

Strawberry Production in Ohio

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STRAWBERRY PRODUCTION IN OHIO

LEON HAVIS

Strawberries are grown extensively in Ohio, both for relatively local markets and for home consumption. A good demand for this fruit is created by the large number of industrial cities in the State, and there are few shipments of berries from the State.

Although there is considerable variation in soil and climate, strawberries can be grown throughout Ohio. The strawberry is well suited to the home garden, and perhaps no other fruit is as responsive to careful management as this crop.

The purpose of this bulletin is to outline methods of culture and management for strawberry growing in Ohio which are based on experimental evidence and observations. Recent experiments and the development of new varieties have been responsible for considerable change in recommended practices during the last 15 years.

The average yield of strawberries in Ohio from 1928 to 1939 inclusive was 1,561 quarts per acre. This is a relatively low yield, since it is possible, with suitable varieties and a good site, soil, and culture, to obtain up to 10,000 quarts per acre.

According to the Agricultural Statistics of the United States Department of Agriculture, there was a yearly average of 3,967 acres devoted to commercial strawberry production in Ohio from 1928 to 1939 inclusive. This acreage produced a yearly average of 258,000 24-quart crates, which sold at an average of \$2.78 each for an annual value of \$717,240. This value is exceeded only by apples, peaches, and grapes among the fruits grown in Ohio. In 1940 the acreage in the State was 4,900; in 1941 it was 5,000 acres, and for the 1942 crop it is estimated at 4,750 acres.

Strawberries are grown to some extent throughout the State, but the commercial acreage lies near the larger cities. The most extensive plantings are in northern Ohio with the principal market at Cleveland. The leading counties here are Lucas, Lorain, Cuyahoga, Lake, and Ashtabula. There is an important eastern Ohio region in Columbiana and Mahoning Counties. The leading strawberry county in the State varies from year to year, but often it is Lawrence, in the southernmost part. This section produces the earliest berries in the State. Hamilton County, near Cincinnati, and Montgomery County, near Dayton, are other major strawberry regions.

Since strawberry plants bear in only one year after they are planted, it is usually advisable to grow a relatively small planting at first before attempting a larger one, especially if the grower is not familiar with the crop. If the market is largely local, he should first become well established and recognized before he goes into extensive production. Often, too, the greatest profit is made not from the largest planting, but from the one that is the most intelligently planned, cared for, and marketed.

LOCATION OF THE PLANTING

In the selection of a location for a commercial strawberry planting, nearness to a good local market is not the only factor to consider although it is an important one. The soil, the site, the road conditions, the climatic conditions, and the labor situation are other factors that are often not considered enough. Of course, a grower may not find all factors perfectly favorable and still maintain a successful planting. For example, the advantages of cheap labor and the ability to produce early berries may offset the advantage of nearness to market. The reverse may also be true. With the exception of the extreme southern portion, the most profitable plantings in Ohio are located near relatively large markets. Many berries are trucked daily into the larger cities from distances of 40 to 60 miles.

The well-located roadside stand offers one of the best markets for strawberries and is used considerably in Ohio. More of this type of marketing could probably be done in certain sections. An attractive, well-recognized stand which becomes well known for its high quality and dependable fruit can be, and often is, a profitable enterprise.

SITE

The commercial strawberry planting should be located somewhat above the surrounding area. This is an important point, because cold air draws into the lower areas, and frost occurs last in higher regions. Where convenient, the home planting also should be placed to afford good air drainage, but here early berries and high production are usually not so important as convenience for table use.

A level site is satisfactory if both the subsoil and the surface soil are well drained. A 2 to 3 per cent slope is preferred, because it makes adequate water and air drainage more likely. If the site is very steep, there may be erosion, since the plants are cultivated intensively during the first season. When it seems necessary to grow strawberries on a slope that is likely to wash, the plants should always be set out on a contour with the slope of the land.

For early market berries, a southern slope is best, but there is more danger of a frost there, since berries on a southern slope start growth early and are further developed at the time of a late frost. A northern or eastern slope is safer from frost and should be used when possible for the midseason crop. The late varieties can be grown on the northern slopes or even in the lower regions sometimes, since they usually blossom late and are, hence, not so subject to frost. These sites also often result in the highest yields and the latest berries.

Eggert (7) found that a northern slope retarded the ripening of Dunlap strawberries by about 9 days. The use of a clay loam soil on the north slope retarded the ripening date an additional 4 days over a sandy loam on the same slope. Through the proper selection of varieties and site, it is possible to affect the ripening season to a considerable degree.

