U. S. DEPARTMENT OF AGRICULTURE
FARMERS BULLETIN No. 1028
rev. Feb. 1941

STRAWBERRY CULTURE

EASTERN UNITED STATES

THE STRAWBERRY is the most popular of the small fruits. It is produced on a large scale for market in many localities and is found in home gardens in all sections of the United States.

The fundamental principles of strawberry growing are similar everywhere, but methods of culture differ somewhat in different parts of the country because of differences in soil and climate.

This bulletin discusses commercial methods in the eastern United States, the territory including approximately one tier of States west of the Mississippi—that part of the country where farm crops are usually grown without irrigation—but not including the South Atlantic and Gulf coast region.

The successful cultural methods followed in the different strawberry districts are described. These commercial methods are not all applicable to the growing of strawberries in the home garden, but as the underlying principles are the same, the practices may be modified without difficulty.

The bulletin gives complete directions for planting, fertilizing, cultivating, harvesting, and marketing.

Washington, D. C.

Issued April 1919
Revised February 1941

STRAWBERRY CULTURE: EASTERN UNITED STATES

By GEORGE M. DARROW, *senior pomologist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry*

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COMMERCIAL IMPORTANCE

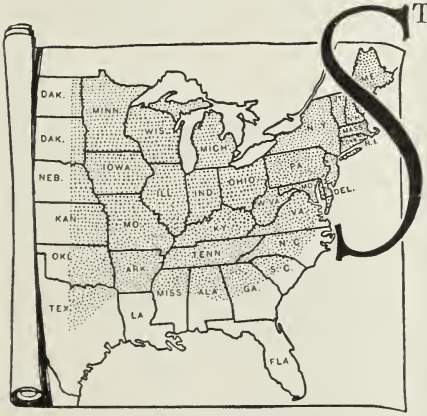

FIGURE 1.—Map of the eastern half of the United States. The shaded portion indicates the region to which this bulletin applies.

STRAWBERRIES are widely grown in the eastern part of the United States. The shaded portion in the map (fig. 1) indicates the region to which this bulletin applies. This region includes in general the humid part of the eastern half of the United States, except a narrow strip along the South Atlantic and Gulf coasts where the elevation is less than 500 feet. It includes that part of the eastern United States where the fruit buds are usually formed only in the fall. The southern boundary is for the most part the northern limit of the Coastal Plain region. This boundary extends from the Virginia-North Carolina boundary on the Atlantic coast, southwest through North Carolina, South Carolina, Georgia, Alabama, Mississippi, Arkansas, and Texas. The western boundary is approximately the eastern edge of the Great Plains region.

The strawberry is the most important small-fruit crop in the United States. The commercial strawberry crop has an annual farm value of about $35,000,000 and the home crop an annual value of about $5,000,000. Not only is it one of the most popular fruits, but it is also the most widely grown, being cultivated commercially from northern Maine to Florida, and in all the irrigated areas of the West where fruits can be grown. It is particularly adapted to the home garden, as it ripens earlier than any other cultivated fruit, does not usually have to be sprayed, and enough to supply an ordinary family can be grown on a very small area.

In years past the strawberry was grown only in the home garden and by gardeners located within a few miles of the market. The fruit was consumed during a very short season, averaging about 3 weeks. Since about 1860 the period of its consumption has been greatly extended, and in the large city markets strawberries can now be obtained throughout the year. Relatively large quantities are consumed from early April until July. Smaller quantities of the everbearing varieties and a continuous crop of the noneverbearing varieties from the coast region of California may be purchased from July until December, after which berries are shipped from Florida.

The map (fig. 2) shows the location of the principal strawberry-producing districts in the United States and the approximate shipping season for each. Strawberries that supply the northern markets after the first part of June are largely raised in the immediate vicinity of the towns and cities and are not shipped any great distances. Although strawberries are grown extensively in the Northern States, the acreage is scattered rather than centralized in certain definite regions, as is the case in the States farther south and west.

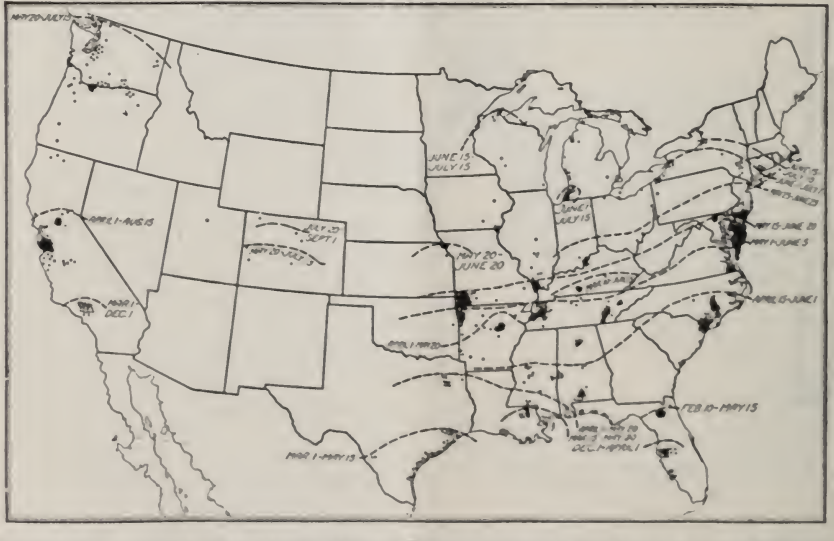

FIGURE 2.—Outline map of the United States, showing the approximate shipping season for each strawberry-producing section. Dots show specific locations of the more important producing areas.

LOCATING THE PLANTATION

The factors that should be considered first in locating a commercial strawberry plantation are the accessibility of markets, transportation facilities, labor supply, community interests, and climate.

The possibility of obtaining labor to harvest the fruit should be carefully considered, as the commercial success or failure of the crop will often depend upon this factor alone.

When strawberries are to be grown for the general markets it is usually better to select a locality where other growers are raising them. Experienced pickers can usually be obtained more easily, and because of the possibility of cooperative handling, baskets, crates, and other supplies can be obtained to better advantage. Furthermore, consignments from several growers can be combined, often making carload shipments possible when, without this combination, small shipments would have to be made by express.

The strawberry may be grown in any part of the United States except in arid and semiarid sections of the West where water for irrigation is not available. Within the northern part of the United States, however, are certain areas where only a few varieties have proved hardy enough to grow successfully. In northern Illinois, in northern Missouri, and in Wisconsin, Minnesota, Iowa, Nebraska, South Dakota, and North Dakota most varieties are somewhat tender, and none should be planted widely until careful trial has proved it hardy. Certain sorts, however, especially the Dunlap, Beaver, and Rockhill, are exceptionally hardy and may be grown throughout this area, except perhaps in the most exposed places. If given winter protection, they may be grown even in the colder parts of Iowa and Minnesota.

In selecting the specific site for the plantation these additional factors should be considered: Air and water drainage, slope, the exposure of the land, and the character of the soil.

In localities subject to late spring frosts, a site somewhat elevated above the surrounding country should be selected. Cold air settles into low places, and frosts occur there more frequently than on the more elevated sites. As the strawberry plant is close to the ground, the blossoms are often caught by unseasonable frosts when the blossoms of fruit trees occupying the same ground would escape. Plants on a site with even a slight elevation above the surrounding country will often escape injury from frosts because of the air drainage thus provided.

Crown and root injury from low temperatures in the late fall and in winter may occur in low spots when less injury occurs on more elevated fields.

Strawberries thrive best on soil that is naturally moist but not wet. On wet soil plants make very little growth in the summer, and the red stele root rot [1] may be serious. Plants are likely to be killed when the wet ground freezes in the winter, as ice is a good conductor of heat and cold, and the soil temperatures follow the air temperature closely unless protected by a mulch. Therefore the site should be well drained.

[1] Red stele is a relatively new root disease of the strawberry. It may injure or destroy the roots from late fall to early spring when the soil is cool and wet.

Ordinarily a site having a gradual rather than a steep slope should be selected for the strawberry. Heavy precipitation, together with a deficient supply of humus, causes soils to wash badly on steep slopes, and cultivation may be expensive. Where strawberries are grown on hillsides, the rows should follow the contour of the hill, as shown in figure 3.

FIGURE 3.—A field of strawberries at Parkersburg, W. Va., trained to wide matted rows and well mulched. The rows follow the contours of the field.

By selecting different slopes, it is possible to vary the period of ripening several days. Where it is important that the berries ripen as early as possible, a site having a southern exposure should be selected. Such an exposure absorbs more of the heat of the sun, and the ground is warmer than on a northern slope. Berries may be obtained from such plantations several days in advance of those on northern slopes. Where it is desirable that the crop ripen as late as possible, a northern exposure should be selected. Such an exposure is cooler and the moisture conditions are usually better than in a southern exposure.

The strawberry not only has a wide climatic adaptation but may be grown successfully upon almost any type of soil, from coarse sand to heavy clay, provided it is well supplied with moisture and at the same time is well drained. In some regions strawberries are usually grown on sandy soils, while in others clay soils are preferred; a heavy yield may be secured in both cases. Although strawberries will grow in practically any kind of soil, particular soils are preferred for certain purposes. Thus, when early fruit is desired a sandy soil is often chosen, since the berries ripen somewhat earlier on sandy than on clay soils, other conditions being the same.

The different varieties of strawberries show decided differences in growth on different soils. Some are much better suited to clay or

heavy soils, whereas others are adapted to sandy or light soils. All varieties, however, show less differences in their adaptation when there is a good supply of humus in the soil than when the humus is deficient. Therefore, in determining the suitability of a soil for growing strawberries the humus content with its effect on soil moisture and fertility is more important than the type of soil.

FACTORS TO BE CONSIDERED IN CHOOSING VARIETIES [2]

In the United States the strawberry is grown in the home garden, by market gardeners, by truck growers, and also as a farm enterprise.

The variety to be planted in any locality will depend upon the climate, the soil, and the purpose for which the crop is to be grown. In the early history of the strawberry industry in this country, when there were fewer varieties, a single sort with recognized superiority over others was often grown nearly throughout the United States. With the development of the industry, however, varieties adapted to the climates of different regions have been produced. In the South the Blakemore, Missionary, and Klondike have been almost the only varieties grown for several years past. In other localities certain varieties especially adapted to local climate and needs have become dominant. In the northeastern part of the United States climatic conditions and soils vary greatly within comparatively short distances, and because of this a larger number of varieties are grown.

As the strawberry industry has developed, varieties particularly adapted to special purposes, also, have been introduced. Some bear firm berries especially adapted to long-distance shipment. Others have large attractive berries of the best quality but too soft for long shipment and therefore suitable only for the local market and for home use. Still other varieties that have a dark-red firm flesh and a brisk subacid or acid flavor are adapted to canning and to the soda-fountain trade.

Varieties of strawberries should be suited to the purpose for which they are to be grown and especially adapted to the particular soil and climate where they are to be grown. The experience of local growers is one of the best guides in selecting the most profitable varieties for planting in any community.

In nearly all regions varieties that will ripen at times when the market is in the best condition and when there is the least competition from other localities must be selected. Thus, in Florida, strawberries ripen and are shipped to northern markets from December until the last of March or into April. As the season advances, localities farther north and nearer the larger cities supply the markets, until in June the territory immediately around Philadelphia, New York, and Boston supplies the same markets that in March were supplied largely by Florida; in April by Florida, North Carolina, and points farther west; in early May by North Carolina and Virginia; and in the latter part of May by Maryland, Delaware, and southern New Jersey. When several points supply the same market, as in this instance, those farthest from the markets are at a disadvantage, as the freight and express rates are higher than for nearer points, and usually the berries cannot arrive in as good condition. The more southern points, therefore, raise chiefly early sorts, for late varieties compete with berries grown near the large markets of the North.

