :d in New Jersey, is good and protects both the producer and the ıner:

'his is to certify that we ——— have bought of ——— the product of ——— acres of ıatoes for the season of ——— at $——— per ton, delivered at our cannery at ———. ck to be in first-class mercantile condition. To be planted about ———.

Provisions are frequently inserted in contracts to cover the date of ә beginning of the delivery, as well as to protect the cannery in case fire, accident, or other contingency.

The cooperation of farmers in the ownership and management of a nnery is practiced in a number of places in the United States, though is not general.

THE DISEASES OF THE TOMATO.

Leaf-spot and leaf-mold, two fungous diseases of similar nature, are arked by the appearance of small, round, or irregular spots on the aves, causing them to curl and finally die. Both are easily prevented y thorough spraying with Bordeaux mixture. The applications should ›gin soon after the plants are transplanted and be repeated at inter- ıls of ten days through the season.[a]

[a] See Farmers' Bulletin No. 91 for directions for preparing Bordeaux mixture.

The principal greenhouse disease of tomatoes is a mildew (C*la-*
sporium fulvum), which grows on the under surface of the le-
causing yellow discolorations, distortion, gradual drying, and fi-
death. The fungus usually appears first on the lower and older l-
which have partly lost their vitality. The plant should, therefor-
carefully watched for the earliest appearance of the disease and i-
diate steps taken for its eradication. One of the best methods i-
spray the plants at intervals of seven to ten days with Bordeaux -
ture or with a solution of ammoniacal carbonate of copper, ma-
follows: Dissolve 5 ounces of copper carbonate in 3 pints of -
ammonia and add 45 gallons of water. This solution, applied -
pump having a fine nozzle, such as the Vermorel, will prove eff-
against the disease.

Fruit-rot is combated with more or less success by pruning -
training vines to admit light and air, together with the destructi-
all diseased fruits, to prevent the spread of infection.

Wilt, principally a southern trouble, is due to three distinct p-
sites. The *Fusarium* wilt, most prevalent in southern Florida, -
pels rotation of crops. Tomatoes in this section should not be p-
on the same land oftener than once in four or five years. The -
tium wilt attacks tomatoes and many other vegetables in the -
States and requires rotation of crops and the destruction of di-
plants. In the autumn, dead plants and decaying matter of all k-
should be removed from the garden and burned. The bacteria-
the most common tomato disease from northern Florida to Mary-
is spread mainly by leaf-eating insects, though the infection pr-
remains in the land as well. Spraying with Bordeaux mixture -
Paris green, together with the destruction of diseased plants -
as observed, is advised.

Root-knot is characterized by the formation of irregular ga-
the roots of infected plants, due to the invasion of minute nema-
or eelworms. Most garden crops are attacked by this disease, -
tomatoes are especially susceptible. They should not be plant-
infected ground. Rotation with crops that do not harbor the w-
tends to free the land from this disease. Nematodes are not tro-
some in the field except in the South. For treatment of nematode-
the greenhouse see page 20.

Western blight or yellows, prevalent in the Rocky Mountain Sta-
is due to a cause not yet fully known, though probably connected -
unfavorable soil conditions. These should be improved by drain-
fertilization, cultivation, and irrigation, and great care should be -
in transplanting not to injure the young plants.

Other diseases, of minor importance except in occasional instan-
are: Oedema (see page 25), rosette (Rhizoctonia), and mosaic dis-

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NAME	DATE DUE