SOIL

Strawberries are grown on many types of soil in Ohio. For early berries, a light or sandy soil is preferable. For late fruit, a heavy type should be selected. Neither type should be extreme, however, and both should be well drained. The sandy types can be prepared early in the spring, tend to produce

earlier berries, and are especially desired for the production of new plants. The heavy or clay soils are often poorly drained and may bake and crack considerably, but they retain more available moisture and nutrients. The best type of soil for high production of runners and fruit is a well-drained sandy or silty loam or clay loam.

Strawberries are not very sensitive to soil reaction, and, therefore, any soil within the acidity range usually found in Ohio is satisfactory from that standpoint. Morris and Crist (17) concluded that a satisfactory reaction was slightly acid, between a pH of 5.0 and 7.0. Good plantings, however, are located on soil that is more acid than this, and the application of limestone is likely to be more harmful than helpful.

VARIETIES

One of the fundamentals of successful strawberry growing is the choice of the correct variety or varieties. This choice depends somewhat on the location of the planting in the State, but even more, on the purpose of the planting. Many new varieties have been introduced recently, and these introductions have made the choice of varieties even more difficult. Many of the new ones have not been grown long or extensively, and, thus, should be tried out on a small scale before they are grown commercially. Some of the relatively new ones, however, have been tested extensively in Ohio, and their characteristics are fairly well known.

The purpose for which the berries are to be produced is very important in the choice of varieties. The variety for commercial purposes should be high yielding, dependable, fairly firm, and attractive in appearance. It should also be fairly easy to pick and be resistant to such climatic conditions as late spring frost and wet weather during ripening. The larger commercial growers in Ohio usually plant only a few varieties, often only one or two. The time of ripening is very important, and often success depends largely on this factor. The berry grower who depends on a local market or a roadside stand should have ripe berries over a long season. A long ripening season can be created either by lengthening the ripening season of one or two varieties or by the choice of early, midseason, and late varieties. The grower for local outlets should select high-quality varieties even though they may not be as firm as is most desirable for the grower who hauls to more distant markets. The home gardener also wants a succession of ripe berries through the season. For this purpose the variety may not be the most productive, but it should be fairly dependable. It should surely be of the quality that is best liked by the family. General suggestions regarding the quality of different varieties can be made, but in the final analysis, individual preferences should rule in the home garden selection.

Most strawberry varieties grown in Ohio have perfect flowers and thus require no cross-pollination with other varieties for fruit set. The Howard Supreme and Sample are two imperfect flowering varieties, and if either of them is used, a perfect flowering variety should be interplanted every three or four rows. It is preferable to choose a perfect flowering variety. Unless otherwise noted, all varieties described in this bulletin are of the perfect flowering type.

JUNE-BEARING VARIETIES

The strawberry varieties described here are either commonly grown in Ohio or particularly promising for this region.

Aberdeen has medium to large, conic-shaped fruit which is attractive, light red in color, slightly acid, and of fair to good quality but not firm. Its plants are vigorous and productive. This would be a good variety to follow Howard 17 (Premier) in Ohio if it were firmer. Aberdeen is highly resistant to red stele disease. It is grown extensively as a late variety for local markets but will probably soon be replaced by recent introductions.

Aroma produces a berry that is medium to large, round to round conic in shape, light red, of fair quality, and very firm. The plants are medium in vigor and healthy, and they have many runners. Aroma is not very productive in northern Ohio but is better farther south on the heavier soils. It is a medium late variety. Aroma has only limited value in Ohio.

Blakemore produces fruit which is medium in size, conic, bright light red, very firm, subacid, and of fair quality. The plants are fairly vigorous and form many runners. Its season is early. Blakemore is now the leading variety in the United States but is low yielding and of only fair quality in most sections of Ohio. It is suggested for trial in Ohio only when an early, very firm, light-colored berry is demanded.

Catskill, a variety that has large, roughly round conic, attractive bright red berries of good quality and medium firmness, has vigorous plants which are leaf spot resistant and produce many runners. It is a productive, early midseason variety. This variety is rapidly being planted more extensively in Ohio because of its vigorous, productive plants and large-sized berries. It is not so resistant to late spring frost as Premier, however. It ripens during the latter part of the Premier season.

Chesapeake produces medium to large, round conic, high-quality, firm-fleshed berries. The plants are vigorous but produce few runners. Chesapeake is not productive. It has a late season. Only in rich soil, under irrigation and intensive culture, does this variety produce well in Ohio.

Clermont has large berries which are conic to wedge shaped and glossy red in color. The berries are of high quality and medium firmness. The plants are vigorous but not always highly productive. Its season is early. At the Experiment Station, the berries have not ripened evenly and have failed to hold their color after ripe. Clermont is subject to leaf spot and should not be grown where this disease is serious.