[2] See Farmers' Bulletin 1043, Strawberry Varieties in the United States.

For the home garden, varieties that have the best dessert quality and ripen through a long season or in succession, without reference to their ability to stand long shipments, are most desirable. However, more than one variety usually should be grown, so that a succession of fruit through a long season may be secured. Such berries are given intensive cultivation and may be treated somewhat differently from those grown for market.

Market gardeners also raise strawberries under intensive methods of culture; and since they are located near the markets in which their crops are sold, they have not been interested primarily in the shipping quality. However, at times such markets may be oversupplied with fruit, so that a part of the crop must be shipped to another market or held for a few days in storage. The market gardener, therefore, may need to pay more attention to the shipping quality of the varieties planted and should adopt more of the practices of truck growers.

For general-market purposes, however, varieties that have been found to be widely adapted should ordinarily be grown. Plants of such varieties can be secured more readily than plants of those that are restricted in their adaptation, and the well-known sorts often are sold at a premium over little-known sorts.

When raising berries for the general market, only two or three varieties should be grown, as buyers prefer to secure full truckloads or carloads of one variety rather than loads of mixed varieties that may differ in their shipping qualities and may have different colors, shapes, and flavors. In most of the larger shipping regions not over two or three varieties are grown. It is safer to grow two or three varieties than just one, because all differ slightly in the time of blossoming. If frosts occur, one variety may be injured much less than the others.

Growers who produce strawberries for local markets often wish a succession of ripening throughout the season and may grow as many as three or four sorts to cover the very early, medium early, midseason, and late periods of ripening.

Truck growers raise the fruit as one of their truck crops for the general market. Under such conditions the strawberry is given intensive culture, and the varieties raised must have good shipping qualities. Varieties that combine good shipping and high dessert qualities have been introduced, and it is becoming essential that truck growers as well as others raise these sorts.

When strawberries are grown as a farm enterprise, the methods used are not generally intensive. In some localities, however, intensive methods have been adopted by farmers. They have found the thorough culture of a few acres more profitable than less intensive methods on a larger area.

In the discussion of cultural methods that follows, directions for growing the strawberry as a truck crop will be given, and where such methods differ from those used in home gardens that fact will be indicated.

PREPARATION OF THE SOIL

The preparation of the soil for planting strawberries usually should begin at least 2 years before the plants are to be set, or the plants should be set in soil that has received adequate preparation in growing other crops. Newly plowed grass-sod land should not be used, because the roots might prove objectionable and because of the danger

that white grubs will injure the plants. The land must also be freed of quackgrass or any other seriously persistent weeds, and a suitable supply of humus must be furnished if not already present.

CLEANING THE SOIL

Destroying White Grubs

The larvae of May beetles, or June bugs, called white grubs, occur throughout the strawberry regions of the eastern part of the United States. They are commonly found in sod land, and are very destructive to strawberries planted on infested soil. Legume sod, except lespedeza, may be used, because for some reason the white grub is not injurious in such soil. The beetles lay their eggs in grasslands, and the larvae stay in the soil for 2 years before becoming mature. It is therefore essential, where white grubs cause serious damage, that the ground be freed from them by being planted to cultivated crops for at least two seasons before strawberries are set.

Where the grub is less threatening, the soil should be plowed in the autumn. The resulting exposure during the winter will kill many of the grubs. The following season some cultivated crop should be raised, the soil plowed again in the autumn, and the strawberries planted the following spring. As the grubs may travel for some distance in the soil, it is often necessary to have a plowed area around the strawberry field; otherwise, plants may be killed for some distance from the border by the grubs which come from the neighboring grassland.[3]

Exterminating Quackgrass and Weeds

It is not usually advisable to raise strawberries in a field where quackgrass is abundant, as it is almost impossible to kill out the grass after the plants are set, and if allowed to grow it will make the strawberry field unproductive. For a season or two before setting strawberries, land infested with quackgrass or other weeds that are difficult to eradicate, such as purslane, chickweed, and the like, should be freed by growing crops that require clean cultivation or that smother out such weeds.

ROTATIONS

With many crops rotation has been practiced, because any one crop grown year after year tends to exhaust the fertility of the soil, taking out more of one than of other fertilizer elements. With the strawberry this may be one reason for rotation, but more likely insect, disease, or weed populations have been built up in the strawberry field until some other crop must be grown. Moreover, as the beds become 2, 3, or 4 years old the crowns have grown so high above the ground that new roots cannot form, the plants become weak, and the berries small. Erosion also helps to raise the crowns by lowering the surface. Many crop rotations are very local, whereas others are widely practiced.

The most widely known factor affecting rotation is the white grub, the larva of the May beetle. These insects are abundant in the Northeastern States in grass-sod land. As stated above, wherever they are

[3] For further information on white grubs, readers are referred to U. S. Department of Agriculture Farmers' Bul. 1798, Control of Common White Grubs in Cereal and Forage Crops.

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a serious pest strawberries should follow a cultivated crop or clover, or other leguminous crop, because the white grub finds most leguminous crops objectionable and is rarely found in such fields. Strawberry root aphids are serious on sandy soils, particularly in the Atlantic Coast States. They are often serious in fields in the Central States. In some years thousands of acres of strawberries die out from this pest. Growers have found losses much greater when the strawberry follows corn, weeds, and grass, because the ants that carry the aphids from plant to plant are usually abundant following such crops. Growers have found sweetpotatoes one of the best crops to precede strawberries. Tobacco, potatoes, and other hoed vegetable crops are also desirable, because there are generally few ants and aphids present in such fields. In eastern Virginia, parts of Tennessee, and in Arkansas the strawberry dwarf disease, caused by a bud nematode, is often a serious pest. It is best to avoid planting in infested soil for at least 2 years.

Because the different crops grow best on soils of different acidity, those crops succeeding best in soils of about the same acidity as the strawberry should be selected for the rotation. Field crops such as sweetpotato, potato, rye, oats, wheat, buckwheat, millet, peanut, cowpea, hairy vetch, crimson clover, corn, cotton, and soybeans; and garden crops such as watermelon, beans, tomato, carrot, cabbage, and cauliflower grow better on somewhat acid soils than do beets, onions, spinach, cucumber, eggplant, pepper, lettuce, and celery. If the soil is very acid, lime should be applied before one of the rotation crops, as liming just before planting strawberries has often resulted in injury.

An example of a good rotation is as follows: (1) Keep in clover for 1 or more years; (2) plow in autumn and sow crimson clover or rye and vetch; (3) plow in spring and raise soybeans or some vegetable; (4) plow again in the autumn and sow to crimson clover. In the spring the clover is plowed under and the strawberries planted.

ADDING HUMUS AND FERTILITY

The extent to which the land to be set to strawberries should be enriched will depend somewhat upon the length of time the berries are to be grown on it. In most localities the strawberry plantation is continued for 2 or more years on the same soil, and such soil should be put in the best possible condition before the plants are set. In other localities strawberries are grown for a single year, and preparations may be less extensive.

Soils lacking in humus should be planted first to some green-manure crop or receive an application of stable manure. Soils very deficient in humus may need at least two green-manure crops turned under before strawberries are planted. Ordinarily, however, one crop of crimson clover or rye and vetch will be sufficient. Where these cannot be grown successfully, cowpeas, Canada peas, buckwheat, or some other commonly used green-manure crop can be substituted. The kind of green-manure crop to be used will differ in various parts of the country; the one best suited to the region should be used.

Some growers have found that sufficient humus can be supplied by using a large quantity of stable manure on a hoed crop planted the year before setting strawberries, and then following the hoed crop with a green-manure crop. When practices such as are outlined here

are used, little stable manure will be needed before the strawberry plants are set. It will seldom be convenient to use green-manure crops as a source of humus in the home garden; therefore, stable manure will generally be preferred.

Whatever the previous crop may have been, the land should be thoroughly pulverized immediately before the strawberry plants are set. If the soil has been plowed in the autumn, in many cases it will not need to be plowed again in the spring, thorough harrowing being sufficient.

Under most conditions, level culture should be used. Occasionally where the surface drainage is poor, a ridge on which to plant the strawberries may be made by throwing two or more furrows together and leveling with a plank drag. The height and width of the ridge should be determined by the character of the soil. Unless the drainage is very poor, the ridge should be relatively wide and only 2 or 3 inches high.

GROWTH OF THE STRAWBERRY PLANT

Healthy dormant plants set in a moist soil in early spring produce new fine fibrous roots within a few days. New leaves appear almost as soon as the new roots. If the new root system is extensive the new leaves are normally large and several in number. By the end of May or in June runners appear from buds in the leaf axils, and with most varieties runner production continues until the end of the growing season. For example, a plant set April 1, in Maryland, produced its seventh leaf about May 1, and its twelfth leaf about June 1. By June 1 the first runner was visible, coming from the axil of the seventh leaf. This mother plant produced 35 leaves, 2 crowns, and 11 runners during the summer. The runners were allowed to form runner plants and the latter other runners and runner plants; in all, 112 runner plants formed. The growth of this mother plant and its runner is illustrated in figure 4. In contrast, a second plant set April 1, which also produced its seventh leaf about May 1 and its first runner about June 1, had all runners picked off as they appeared. By fall this plant had produced 83 leaves, 7 crowns, and 53 runners. At the end of summer 42 of its leaves were alive, whereas only 12 leaves of the plant on which the runners were allowed to grow were alive.

About September 1, in early varieties and from September 20 to about October 10 in late varieties, the growing points in the crowns change into fruit buds. These fruit buds develop rapidly, and by the end of October the crowns can be picked open and the fruit buds readily seen. Except in the southern United States and along the Pacific coast, all the fruit buds are formed in the fall. In the spring the fruit buds develop into flower and fruit clusters, but no more buds form in the spring. Of the two plants described above, the one with 7 crowns and 42 leaves at the end of summer would produce many more fruit buds and consequently much more fruit than the one with 2 crowns and 12 leaves. A fruit bud usually forms in the growing point of each crown and, if the plant is vigorous, in many of the leaf axils as well. Records of many plants with different numbers of leaves have consistently shown that the greater the number of leaves on a plant in the fall the greater the number of berries it will produce the

next spring. Thus plants of one variety with 4 leaves in the fall averaged 42 berries each; plants with 11 leaves averaged 102 berries; those with 21 leaves, 142 berries; and those with 42 leaves, 230 berries.