Dorsett produces a large berry which is wedge-conic in shape, glossy bright red in color, of excellent quality and medium firmness. Its plants are vigorous and free from leaf spot and produce many runners. Its season is early. Dorsett lacks productiveness under most Ohio conditions and is susceptible to late frost injury. The high quality of the fruit and the vigorous plants make this variety desirable in some sections of the State, but its lack of productiveness makes it questionable as a commercial variety in Ohio. It is valuable for home use.

Dresden fruit is large, uniform, regular, conic in shape, an attractive bright red color, of fair quality and medium firmness. The plants are vigorous, very productive, and free from leaf spot. The Dresden season is early. The size of the berries holds up well, but the picking season extends little later

than that of Howard 17 (Premier). The Dresden is well liked by most who have tried it in Ohio. It is preferred by some because of its high quality and large, uniform fruit.

Dunlap (Senator Dunlap) has fruit which is medium to below medium in size, long conic in shape, deep red in flesh color, of high quality, but not firm. Its plants are not vigorous but form many runners. Dunlap is relatively unproductive. Its season is medium early. Since the foliage is healthy and the berries are of high quality, this was once an important variety in Ohio. It has been replaced largely by Howard 17 (Premier) because of size of fruit and productiveness.

Fairfax produces large berries which are wedge-conic in shape. Its berries are bright red when first ripe and soon turn to deep red. They have excellent quality for dessert and firm flesh. The plants are vigorous and form many runners which often require thinning. Fairfax is fairly productive, medium early. The chief fault of this variety is that its berries turn dark soon after they are ripe, even though they are still firm. Because of its high quality, large-sized berries, and vigorous plants, Fairfax is especially suited to the home garden.

Gandy fruit is medium to large, crimson in color with red flesh, of good quality, and firm. The plants are fairly vigorous but not highly productive. The Gandy season is late. This variety is susceptible to leaf spot and other foliage diseases. It is not grown in Ohio so much as formerly. It is most productive on heavy soil.

Howard 17 (Premier) has a medium to large berry of conic to long conic shape, red color, good quality, and medium firmness. Its plants are vigorous and exceptionally free from foliage diseases. Premier is productive and has an early season. It is one of the most resistant varieties to frost damage. Because of its productiveness, suitability to many soil and climatic conditions, early and long ripening season, and its freedom from foliage diseases, this is by far the leading variety in Ohio. It is not of as high quality as Dorsett or Fairfax, nor is it as firm as Blakemore; nevertheless, it should at present be the standard variety for commercial planting in this State.

Northstar berries are large, conic to oval in shape, light, attractive, and uniform in color, tart flavored, and fairly firm. The plants are vigorous and medium in productiveness. The Northstar season is early. This variety is recommended for trial as a commercial berry because of the large and attractive berries and the vigor of the plants.

Parsons (Gibson) produces fruit that is medium in size, wedge-conic in shape, dark red, of fair quality and medium firmness. Its plants make many runners, and the foliage is susceptible to leaf spot. It is a productive, early midseason variety. This variety ripens during the latter part of, and just following, the Howard 17 (Premier) season. The more recent variety, Catskill, is preferable for that season.

Pathfinder has large, round to round-conic, light to medium red, good quality, medium firm fruit. Its plants are vigorous, form many runners, and are productive. Its season is a little later than that of Howard 17 (Premier). The plants are not entirely free from leaf spot in Ohio but evidently are resistant to red stele. Pathfinder is worthy of trial where a berry of good size and light color is desired.

Premier is a synonym for Howard 17. See the description of that variety.

Redstar, which has large-sized fruit and vigorous, productive plants, is a late variety that was recently introduced. It is very promising as a commercial and home garden berry for Ohio. It seems resistant to leaf spot, and its firm berries are of high quality. Redstar is suggested for trial as a late variety.

Sample, an imperfect variety, has a medium-sized, conic-shaped berry that is medium dark red in color, of good quality, but rather soft. Sample produces many runners and is a productive midseason variety. It is liked by some because of its attractive dark red fruit and productiveness. It is sometimes subject to leaf spot, however, and the fruit is too soft. It is an imperfect variety and thus requires another variety to pollinate it. It has largely been replaced by Howard 17 (Premier).

FALL, OR EVERBEARING, VARIETIES

Gem berries are of medium size, a light red color, tart, of fair to poor quality, and firm. The plants are small but form many runners. The peak production of Gem comes during the first part of August.

Green Mountain produces berries that are medium to large in size, light red in color, of fair quality, and firm. The plants are vigorous and produce a limited number of runners. This variety reaches the height of its production during September. It is not very productive at Wooster.