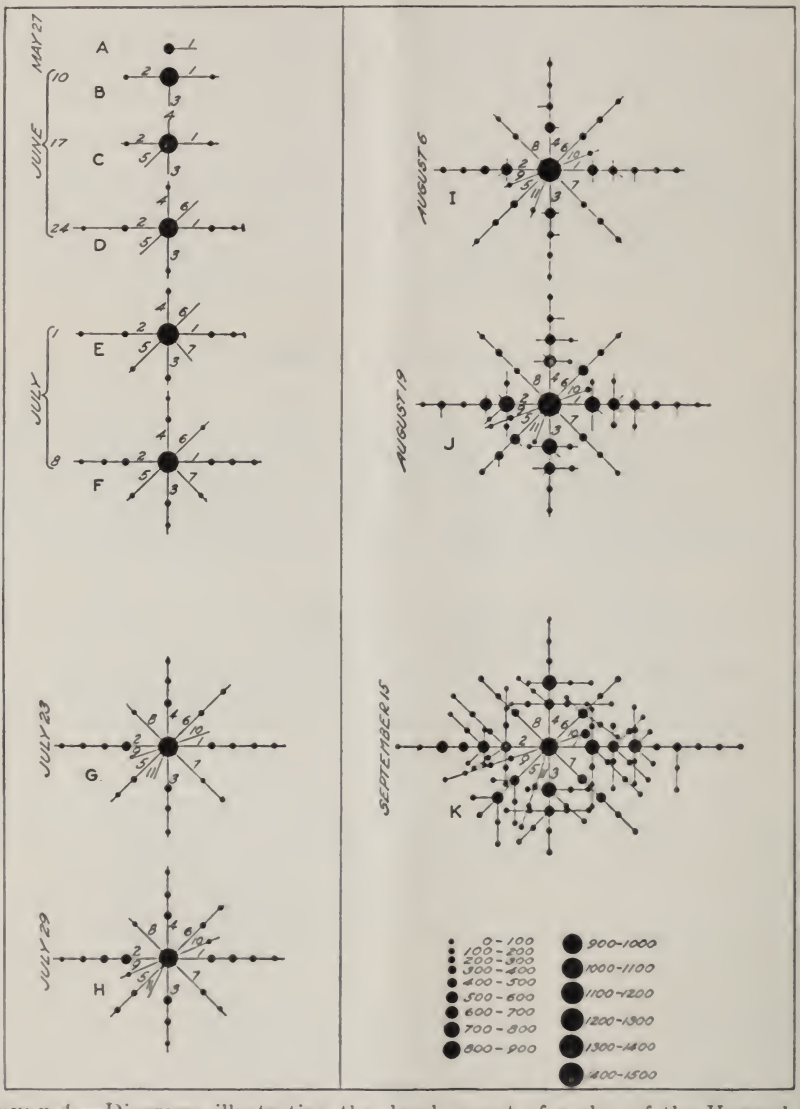

FIGURE 4.—Diagrams illustrating the development of a clon of the Howard 17 strawberry; *A*, Development of mother plant May 27 when runner 1 first appeared; *B*, first formation of a clon June 10; *C*, *D*, *E*, *F*, *G*, *H*, *I*, *J*, and *K*, the clon as it appeared June 17, 24, July 1, 8, 23, 29, August 6, 19, and September 15. The relative size of the plants as measured by leaf area is shown by the size of the dots.

Records of many other varieties have shown that this rule holds, that the more leaves per plant in the fall, the greater the number of berries the next year. Then every practice should be directed toward the

largest possible individual plants in the fall—early planting in the spring, control of weeds, adequate cultivation to conserve moisture, early rooting of a full stand of well-spread runners, later control of surplus runners, and liming and fertilizing if they help to build up large plants.

In the fall after the days have become short and cool, these plants, with fruit buds well developed and enclosed by one or two leaves, start a rest period. All the older green leaves die off during the winter, and the connecting runners die. With the first warm days of spring the leaves enclosing the fruit buds unfold, and the fruit buds develop into flower and fruit clusters. The first flower to open on a cluster contains the most pistils, is the largest, and develops into the largest fruit with the largest number of seeds. The next flower develops into the second fruit in size, and the later flowers into successively smaller berries. The flowers are pollinated chiefly by bees. The berries mature in about 30 days after bloom, with moderate weather and even more quickly with warm weather. While the fruit is maturing the root system is often weakening, and by the end of the fruiting season may be inadequate to support the top. By mowing the tops immediately after harvesting, new foliage appears, the root system is again adequate to support the tops, and vigorous growth results.

ESTABLISHING THE PLANTATION

TIME OF PLANTING

Temperature, moisture, and type of soil determine the time of planting. Plants may be set at any time in the spring or summer if moisture conditions are favorable; these are usually best in early spring, so that over 99 percent of the planting is done then. Late-set plants, unless held in cold storage, have exhausted themselves in producing leaves and flowers and do not grow as well as early-set plants. If the weather is such that the plants cannot be set promptly they may be held in cold storage at 31° to 32° F. until conditions are favorable. Though such plants may have no leaves showing, they may grow much better than freshly dug plants. Near large cities where the land must be utilized to the fullest extent and where abundant rainfall can be depended on, plants of certain varieties are sometimes set in August and a fair crop secured the following year. When plants are set at this season a large quantity of stable manure is used in the soil before planting and as a fall mulch, so that the plants may be protected as fully as possible during the winter, and the roots can grow until very late in the autumn and start to grow early in the spring.

Fall planting is rarely practiced. If the fall is dry or wet, or if a heavy mulch is not used to protect the plants against cold, the plants may be killed. Plants may be set on sandy soils in autumn when it would not be safe to plant them on clay soils. When fine sandy silt or clay soils freeze and thaw, the plants are likely to be heaved out of the ground and destroyed. As there is only a short time in the spring when conditions are just right for setting plants on heavy soils, early autumn may be found a more desirable planting season, though it is essential that plants on such soils be protected by a mulch in winter.

In general, early-spring planting is preferred by most growers, as the moisture supply and temperature are most favorable at that time.

It is also much easier to secure nursery-grown plants in the spring, as nurserymen do not usually care to supply them during the period when planting conditions are best in the autumn, as they want to take advantage of those conditions for largely increasing their own stock.

In southern New Jersey and the southern parts of Ohio, Indiana, and Illinois the usual planting season is late March and early April. Farther north the plants should be set in April or as early in May as it is possible to prepare the soil.

Fall-Set Plants for Fancy Fruit

In New England, New York, New Jersey, and in some other parts of the North, gardeners sometimes set plants in August, which produce a crop the following year. When this practice is followed the plants must be large, must have good root systems, and must be set in rich moist ground. Usually irrigation is available. The plants are grown under the hill system, two rows of plants being set close together, as shown in figure 5, *B*. They should be set much closer than

FIGURE 5.—*A*, Chesapeake strawberries grown in hills under irrigation. The third crop is being harvested from this plantation. (Photographed at Bridgeton, N. J., June 10.) *B*, Chesapeake strawberries grown in hills in double rows. The rows in each pair are 8 inches apart and the plants 6 inches apart in the rows. From center to center of each pair of rows the distance is 3 feet 8 inches. (Photographed at Vineland, N. J., June 12.) *C*, Strawberries set in hills in triple rows. The plants are 12 inches apart each way. The alley between the sets of triple rows is 18 inches wide. (Photographed at Three Rivers, Mich., June 29.)

when planted in the spring, sometimes as close as 4 to 6 inches apart in rows 3 feet apart. Such plants ordinarily should be mulched with strawy manure in the autumn and given the best of care. They will produce very large fruit the following year, a few days later than the usual season for the variety. When the Chesapeake is used and irrigation is given as needed, crops as large as if the plants had been set in early spring and grown for a full year occasionally are produced, but the average yield from plants grown in this manner will not be so large as that from spring-set plantations.

SYSTEMS OF TRAINING

Three main systems of training strawberries, the hill system, the spaced-row system, and the matted-row system, are in general use.

Hill System

The hill system is the method of training under which all runners are removed from the plants as they appear, so that at the fruiting season there are no more plants than were originally set. Such plants become much larger than those grown under the matted-row system and bear more than do the individual plants in matted rows where the runners are allowed to remain and take root. Under the hill system the plants are set 6 to 24 inches (commonly 12 to 18 inches) apart in rows which are 3 to 3½ feet apart. When such a planting distance is adopted a horse cultivator can be used, greatly reducing the expense of tillage. In a home garden where horse cultivation cannot be given, the distance between the rows need not be more than 18 inches. Sometimes two rows of plants are set from 6 to 24 inches apart; then a wider space is left and two other rows are set. These are called double or twin rows. Sometimes triple rows are set. These are, however, simply modifications of the hill system and the plants are set the same distance apart in the row. Figure 5, *A*, *B*, and *C*, shows strawberries set under the hill system, in single, double, and triple rows, respectively.

Spaced-Row System

A spaced row is one where the runners are set by hand until the desired stand is obtained, and then either the later formed runners are removed as they appear or all the surplus runner plants are removed at one time, so that the plants left to fruit are spaced at a fairly uniform distance apart. In the Cape Cod section of Massachusetts, where spacing is a general practice, the mother plants are set about 12 inches apart and only two runner series allowed to form, usually one with three and the other with four runner plants, as shown in figure 6, *D*. These plants become very large, and plantings grown by this method produce very large crops, even 8,000 to 11,000 quarts per acre. In other sections each runner plant is rooted 6 to 12 inches distant, and after the stand is completed all later runners are removed (figs. 6, *A*, *B*, *C;* 4, *C;* and 7, *B*). Such rows are usually from 24 to 30 inches wide and produce very large crops of fancy berries. A modification of the matted row, sometimes called a spaced row, is to allow all the runners to root, and after enough are well rooted to rake across the rows with a steel-toothed horse rake, which pulls the poorly rooted runners into the middles. Finally, a cultivator with a circular

disk next to the row is run down the rows to cut off surplus runners. Some growers use this practice regularly. Of course a thin stand of plants in an unspaced matted row is about the equivalent of such a thinned matted row. In a test with the Blakemore variety with 30, 4, 1.8, and two-thirds of a plant per square foot of row, the yields were respectively 42, 119, 131, and 99 bushel crates of marketable fruit per acre. With this variety under the conditions of the test, 25,000 to 100,000 plants left to fruit per acre were best. All plants in excess of this number are so many weeds, taking moisture, space, and plant food from those that should produce the maximum crop.

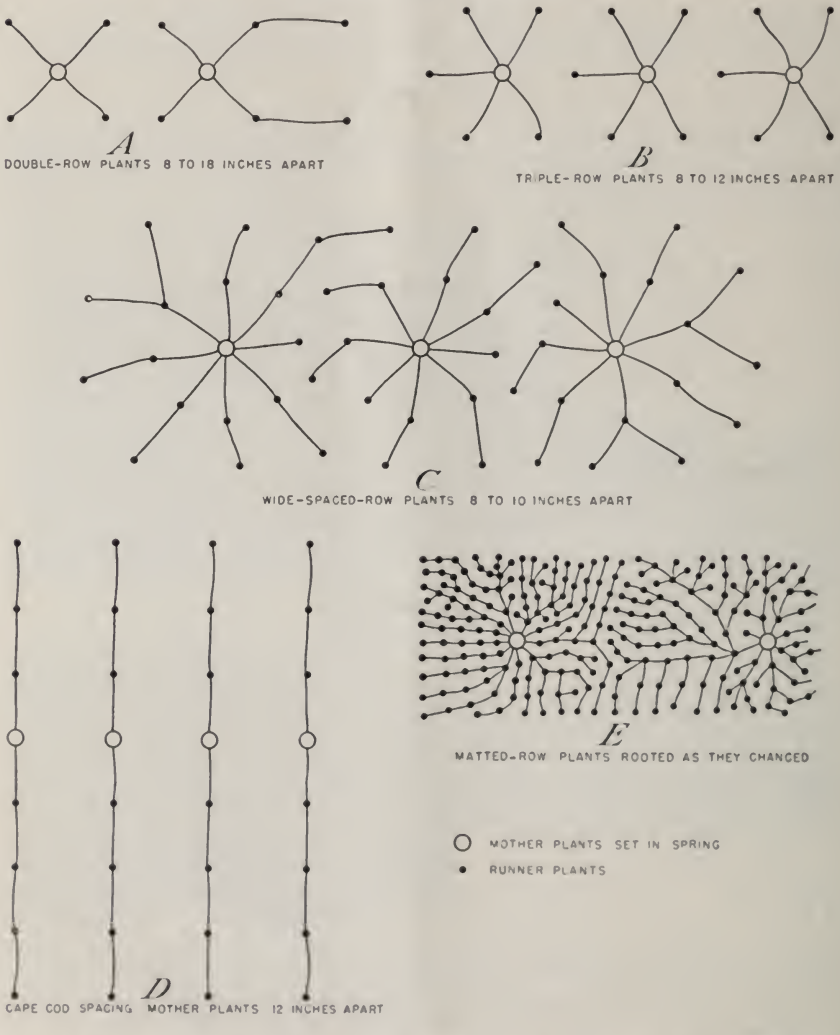

FIGURE 6.—Spacing systems in common use in the United States: O = Mother plant set in the spring; ● = runner plant. The systems shown in *A*, *B*, and *C* are most commonly used, but that shown in *D* is used extensively on Cape Cod in Massachusetts. The highest yields of fancy fruit are produced by such spacing methods. (See table 1.)

Matted-Row System

Under the matted-row system the plants are set in rows, and all or part of the runners that form during the summer are allowed to take root in the spaces between the original plants. By the end of the season a mat of plants will have formed. The width of this mat may vary from a few inches to 2½ or 3 feet, and in a few localities may even reach 4 or 5 feet (fig. 7, *A*).

It is easier to harvest the berries from plantations where the rows are narrow, and some varieties produce better under such condi-

FIGURE 7.—*A*, Strawberries grown in accordance with the wide matted-row system in a peach orchard. (Photographed at Bridgeville, Del., June 2.) *B*, Strawberries grown in spaced rows. The rows are 4½ feet from center to center. (Photographed at Marshfield Hills, Mass., June 20.) *C*, Strawberry plants set 30 by 36 inches apart under overhead irrigation. (Photographed at Rancocas, N. J., June 16, about 2 months after the plants were set.)

tions. When the width is greater than 2 feet, some ripe berries along the center are likely to be overlooked by pickers, and unless the plants are well spaced many berries are likely to be small. In general, therefore, the width of the matted row of plants should not be more than 24 inches, and many growers find that rows about 12 inches wide are most desirable. Matted rows may be grown on the same plan as double or twin rows under the hill system—that is, two rather narrow matted rows from 6 to 24 inches apart may be allowed to form, then a wide alley be left and two other rows 6 to 24 inches apart formed. These two rows are sometimes formed by allowing a 24- to 30-inch wide mat to form and then plowing up the center 12 inches of the row.

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Under the matted-row system the plants should be set 18 to 42 inches apart in rows 3 to 4½ feet apart. Varieties such as the Chesapeake, which does not make runners readily, should not be set farther apart than 18 inches, whereas the Dunlap, Blakemore, Dorsett, Catskill, and others may be set at a greater distance.

If there is much danger of loss of plants from white grubs or severe droughts, the planting distance in the rows should not exceed 18 inches for all varieties; then if a plant is lost through any cause, the adjoining plants will make sufficient runners to form a continuous mat.

On steep slopes the rows should be somewhat farther apart than on level or nearly level land. Ordinarily they should be at least 4 feet apart on such sites. Certain varieties that make few runner plants on poor land may make a large number on very fertile land. The plants of the Chesapeake, for example, should be set no farther apart than 18 inches on land of moderate fertility, but on very fertile low land they will make a large number of runners and may be set much farther apart.

Comparison of Systems of Training

The system of training to be used is determined chiefly by the climate, the variety, the soil, and the preferences of the grower. Commonly where the land is irrigated and tillage is intensive, growers find the hill and spaced row systems better adapted to their purpose than the ordinary matted row.

Where there is considerable danger of injury from white grubs, from drought, or from severe winters, the hill system is not satisfactory; and if it is used, there is frequently so great a loss that the remaining plants will not produce a profitable crop. In such localities the matted-row system should be used; and although some plants may be killed, enough will ordinarily survive to produce a good yield.

In a comparison of systems of training at Willard, N. C., the Blakemore variety, which produces plants freely, was used. By November 1 the matted row had set a dense stand of plants, by actual count over 30 plants per square foot. Such plants were crowded, had few leaves per plant, the leaves were small, and many plants produced no berries the next year. The spaced plants in a 24-inch wide row and the double-hill row plants were large, and each produced a good crop the following year, as shown in table 1. The yield was greatest in the 9-inch spaced row, the size was greatest in the double-hill

TABLE 1.—*Yield per acre, relative size of berry, percentage of decay 1 day after picking, average number of leaves per plant, and number of leaves per foot of row for strawberries under 5 methods of training, Willard, N. C.*

Growing system	Yield per acre			Relative size	Decay after 1 day	Average leaves per plant Nov. 1	Leaves per foot of row	Plants per square foot of row
	Total	No. 1	Culls					
	Quarts	*Percent*	*Percent*	*Percent*	*Percent*	*Number*	*Number*	*Number*
9-inch spacing, 24-inch row	4,903	84	16	88	8	9.2	45	1.8
6-inch spacing, 24-inch row	4,760	80	20	80	10	7.0	70	4.0
Double-hill row	3,506	90	10	100	5	10.0	10	.7
30-inch matted row	2,331	57	43	62	26	3.0	220	30.0
12-inch matted row	2,098	68	32	72	16	.....	120	.....

row, and the decay 1 day after picking was least in the double-hill row. In this test, with a drought toward the end of the season, the percentage of marketable berries went as low as 18 percent for the 30-inch matted row, when it was 90 percent for the double-hill row.

Similar results have been obtained in other regions. As strawberry production becomes more and more intensive in any section, some method of spacing is adopted. The cost of growing an acre in spaced rows is higher than in matted rows, and in deciding which system to use the cost must be considered against the returns.

Certain varieties are much better adapted to the hill and spaced row than to the matted-row system, whereas others give their best results in matted rows. Thus, the Chesapeake and Marshall are frequently grown in hills, while the Dunlap and Aroma are rarely grown in any but matted rows. The last-named varieties make a large number of runners, and the expense of removing them is comparatively heavy. The Aroma makes few crowns per plant, even when the runners are kept off.

MARKING ROWS

Except when a machine planter is used, the position of the rows should be indicated by the use of markers, one type of which is shown in figure 8. This will make it possible to set the plants in straight lines. In using a horse cultivator there is less danger of disturbing the plants if they are properly placed, and less hand labor in hoeing will be necessary, since the horse cultivator can be gaged so that it will run close to the plants without disturbing them.

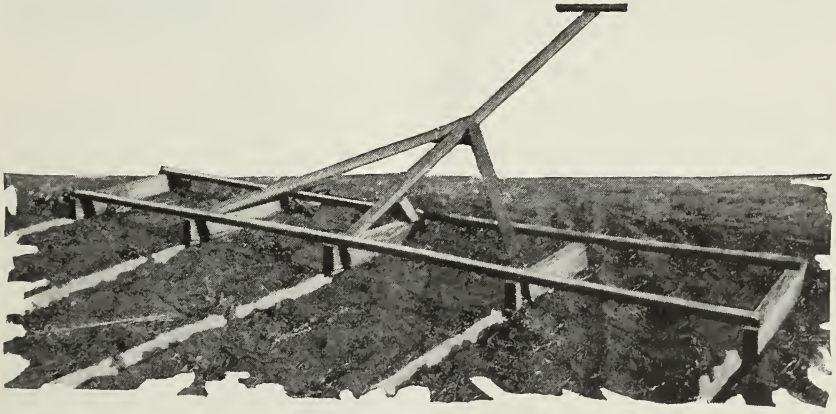

FIGURE 8.—A home-made marker for laying off the rows. By marking across the first rows and setting the plants at the intersections, using a horse cultivator in both directions is made possible.

Fields are easier to cultivate when the plants are set in rows both ways, and if the plants are set 2½ feet or more apart in the rows, as shown in figure 7, *C*, a horse cultivator may be used in both directions until the runners begin to grow freely.

Where it is necessary to get surface drainage by making ridges on which to set the strawberries, the rows are indicated by the ridges; therefore no marking out of rows is necessary.

In marking out a field where the surface is irregular and steep enough to wash badly during heavy rains, the rows should follow the contours of the land as far as possible, and should run the long way of the field for convenience and economy in cultivation (fig. 3).

NUMBER OF PLANTS REQUIRED FOR AN ACRE

The best distance at which to plant differs according to the system, the plant-making habit of the variety, the soil, the slope, the climatic conditions, the danger from white grubs, and the cost of labor.

Table 2 shows the number of plants needed to set an acre of ground when spaced according to the systems commonly used.

TABLE 2.—*Number of strawberry plants required to set an acre of ground when spaced at different distances*

Distance (feet)	Plants to the acre	Distance (feet)	Plants to the acre	Distance (feet)	Plants to the acre
	Number		*Number*		*Number*
3 by 1	14,520	3½ by 1½	8,296	4 by 1	10,890
3 by 1½	9,680	3½ by 2	6,223	4 by 1½	7,260
3 by 2	7,260	3½ by 2½	4,980	4 by 2	5,445
3½ by 1	12,446	3½ by 3	4,148	4 by 2½	4,356

Where there is little danger of loss of plants from any cause, only the number specified in table 2 will be needed. If such danger exists, a larger number should be obtained to provide a surplus for replanting, as caring for a field that has many blank spaces will make the cost entirely out of proportion to the value of the crop obtained.

CARE OF PLANTS BEFORE SETTING

When the plants are received from the nursery, the outer and older leaves usually have been removed, and only one to three young leaves in the center left on. Such plants are easier to handle and will grow better than if the older leaves had been allowed to remain. Usually, however, all except one small leaf should be removed, as shown in figure 9, *A*. The roots should be fresh and bright and are usually white or slightly yellowish in color, though if grown on muck soil they will be dark, but are just as good as if white. Old plants can usually be distinguished from young plants because some of their roots are black and dead. Plants in good shape for setting are shown in figure 9, *A*. The roots of these plants have not been pruned, and at present there is no evidence to show that pruning the roots of strawberry plants before setting them is advantageous. However, for ease in planting, the ends of the longer roots may be cut back without harm.

If the plants cannot be set for several days after their arrival, the bundles should be opened and the plants separated and heeled in, as shown in figure 9, *B* and *C*. The crowns should be placed even with the surface of the ground; then the trench filled with soil, which is packed around the roots firmly, so that it is in close contact with all of them.

If the roots are very dry upon arrival, they should be soaked in water for several hours before being heeled in or planted.

When they are heeled in later, the soil, which is drawn about the roots of the plants, should be moistened thoroughly. If the plants

FIGURE 9.—*A*, Strawberry plants in bundles as received from the nursery: Left, a single plant and a bundle of 27 plants of the Dunlap; right, a single plant and a bundle of 27 plants of the Pearl. All are good plants for setting, though they have very different root systems. Other varieties show even greater differences in the habit and vigor of their root systems. *B*, *C*, Caring for strawberry plants received from the nursery. The bundles are opened and each plant placed in a trench separately. They should then be covered with soil to their crowns. (Photographed at Salisbury, Md., March 31.)

are extremely dry, it may be necessary to allow them to start a new root system while they are heeled in and before they are set in the field.

The supply of plants that has come from the nursery should also be protected from sun and wind by covering them with a piece of wet burlap or other wet material.

SETTING THE PLANTS

Plants may be set with the hand, with a dibble, spade, or punch, or with a machine made for the purpose. Whatever the method used, two things are of special importance in obtaining successful results: Setting the plants at the right depth and making the soil very firm about the roots.

The plants should be set so that the crowns are even with the surface of the ground after the soil has been packed about the roots. The proper depth for planting is shown in figure 11.

FIGURE 10.—Dropping strawberry plants, showing a good way to protect them from the sun and wind. A fertilizer sack is slit across the front and the plants are put in the bottom. Another slit near the top enables the dropper to hang it around his neck. (Photographed at Atmore, Ala., April 8.)

FIGURE 11.—Strawberry plants set at different depths in the soil. At the left is shown a plant set too deep and likely to smother and die; in the center is one set at the proper depth; and at the right is a plant set too shallow, which will dry out.

When being set by hand the plants should be dipped in water and then protected from the sun and wind, so that the roots will not dry out. A basket or bucket may be used to hold them as they are being dropped, or they may be put in the bottom of a fertilizer sack which has been cut across one side with a slit across the top to hang the sack about the neck, as shown in figure 10. This protection from the sun and wind is especially important on clear, bright days; on damp, cloudy days less attention is necessary. Not only should the plants be protected while being carried to the field and while in the field, but they should not be dropped much ahead of the setter.

If the soil is not properly firmed about the roots, air gets to them and they are likely to dry out. Besides, such plants usually will start growth feebly or not at all. If the soil is thoroughly firmed, very little trouble will be experienced in getting plants to live. Some growers step on each plant after it has been set, to firm the soil properly. When this is done the instep should come over the crown of the plant in order to avoid injuring it.

Setting by Hand

Setting strawberries with the opening made by hand is satisfactory only in very loose soils. A wedge-shaped opening about 4 inches deep

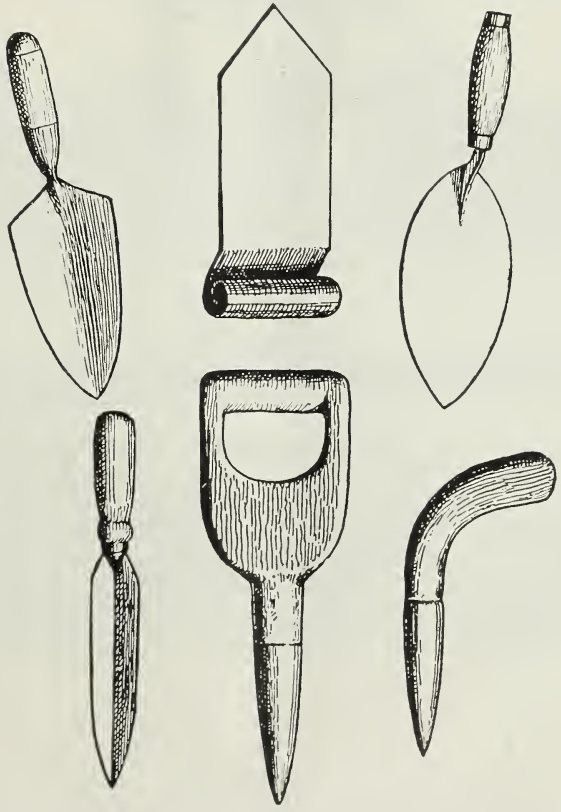

FIGURE 12.—Different types of dibbles and trowels commonly used in transplanting strawberries.

FIGURE 13.—Different methods of setting strawberries. *A*, A packer. The strawberry plant is forced into the ground with a paddle and the earth firmed around it with the packer, which is fastened to the paddle handle by clips and works up and down on it, as here shown. *B*, Setting a strawberry plant with a paddle. When the soil is very mellow the plants are dropped, the roots forced into the ground with the steel-tipped paddle shown, and the soil firmed with the foot. *C*, A punch and tongs used to set strawberry plants. A hole is made with the punch, the plant is picked up and placed in the hole with the tongs, and the earth firmed about it with the foot. *D*, A crew setting straw-

is made in the soil with one hand and the plant inserted with the other. The earth is then drawn about it and firmed. Plants may be set rapidly in this manner, but it is used in only a few localities, as the work is hard and the soil not often sufficiently mellow. It is chiefly used where the plants are set close together and those setting them do not have to move about much.

In most localities an opening is made in the soil with a dibble, trowel, or punch. Dibbles and trowels of different sorts used for this purpose are shown in figure 12. With one of these implements an opening 4 to 6 inches deep is made in the soil, the plant is inserted, with the roots spread as shown in figure 11, and the earth pressed back firmly about the roots.

When a punch, such as is shown in figure 13, *D*, is used, one man usually goes ahead making the holes, another follows dropping the plants, and one or two others place the plants in the holes and draw the earth about them. The punch cannot be used readily in soils which contain straw or stones, but it is especially adapted for use in loose soils. The dibble, however, can be used in any soil that is properly prepared.

A common method of setting the plants is with a spade. Two men form a setting crew. One inserts the spade and by forcing it forward opens a hole. After the roots of the plant have been inserted, he withdraws the spade and with his foot presses the soil firmly about them. The second man carries the plants and inserts them in the holes as they are made by the spade. Plants can be set rapidly in this manner.

The paddle shown in figure 13, *B*, is another tool often used to set plants. The plants are dropped in the exact place where they are to be set, and a man following presses the roots into the ground with the paddle and thoroughly packs the earth about them with his foot. Plants can be set very rapidly in this way, but the soil must be loose, friable, and moist.

A variation of this tool, called a packer, is shown in figure 13, *A*. The plant is pressed into the ground with the paddle and the earth firmed around it with the packer.

Another device, shown in figure 13, *C*, is a punch and tongs, used more extensively for setting sweetpotatoes than strawberries. A hole is made with the punch, the plant picked up with the tongs and placed in the hole, and the earth firmed with the foot. An experienced worker can set 10,000 plants a day with this instrument, while an expert can set many more. Under favorable soil conditions it is easier to set 10,000 plants a day with this than to set 5,000 with a dibble or trowel.

Setting by Machine

On level land, planting machines used in trucking sections for transplanting tomatoes, cabbages, sweetpotatoes, and the like are often used to set strawberry plants (fig. 13, *E*). The soil should be moist, or water must be applied when the plants are set with this machine. Usually

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berries. The first man levels the top of the ridge or list, the second punches the holes, the third drops the plants, and the fourth and fifth men set them. *E*, Setting by machine. The two men are feeding plants alternately to the machine. Sometimes a man follows, stepping on the plants to firm them.

one man drives the machine and two others feed plants into it. About 30,000 plants, or 3 to 5 acres a day, can be set in this way.

The chief difficulty in the use of a planting machine is that it is hard to get all the plants set at the right depth. After some practice, however, intelligent droppers become so expert that practically all plants are set at the proper depth, with the roots straight down. A roller attached to the planter may be used to firm the soil, or a man may be employed to walk along the rows, firming the plants with his foot. When all conditions are favorable, especially where cool, moist weather may be depended on for some time after the plants have been set, such a machine may be used very successfully, and the cost of planting will be comparatively low.

CARE DURING THE FIRST SUMMER

REMOVING THE FLOWER STEMS

Flower stems usually appear on strawberry plants soon after they are set in the field. Because the production of flowers and fruit is an especially severe drain on the vitality of newly transplanted plants, the flower stems should be removed as they appear. Furthermore, if a very large number of plants is needed, or if the variety used does not naturally make many plants, the number of runner plants can be increased very materially by removing the flower stems as soon as they appear. Experiments have shown that early-formed runner plants produce the most fruit the following year, and removal of flower stems can materially help in getting early runners.

CUTTING RUNNERS AND THINNING AND SPACING PLANTS

Under the hill system of culture the runners should be cut whenever they appear throughout the summer. A sharp hoe is ordinarily used for this purpose. Occasionally, a circular cutter about 8 or 10 inches in diameter, which cuts runners on all sides of the plants at once, is used. Much labor in cutting runners can be saved if two rolling cutters are attached to the cultivator and set just far enough apart to run between the rows. Most of the runners can then be cut at the time of cultivation. Such a cutter, however, can be used to advantage only where the soil is free from stones and straw.

Under the spaced-row system of culture, the runner plants may be spaced by hand rather than allowed to root at will. When this is done, the tips of the runners are covered with earth as soon as they begin to enlarge. The first runner plant should be placed between the mother plants in the rows. The next ones should be placed at the length of one runner out from the original row and on each side of it. There will then be three rows of plants, and all other runners may be removed, or additional runners may be rooted until a wide bed has been formed with the plants at least 6 to 12 inches apart as desired. Thereafter all runners should be cut off.

Growers who do their own hoeing or have dependable help can space plants when the field is hoed. The runners can be readily spaced and surplus runners cut off, leaving the runner plants 6 to 10 inches apart, depending on how early the plants form.

Sometimes it will be found cheaper to allow the runner plants to root at will until the middle of August. All superfluous plants are

then dug out and the remainder spaced at equal distances. However, by this delay in removing the extra plants the remainder are weakened and much of the value of the spacing is lost.

Under the matted-row system of culture it will usually be necessary to thin the plants in some way during the late summer and autumn. For this purpose rolling cutters may be attached to the cultivator so that all runners extending into the alleys beyond a certain distance will be cut off. Other surplus runners are removed when the field is hoed.

Where the matted row is 2 feet or more in width, growers sometimes use some method to thin the plants in addition to attaching rolling cutters to the cultivator. Some run a bull-tongue plow with a point about 4 or 5 inches wide down the center lengthwise of each row, tearing up the center plants. This leaves the row cut in two parts or in what might be called a double-matted row. Other growers sometimes run a spike-toothed harrow across the rows in late summer or autumn. The teeth should slant backward, so that only the plants that have not become thoroughly rooted will be torn up. The harrow, however, should be used only after careful trial, as there is some danger that too many plants may be loosened by its use.

TILLAGE

Tillage in newly set strawberry plantations must be very thorough in the early part of the season, in order to conserve moisture so that the plants can become thoroughly established in the soil, and later in the season to conserve moisture so that the plants can develop runners and runner plants. Weeds and grass should be kept out of the fields, as it is very difficult to eradicate them after they have become established. In both hoeing and cultivating, the soil should be worked toward the plants, not away from them. Growth of new leaves on the strawberry plant takes place at the top, so that the crown grows out of the ground, though slowly. Under some conditions rains tend to wash the soil away from the crowns, leaving them above the ground. Because all new roots from the crown grow out at the base of the new leaves and because they are readily killed by dry air, it is particularly important that moist soil be both hoed and cultivated to the plants, so that the new roots have a chance to form. Many growers use the cultivator as often as once each week throughout the first season. Hoeing should be done as often as it is found necessary to clean out all weeds between the plants. Tillage should be shallow near the plants, both because of the danger of loosening them in the soil and because if too deep the roots near the surface will be broken. The teeth on each side of the cultivator should be shortened, so that they will not stir the soil near the rows to a depth of more than about 1 or 2 inches.

Tillage should be kept up until hard frosts occur. Many kinds of weeds continue to grow during the warm periods of late autumn, and start to grow very early in the spring. Therefore, where a mulch is used for a winter covering and to keep the fruit clean in the spring, it is especially important that cultivation be continued as long as there is any chance of weeds growing. The field will then be free from weeds, and in the following year very few will have time to grow before the harvest season.

If weeds are not kept out, they will take the moisture needed by the strawberry plants. Weeds also interfere with the proper pollination of the blossoms by hindering the flight of insects from flower to flower, and many nubbins may result.

In figure 14 two adjoining strawberry fields that have been given different cultivation and mulching are shown. From the field shown in the upper view all weeds were kept out, whereas in the adjoining field shown below many weeds can be seen. These weeds took the moisture supply and interfered with pollination, and as a result about 1,200 quarts more berries per acre were harvested from the first field than from the other.

FIGURE 14.—*A*, Field of Aroma strawberries managed by the owner at Bowling Green, Ky. Note the absence of weeds and the presence of a good mulch. *B*, Field of Aroma strawberries adjoining the field shown above but managed by a tenant. The yield from this field was slightly more than 100 crates of 24 quarts each per acre, whereas nearly 150 crates were harvested from the field shown in *A*.

COMPANION CROPS

In home gardens and where intensive cultivation is practiced, growers wishing to secure the greatest possible return from their ground often grow vegetables with strawberries as companion crops during the first summer after planting. Nearly all kinds of vegetables may be raised as companion crops, and the thorough cultivation given them will be sufficient for the strawberries.

Such crops as onion sets may be grown in the strawberry rows, as shown in figure 15, *A*, while quick-maturing plants, such as lettuce, radishes, peas, carrots, and beets, requiring similar culture, may be grown between the rows, as shown in figure 15, *C*. The berry rows are planted the same distance apart as under ordinary conditions and the vegetables are removed before the strawberry plants begin to spread over the ground to any extent.

FIGURE 15.—*A*, Strawberries with onions as a companion crop. The onion sets are removed early in the summer and the strawberries can then occupy all the space. (Photographed at Salisbury, Md., June 15.) *B*, Strawberries growing with an oat mulch. The oats were sown in the alleys in late summer and have made rank growth which, when killed by frost, will fall partly on the plants, protecting them from winter injury and the following year will keep the berries clean. (Photographed at Marlboro, N. Y., Oct. 23.) *C*, Lettuce, carrots, and beets between rows of strawberry plants. Radishes have already been harvested from the alley at the right. (Photographed at Three Rivers, Mich., July 8.)

When such crops as potatoes, beans, peas, and cabbage are grown with strawberries, other systems are often followed. If cabbage or cauliflower is used, the plants may be set about 6 inches to one side of the rows of berries. The strawberry plants will be shaded to some extent by the leaves of the cabbage and cauliflower, but when these

are removed during the summer the strawberries will spread over the ground and occupy the whole space. These companion crops are used chiefly in southern regions where the growing season is long. In the North this practice should not be followed, because the strawberry plants would not become large enough by the end of the growing season to bear a full crop.

When potatoes and beans are used as companion crops, the strawberry rows are usually set somewhat farther apart than in ordinary practice, and the companion crop is planted in the middle of the alleys between the strawberry rows. The berry rows should be at least 4 or 4½ feet apart, and only a narrow mat of plants should be allowed to form. The beans and potatoes are not removed until late in the season in northern districts, and the mat of plants therefore must be narrower than in more southern regions.

STRAWBERRIES AS AN INTERCROP

Strawberries are sometimes planted in apple and other orchards. As a rule this practice is not to be advised, beyond possibly the planting of a row or two of berries along the center of the space between the rows of trees. This plan leaves free for cultivation a relatively wide strip on both sides of the tree rows. The strawberry plants however, even when thus planted, should not be allowed to remain longer than 2 or 3 years.

Strawberries ordinarily are not cultivated in the spring until after the crop is harvested. This covers a period when good tillage is usually very important to the trees. Further, strawberries generally require tillage considerably later in the season than is advisable for fruit trees in the regions to which the directions in this bulletin apply. In other words, the tillage requirements of strawberries and of fruit trees differ so much that they are unsuited for growing together except as above noted.

FERTILIZERS

The strawberry in the northeastern United States makes less response to fertilizer than do most other cultivated crops. Because it is generally grown in a rotation following cultivated crops that have been fertilized, the residue is usually sufficient for the strawberry, and no additional supply is needed. If the plants are making a strong, vigorous growth and have dark-green foliage throughout the summer, this should be taken as an indication that the supply is probably adequate, and none should be used unless tests have shown their value.

A good crop of berries will remove considerable quantities of nitrogen, potash, and phosphoric acid, but most fertile soils in the area to which this bulletin applies are so well supplied with plant foods that strawberries could be grown indefinitely, if the physical condition of the soil is good. The strawberry can obtain these materials when less is available than is essential for good crops of most vegetables. If, therefore, the soil is kept in a satisfactory condition by frequent tillage, and if the moisture supply is ample, many strawberry fields will need no fertilizers or stable manure.

In experiments in eastern North Carolina, applications of 60 pounds of nitrogen per acre, half derived from inorganic fertilizers

(nitrate of soda and sulfate of ammonia) and half from organic sources (cottonseed meal and tankage), increased yields for 3 years an average of 94 percent (3,144 quarts), whereas the addition of potash (75 pounds of potassium) and superphosphate (120 pounds of phosphoric acid) or both with the nitrogen depressed the yields over nitrogen alone by 1,163 quarts. Soils in this area are low in available nitrogen, and plants respond to its application more than farther north. However, farther north along the Atlantic coast nitrogen is often deficient, and applications of a mixture of organic and inorganic sources of nitrogen up to an equivalent of 60 pounds of nitrogen per acre, applied about August 15 in Maryland and New Jersey, and about September 1 in Virginia, are suggested. Many more early berries are picked from plantings where the nitrogen is adequate than where it is deficient, or where it is in excess. If nitrogen is applied where the supply is already adequate it tends to stimulate such a vigorous top growth that the yields are decreased, the berries decay more, and the plants are more subject to dry-weather injury. Soils in the Atlantic Coast States are usually acid and respond to nitrate of soda far more than to ammonium sulfate. In the Central States, though some soils are acid, more of them are nearer the neutral point, and these may respond more to ammonium sulfate if nitrogen is needed.

Experiments have shown that in some soils in the Mississippi Valley region the application of phosphoric acid has greatly increased the yields; in fact, this element of plant food is probably needed more often than any other in the central part of the United States. Applications ranging from 100 to 700 or 800 pounds per acre should be made in testing the possible value of this element.

Potash has been found beneficial on a few soils but of no value on most soils. Different quantities, from 50 to 300 pounds per acre, should be used on test plots if it is thought to be deficient.

The use of nitrogen in the spring of the fruiting year has been found profitable in growing a few varieties, especially the Marshall, Fairfax, Belt (William Belt), and Chesapeake. These seem to need the stimulating effect of this fertilizer in early spring. Though some growers still use nitrate of soda about 1 week after the plants of other varieties have started to grow in the spring of the fruiting year, applying 50 to 200 pounds per acre, extensive tests have shown that only on poor soils does nitrate of soda help, and usually it injures the crop. In general, nitrate of soda should be applied during the latter part of August to be useful.

Stable manure is sometimes used in place of nitrate of soda or in addition to it. When needed it should be applied in the autumn in the form of a mulch which helps to protect the plants from heaving and from severe winter weather. The nitrogen in the stable manure helps to stimulate a heavy leaf growth. In addition, stable manure contains other elements of plant food, as well as large quantities of humus. Tests should be made by each grower to determine whether it is beneficial and the best quantities for his conditions.

WHEN TO APPLY FERTILIZERS

As stated above, nitrogen should be applied to strawberries on moderately fertile soils during the latter part of August or during the first part of September. Potash and phosphoric acid may be

applied before or at the time of setting the plants. Because these materials do not readily leach out of the soil this may be the best time.

When potash and phosphoric acid are used before the plants are set, they may be broadcast or drilled in where the plant rows are to be. Later applications of these materials and of nitrogen may be drilled in along the rows or scattered on the plants, taking care to put it on where the plants are dry. In the latter case, a brush should be dragged over the rows to remove the fertilizer from the leaves in order to prevent burning the foliage. When a plantation is to be renewed, the nitrogen, potash, and phosphoric acid should be applied at the time of renewal.

USE OF LIME

Lime serves at least two purposes in a strawberry field. It serves as a source of calcium, and if the lime is in the form of dolomite, as a source of magnesium also. Lime also lessens the acidity of the soil. Strawberries usually grow well when the acidity measures between pH[4] 5.7 to 6.5, but may still grow well between pH 5.0 to 7.0 if there is a high content of organic matter in the soil. An application of 1,000 to 2,000 pounds or more of lime per acre to an acid soil changes the pH value toward the neutral point, thus tying up the free aluminum, which is toxic to strawberry plants, and making available calcium and magnesium. Such an application may also help to put the soil in a better state of tilth. Strawberry fields that have a pH value of 5.3 or below should be limed, the amount depending on local experience with liming on that particular soil. Lime is commonly needed on the limestone soils of the Atlantic Coast States, more rarely in the Mississippi Valley and Pacific Coast States soils. Lime must be applied with care, for an excess of it is harmful, dwarfing the plants and reducing the size of the fruit. It should be applied a year or two in advance of strawberries to previous crops if possible. Otherwise it should be applied and thoroughly worked into the soil before the plants are set.

IRRIGATION

In many sections of the northern United States severe droughts cause considerable loss to strawberry growers. If droughts of greater or less severity come during the fruiting season, the berries do not reach full size, and much of the crop may be too small to market. Where such droughts frequently occur during the period when the fruit is developing, irrigation may be desirable. Where it is practicable to install an irrigation system the water needed for the establishment and proper growth of the young plants and for the development of the runners is very largely under the control of the grower. Furthermore, if a drought occurs early in the growing season, the field may be irrigated regularly and a full crop secured.

To make irrigation practicable, there should be an abundant supply of water near the field to be irrigated. The crop must be grown under an intensive system of culture, as the cost of installing an irrigation

[4] The acidity or alkalinity of the soil is measured by the pH scale. Neutral is 7.0. The intensity of acidity increases from 7.0 toward zero, and the intensity of alkalinity increases from 7.0 toward 14.

system is considerable and materially increases the investment on which the grower must make adequate returns if his strawberry enterprise is to be financially successful.

The installation of an irrigation system is a permanent improvement on the farm, but it should not be made until the possibility of securing the labor necessary to grow intensive crops is fully assured.

OVERHEAD IRRIGATION

Overhead sprinkling or spray systems of irrigation are used extensively in southern New Jersey, while smaller areas irrigated in this way have been found profitable in nearly all of the Northern States. Surface irrigation has been used very little in these States; it can be employed only on fields that have gentle, uniform slopes and either a rather heavy surface soil or a heavy subsoil at a slight depth below the surface of the ground. The spray system, however, has no such restrictions.

In figure 5, *A* and *B*, is shown one type of overhead spray irrigation system in New Jersey, and *C* illustrates this system as used in Michigan. In the New Jersey fields shown the Chesapeake strawberry is grown. Crops of 8,000 quarts per acre and more of this variety have been obtained under irrigation when not more than 3,000 quarts were secured on similar soil in an adjoining field not irrigated. The Chesapeake has been found to respond especially well to irrigation.

As the cost of a system of overhead pipe spray irrigation will range from $80 for a system with portable laterals to $400 or more for new permanent equipment per acre, growers should, when possible, obtain information on the experience of others in the use of irrigation before investing heavily.[5]

A recently developed type of sprinkling irrigation with whirling sprinkler heads and portable pipes with jiffy couplings is now available. Owing to its portable feature the investment cost per irrigated acre averages much lower. Costs as low as $35 per acre have been reported where conditions were favorable.

SURFACE IRRIGATION

For many home gardens, as well as in commercial plantations, surface irrigation will be found satisfactory. The rows should not be more than 200 to 250 feet long, and furrows should be made in the alleys to direct the flow of the water. Surface irrigation is better adapted to silt and clay than to sandy soils.

For sandy soils where the slope is not too great, either porous hose or eyelet hose may be useful. The former permits the irrigation water to ooze through the openings between the threads of the canvas cloth from which the hose is made. Very little pressure is needed for porous hose irrigation. Only one row can ordinarily be irrigated at one placing of the hose. Eyelet hose has little eyelet holes about one-sixteenth of an inch in diameter, every 2 feet or so along the hose. Under suitable pressure three or four rows may be irrigated from each placement of the hose.

[5] U. S. Department of Agriculture Farmers' Bulletin 1529, Spray Irrigation in the Eastern States, gives detailed information on the installation of spray-irrigation equipment. For sale by the Superintendent of Documents, Washington, D. C., at 5 cents a copy.

WINTER PROTECTION AND MULCHING

During the summer the leaves of the strawberry are so succulent that an ordinary frost might kill them. In the fall, when the days become cooler and the daylight periods shorter, the plants gradually become hardier and by winter can stand a temperature as low as 15° F. without injury. However, if a sudden cold snap with temperatures below 15° occurs before the plants harden, or if the temperature goes to 0° or below, with no snow covering at any time during the winter, then severe injury may result. Temperatures below 15° may so injure the crowns and roots as to kill the plants outright. Less severe injury may cause browning of the center of the lower part of the crowns and roots (fig. 16).

FIGURE 16.—Effect of low winter temperatures on the crowns and roots. Note the dark centers of crowns that have been cut, particularly in the lower part, which is most tender. The crowns have been so severely injured that no fruit was produced. The roots are black and nearly dead.

By alternate freezing and thawing the plants may be heaved out of the ground, or their roots may be broken so that they dry out and die. Heaving occurs more often in heavy soils than in light soils, because of the lower water content of the light soils. However, heaving may occur even on light soils. If the ground is covered with ice, and low temperatures occur, the injury may be almost as severe as if the ground were bare. Ice affords little protection against cold. Although mulching is a regular practice of growers on tens of thousands of acres, many other growers can profitably mulch their fields, and many who do should mulch earlier.

The shaded area on the map shown in figure 17 indicates the region where the strawberry is not fully hardy and should be protected by a straw or hay mulch against cold injury. In the northern Mississippi Valley region the mulch should be ready for application by October 15, so the field can be covered quickly if severe cold is predicted, but it should be applied by October 31, at the latest. In like manner in

each region outlined the mulch should be ready for application by the earlier date, and should have been applied by the latter date.

Too early mulching may result in as severe injury to the plants as too late mulching. Ordinarily, as soon as temperatures of 20° F. or lower have occurred, the plants have become hardened, and the mulch should be applied.

Long experience has shown that wheat (fig. 18) and other straws and marsh hay are the most useful mulching materials. Pine needles and ferns are also satisfactory. The straw should be as free as possible

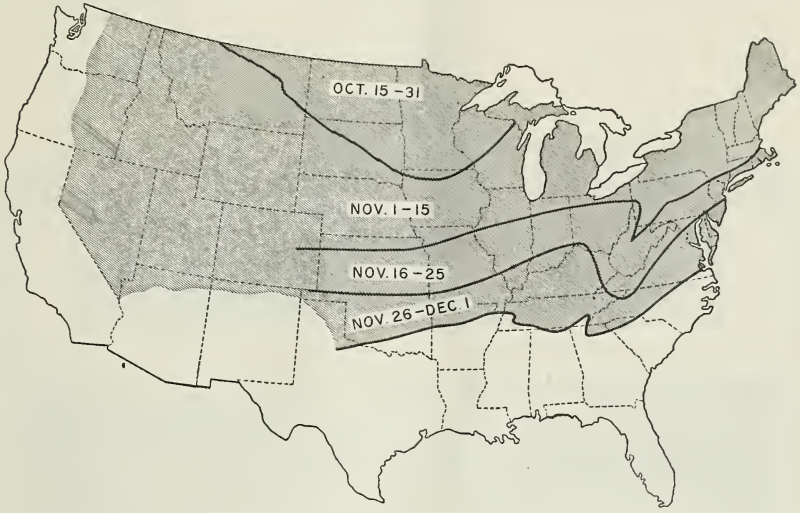

FIGURE 17.—Map showing areas in which strawberries should be mulched during certain periods to protect plants against cold. Growers in each area should be ready to put on the mulch by the first date listed above and should have applied the mulch by the latter date. Because warm periods frequently occur in the fall it is not always safe to apply the mulch by the earlier date, but because temperatures as low as 15° F. in the field occur during the periods in such areas, early mulching may be necessary to save the crop. The shaded area indicates the region where cold injury to the plants may be expected often enough to make mulching pay.

from grain and weed seed, as these may grow in the spring and become troublesome. Unpacked snow is as good a protection against cold as a similar depth of straw. However, in most regions a sufficient depth of snow to furnish protection cannot be depended upon early enough or to stay on throughout the winter, and growers have been forced to mulch. In the upper Mississippi Valley region, about 6 tons of straw are applied to furnish sufficient protection. In the rest of the country where mulch is applied, 2 to 2½ tons per acre is sufficient.

Strawy stable manure is sometimes used, but should not be generally applied to fertile soil, or too rank a growth may result. It may be used on the poorer soils and on a few varieties such as Chesapeake and the everbearers, which usually make a thin stand.

Where straw is not available, Sudan grass may be raised for mulching. It should not be allowed to become too coarse before cutting. Spring oats, Sudan grass, a mixture of kafir and sorghum,

or of spring oats and sorghum are sometimes grown as a mulch in the strawberry field itself. Oats are sowed between August 15 and September 1 in the latitude of Maryland and Missouri and earlier for the North (about 50 days before a killing frost is expected). The oats should be sowed thickly at the rate of 1½ to 2 bushels per acre in the alleys. When it dies down in early winter it furnishes a thin mulch.

As soon as growth starts in the spring the surplus mulch should be removed from the rows and placed in the alleys. A light covering of straw may be left over the plants, as they will come up through it. A mulched field is usually a few days later in blooming and ripening

FIGURE 18.—Mulching a strawberry field (*A*) at Bowling Green, Ky., with wheat straw, and (*B*) a field shown when partly mulched. The straw was thrown off the wagon in windrows, as shown, and spread by hand over the rows of plants. The straw should be spread before the ground is frozen.

than an unmulched one. If a heavy mulch is applied, the crop may be a week later than on unmulched fields.

Mulching also helps to keep down weeds, to keep the berries clean, and to conserve moisture. In the South, tens of thousands of acres are mulched, not for cold protection but to keep the berries clean and to conserve moisture.

FROST PROTECTION

Where the strawberry is frequently injured by unseasonable frosts in the spring, various methods of protecting the flowers may be used.

Where material for mulching is fairly cheap it may be raked from the alleys to the top of the rows the day before a freeze is expected. This involves considerable hand labor and is costly, but will sometimes prove profitable. It is possible to delay the blossoming period a few days by covering plants with a heavy mulch in the autumn and leav-

ing it on as late as possible. When the weather becomes warm and growth has begun, part of the mulch should be placed in the alleys and the remainder left over the plants.

Where overhead spray irrigation is practiced it is possible to start sprinkling late in the evening and continue until after danger from frost is over the next morning. This will protect the plants very largely from frost injury.

Smudging and heating are occasionally practiced. The strawberry plant, however, is close to the ground, where the temperature is lowest, and it is difficult to raise the temperature of the air next to the plants. If the heaters are used, 100 per acre will be needed to protect the plants from a frost when the temperature drops to 6° or 8° below the freezing point at the surface of the ground. If fires are used to protect the strawberries from frosts, many small fires should be built throughout the strawberry field, or at the lower side if it is on a slope.

Late-blossoming sorts may be selected in some cases or, if frost is expected very late in the spring, the everbearing varieties should be grown.[6] If the first blossoms of these are killed they will send out a new set of flower buds and produce a crop of fruit in due course provided other conditions are favorable.

PICKING

The different varieties of strawberries differ somewhat in the degree of maturity at which they should be picked. Varieties with soft flesh must be picked before they are fully ripe, in order to get them to market in good condition. Firm varieties, however, may be left on the plants until thoroughly ripe, and will have a better appearance on the market than those picked when not fully ripe.

Varieties also differ greatly in the length of the picking season. Many, like the Gandy, have a very short season of 10 days or 2 weeks, while others, like the Fairfax and Howard 17, have a relatively long picking season, which may last 4 weeks or even longer. The grower must plan his work according to the habit of the variety.

Varieties differ also in the frequency with which they need to be picked. Usually the berries should be picked every other day, but in cool weather certain varieties may be left 3 days between pickings, while in hot weather still others should be picked daily.

The length of time that the fruit will stand up after it has been picked depends upon the variety, the degree of ripeness, the care with which it is handled, and the temperature of the berries at the time they are picked and at which they are held after picking. Experiments have shown that for each rise in temperature of about 15° F., the life of the berry, other things being equal, is decreased one-half—that is, if the strawberry will keep for 8 days in good condition at a temperature of 40°, it will keep for only 4 days at a temperature of 55°, only 2 days at a temperature of 70°, and only 1 day at a temperature of 85°. If the berries are picked in the early morning when they are relatively cool, and put at once in the shade, they will keep much better and have a much better appearance on the market than if picked at midday when they are warmer, or if left in the sun after picking.

[6] See Farmers' Bulletin 901, Everbearing Strawberries.

Carriers used in picking berries are shown in figure 19. The 6-quart carrier illustrated (*A*) is commonly used for picking, and the 10- or 12-quart carriers (*B*) are used to carry the berries to the packing house. Such carriers are used only when the packing is done at some little distance from the place where the berries are being picked. In smaller fields, where the packing house is located within a short

FIGURE 19.—*A*, Two 6-quart carriers filled with Chesapeake strawberries. These carriers are commonly used in picking berries. *B*, Carriers holding 1-quart baskets used to carry strawberries from the field to the packing house.

distance of the pickers, each picker usually carries his berries to it, and the larger carriers are unnecessary.

RENEWING THE PLANTATION

The number of crops harvested from a plantation varies greatly in different parts of the country. In some localities, one crop only is harvested, and then the field is plowed up; in others, two, three, or even more crops are secured. The length of time the plantation should be kept depends upon the variety, the number of weeds in the field, the infestation of insects and diseases, the character of the soil, and the comparative cost of renewing an old plantation and setting a new one.

Certain varieties of strawberries produce their largest crop the first year after setting, while others yield a larger crop the second and third years. Plantings of varieties that often bear a larger crop the second season than the first should be continued for at least 2 years. From plantations of some varieties, such as the Aroma, for example, very large crops may be secured for a number of years, and, if possible, fields of such varieties should be kept for several seasons.

Where certain kinds of weeds, such as white clover, purslane, chickweed, and crabgrass, are prevalent, it may be necessary to plow up the plantation after only one crop has been obtained. When white clover starts in a plantation, it is almost impossible to eradicate it, and the cost of eradication is usually much greater than that of setting out and growing a new plantation. The same is often true when some other weeds become established in the strawberry field.

In many localities where the soil is not well supplied with humus, one crop only should be harvested before the plantation is renewed. The yields after the first year are too small to be profitable. Ordinarily, in such sections, it will pay to turn under green-manure crops or apply stable manure before the strawberries are set, in order that the plantation may be kept profitable more than 1 year.

The length of time that a strawberry plantation should be maintained depends, therefore, upon several conditions. Wherever intensive culture is practiced, the plantation usually should be kept for at least three crops, and sometimes for five or six crops or as long as it gives paying returns. The cost of renewing a plantation under ordinary conditions is less than the cost of setting out the plants on a new field and taking care of such a plantation until midsummer, the time when an old plantation is renewed.

MOWING THE FIELD

In renewing a plantation, the field should first be mowed over. Fields of plants trained to the matted-row system are usually mowed by machine, whereas the foliage of plants under the hill system may be cut off with a scythe, sickle, or sharp hoe, as shown in figure 20. In the North, where the growing season is short, the foliage should be mowed as soon as the crop has been picked. Where the growing season is longer, the mowing may be delayed for several weeks. Thus, in Maryland, where there is an intermediate growing season, tests were made of the effect of mowing at different times, as shown in table 3. All the varieties tested bore increased crops if the tops were cut by July 1, only part bore increased crops if this was

TABLE 3.—*Effect of mowing leaves after harvest on yield for the following year for 3 varieties of strawberries in Maryland*

Time of mowing	Increase (+) or decrease (−) in yield over unmowed		
	Blakemore	Joe	Howard 17 (Premier)
	Percent	*Percent*	*Percent*
July 1	+22.0	+13.5	+12.1
Aug. 1	+11.8	−7.7	−0.1
Sept. 1	−10.5	−10.6	−24.2

delayed until August 1, and all produced less if it was delayed until September 1.

If injury from insects and diseases is not serious, the mulch and leaves should, if possible, be turned under. This will increase the humus content of the soil and put it in better condition than if foliage and mulch are burned. When the mulch is very heavy, however, it may be necessary to remove a part of it before plowing. The mulch

FIGURE 20.—Strawberry plants (at right) that have just had their tops cut off. This should be done with a hoe or a mowing machine immediately after the crop has been harvested. (Photographed at Vashon, Wash., Aug. 7.)

may be raked up and stacked for use the following year if it is not too much decayed. In that case only the strawberry foliage that has been cut off is plowed under.

BURNING LEAVES AND MULCH

Where insects and leaf-spot diseases are prevalent, growers prefer to burn the foliage and the mulch without removing them from the field. It is then easier to thin the plants and narrow the rows than if the mulch and leaves are left on the ground. In some localities and with certain varieties, as soon as the foliage has dried, the mulch should be raked on top of the rows, and when a good breeze is blowing in the direction in which the rows run, the fire should be started on the windward side. When handled in this way, the fire will pass quickly. If the ground is very dry or if the mulch and leaves are damp, the roots and crowns of the plants are likely to be injured. As the crowns of some varieties are more tender than those of others, a test should be made before burning over a field of a variety not previously

subjected to such treatment. In some localities the Dunlap and other varieties are severely injured if the mulch is over the plants when burned. Where such sorts are grown, the leaves and mulch should be raked into the alleys between the rows before burning.

A few growers practice burning over their fields in early spring before growth starts, and in this way they remove diseased foliage and insect eggs. If the leaves are not dry enough to burn quickly, coal oil may be sprayed on the plants to hasten the burning. The mulch, of course, should be removed before the field is burned over, and should be replaced afterward.

THINNING THE PLANTS

When renewing a plantation, it is desirable to reduce the number of plants in the matted row after the crop is harvested, so that new runner plants may develop. The amount of thinning necessary will depend upon the variety, and to some extent upon the season and the soil. If the variety raised is one that will make a large number of runner plants later in the year, the row should be reduced to 6 or 8 inches in width, and the plants in this row thinned so that they are at least 10 inches apart. If the variety does not make many runner plants in late summer and autumn, the row should be left 12 or 15 inches wide and the plants about 10 inches apart.

To reduce the width of the row either one side or a part of both sides should be plowed up. Usually it is best to plow up one entire side of the row and also the old plants in the middle. This will leave only the young plants on one side. These remaining plants are then thinned by running a spike-tooth harrow or a cultivator across the rows once or twice and then once down the row. The weaker plants are torn up and the ridges made by plowing up one side of the row are leveled. Hoes may then be used to thin out the remaining plants, if they are still too thick. The crowns of the plants that are left are usually covered with an inch or two of soil. Within 2 or 3 weeks the plants will have sent out new foliage, and the field will have the appearance of a young plantation.

In many cases the location of the rows is changed by plowing up one side of each one year and having the remaining plants set runners in the alleys. The second half of the old row of plants is plowed up the following year, so that by the third year the rows run where the alleys were the first year.

If the narrow matted-row system is used it may be necessary to reduce the width of the rows very little, if at all. A shovel cultivator may then be used to plow across the rows, leaving the plants in small clumps about 24 inches apart. Later in the summer the runners will fill the spaces thus plowed up and make continuous matted rows by winter.

PROPAGATION

Strawberries are propagated commercially chiefly by the use of runner plants. When raised from seed, most plants will bear fruit inferior to that borne by the parent plants, and none of the seedlings may resemble the parents closely. Dividing the crowns of strawberry plants to make new plants is too slow and expensive for ordinary use but is used in the propagation of the Rockhill (Wazata) everbearing variety, which makes few runners. Such crown divisions have borne

well but are probably not usually so good as runner plants of the same variety. Therefore, propagation by runner plants offers the only practicable method of securing large numbers of plants of ordinary varieties.

PLANTS FOR SPRING SETTING

After a grower has once established a strawberry field he usually can procure plants for setting from his bearing plantation. The younger plants along the sides of the alleys in the matted rows are satisfactory, if they have a good root system and have not been injured by the cold of winter. Many growers prefer to dig up an entire matted row of plants instead of disturbing the roots of the fruiting beds. From 6 to 25 good plants per lineal foot of row are obtained when the entire bed is dug, 6 plants per foot for varieties like the Marshall and Chesapeake, and up to 25 for varieties such as Blakemore and Missionary under very favorable conditions. If a grower's planting is free from diseases and insects and has not been injured by cold, his own plants may be just as satisfactory as plants purchased from a nursery. However, if weather conditions prevent early setting, plants from a nursery held in cold storage may grow much better than plants dug after growth has started in the field.

Strawberries raised on clay soil are difficult to transplant. Growers who have no other soil often prefer to procure plants from other localities rather than attempt to use their own stock. Sandy soil should always be chosen for a strawberry-plant nursery.

PLANTS FOR FALL SETTING

For August planting, growers should select plants having the best root systems and the largest crowns obtainable. Such plants will produce larger crops the following year than weaker plants.

Both pot-grown and field-grown plants are used for late summer

FIGURE 21.—A Marshall strawberry plant grown from a runner in a plunged pot. This plant is larger than the average of those produced in August or September. It may be planted with little or no disturbance of the roots and will bear fruit the next season.

planting. To raise pot-grown plants, small pots filled with rich earth are plunged into the ground near the parent plants, and the first runners to appear are made to root in them. These potted plants can be transplanted with the least injury to the root systems and with a likelihood of best results the following year (fig. 21).

If the plants are to be dug in the field where the runners have rooted in the ground, those with the thickest crown and best root systems should be selected, and the greatest care must be used to protect their roots from injury by the sun or drying winds. Usually a clump of soil can be dug with each plant. thus disturbing the roots as little as possible.

PLANTS WITH PERFECT AND WITH IMPERFECT FLOWERS

Strawberry varieties in cultivation have two types of flowers, perfect and imperfect. Figure 22 shows the difference between these two flower types. It will be noticed that the perfect flower has both pistils and stamens, whereas the imperfect one has only pistils. To produce berries, pollen from the stamens must be carried by wind or insects to the pistils. Therefore, varieties having perfect flowers will produce a crop of fruit when set by themselves, whereas those having imperfect flowers will not bear fruit unless planted near perfect sorts.

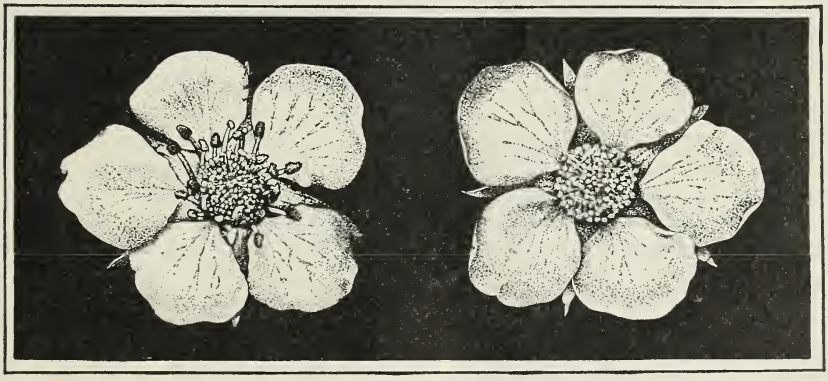

FIGURE 22.—A perfect or staminate strawberry blossom (left), having both pistils and stamens, and an imperfect or pistillate blossom (right), having pistils but no stamens. Imperfect varieties will not produce fruit unless grown near plants having perfect pollen-producing blossoms.

Most of the varieties cultivated extensively at the present time are the perfect sorts. A few very productive sorts have imperfect flowers, but they are not more productive than many perfect sorts. Imperfect sorts are still grown in certain localities where the weevil is very destructive, because that insect feeds on the immature pollen found in the buds of perfect-flowered sorts, but leaves varieties having imperfect flowers almost untouched.

Whenever imperfect varieties are planted, there should be at least one row of a perfect variety to every three rows of the imperfect one, and it is usually better to plant one row of the former to every two of the latter. A few growers prefer to mix the plants of both sorts

in the same row, but as varieties differ in their shipping quality and in their shape, size, and color, and as the markets prefer to have each variety in a basket by itself, this practice should be discouraged.

Pollination is influenced not only by the variety, but by the weather conditions, by the amount of moisture in the soil, and by weeds. When rainy weather occurs at blossoming time, some varieties, such as the Glen Mary, which are not strongly staminate, do not develop sufficient pollen to make them fully self-fertile. These sorts should be interplanted with some strong pollen-producing variety. In seasons with cool moist springs, the first flowers to open on many varieties may have no good pollen, and such flowers produce only nubbins. The Marshall, Redheart, Fairfax, Fairmore, and some other varieties produce abundant pollen even in the first flowers.

UTILIZATION PROCESSES

Many million dollars' worth of strawberry products are manufactured each year. Among the more important of these are preserves, jams, essences for flavoring candies, flavoring extracts, sirup for soda fountains, and crushed fruit for flavoring ice cream and sauces. Strawberries are also packed in the proportion of about 3 parts fruit to 1 part sugar (or its equivalent in a heavy sirup) in small packages, frozen, and sold to the retail trade. The varieties considered best for preserving are light, bright red, acid, with a strong strawberry flavor, and firm fleshed, so they will not break to pieces in cooking. For the ice cream trade, varieties with a deep-red color and high flavor are desired.

The varieties chiefly used in eastern United States are Blakemore, Klondike, Missionary, Howard 17 (*Premier*), and Parsons (*Gibson*). Blakemore is the best variety for preserving, but is used for the small package trade as well. Klondike is one of the best for both ice cream trade and the small package trade but is dark for preserves. Missionary is used for both preserves and for flavoring ice cream. Although Howard 17 (*Premier*) is reported as very good for ice cream flavoring and the package trade in Massachusetts, it is not so desirable farther south as other sorts. In Minnesota, Beaver, Culver, and Dorsett are considered suitable for freezing. In tests in Maryland, Joe and Blakemore rate highly as varieties for the small package trade. Eastern berries are rarely canned.

The recent extension of the cold-storage-locker movement is causing the replacement of canning and even of preserving for home use by the freezing of strawberries as well as other fruits in small containers. A heavy sirup is poured over the berries, and the berries are placed in the cold storage as soon as possible.

Preservers and large manufacturers of the crushed fruits and sirups used by the soda-fountain and ice-cream trade prepare their product as it is needed at any time during the year from uncooked berries kept in barrels and smaller containers in cold storage and preserved as described in the following paragraphs (see also U. S. Dept. of Agr. Tech. Bul. 148, The Frozen-Pack Method of Preserving Berries in the Pacific Northwest).

The berries are hulled and sorted, and then washed. Various kinds of washing machines are employed. Usually the machine has a water tank at one end, into which the berries are dumped for a brief

soaking to loosen the dirt. From this tank they are removed by an endless belt which carries them under sprays of fresh water. This belt delivers them to inspection belts where the water drains away and the final sorting and grading are done. The berries are then put in containers, with the desired quantity of sugar. Usually, the proportion is 1 pound of sugar to 3 pounds of fruit, though 1 to 4 and 1 to 5 packs are also made, as these are preferable for some purposes. Heavy watertight barrels holding about 450 pounds of the mixture of berries and sugar are used. Before being used they are carefully examined and coated on the inside with paraffin applied, while hot, with a paint brush. New barrels made of some kinds of wood may need special treatment to prevent the berries from absorbing a woody taste.

The sugar and berries are put in the barrels in alternate layers and mixed by machine or by hand. A jolting platform which jars the barrel as it is being filled with berries and sugar has come into common use. As soon as the barrels are headed, they are shipped to a cold-storage warehouse, where they are stored for at least a week at 0° F. and then held at about 15°. From 75,000 to 125,000 barrels, each holding 50 gallons, or the equivalent in smaller containers of strawberries, are put up in this manner every year.

For dessert use, berries are packed in small cartons, usually containing about a pound of berries, either entire or sliced, and with or without the addition of sugar or sirup. The berries are washed and prepared as for packing in barrels but are placed in the smaller packages for retail use. A recent development consists in freezing the berries by immersing in or spraying them with a sirup, which freezes them very quickly.

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U. S. GOVERNMENT PRINTING OFFICE: 1941

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