Mastodon is the most common everbearing variety. Its berry is of medium to large size, fair quality, and firm. Its plants are vigorous and usually form a good matted row. It is productive in comparison with most other everbearers. Its season is long, extending through August and September and reaching a peak about October 1.

Rockhill (Wayzata) has large berries, roughly conic in shape, bright red in color, of high quality, and firm. The plants are vigorous but form few runners. Its season and productiveness are about like those of Mastodon at Wooster.

WHICH VARIETIES TO GROW

A few general suggestions may be helpful in the selection of strawberry varieties, but it is well recognized that local conditions may warrant quite different recommendations.

The Howard 17 (Premier) is, and should be, the standard commercial strawberry variety in Ohio. For over 25 years it has been, in general, the most satisfactory variety tested at the Experiment Station for commercial planting. Its earliness, long ripening season, productiveness, freedom from disease, and frost resistance have all contributed to this result. Nevertheless, some of the newer varieties are now being suggested for trial or for limited commercial planting. When a premium is paid for high quality, the Dorsett and Fairfax can be used, preferably as a supplement to Premier, since they usually yield less than Premier. The Catskill is also being used as a supplement to Premier because of its higher quality and larger size during the latter part of the Premier season. The Dresden and Northstar are suggested for trial commercially because of their high yields and uniformly larger berries. No everbearing varieties are suggested commercially, since all those tried have been low yielding.

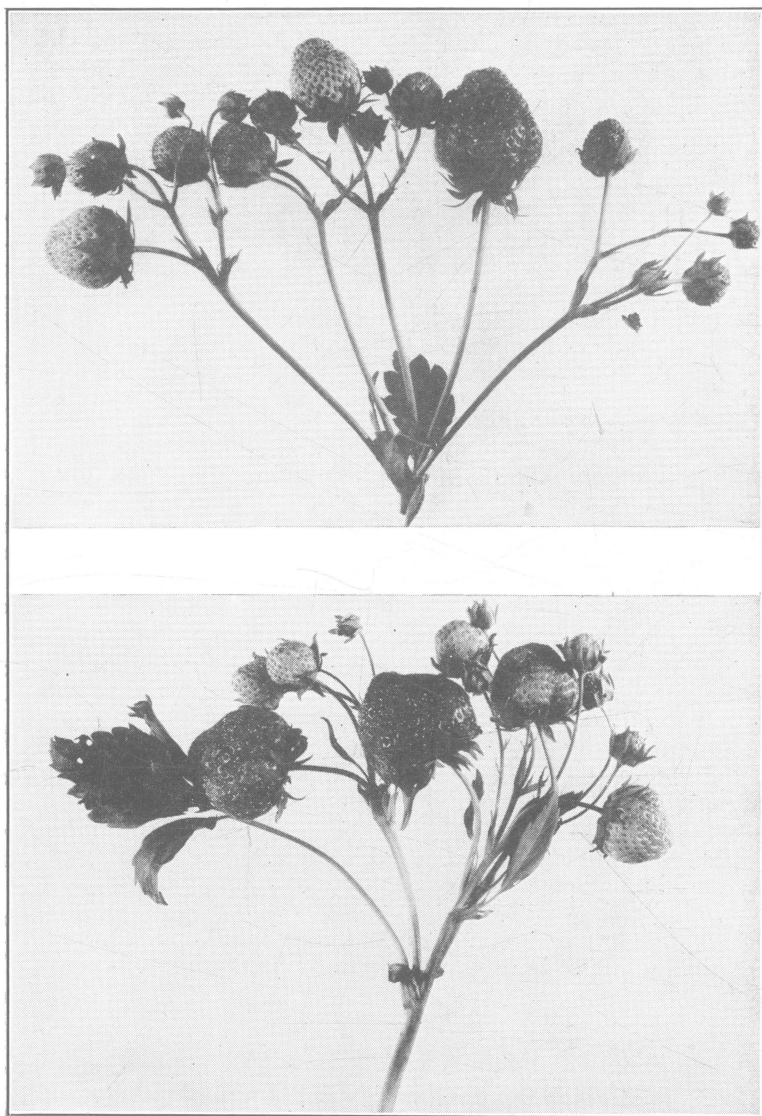


Fig. 1.—Two large-sized, productive new varieties
Top, Catskill; bottom, Pathfinder

The varieties for the home garden should include such high-quality ones as the Dorsett and Fairfax or both. The Aberdeen and the Chesapeake also may be used to extend the season. The Starbright and Redstar can be tried for the later varieties, since they are promising new ones of high quality. If a fall-bearing, or everbearing, type is desired, the Rockhill (Wayzata) is suggested.

OBTAINING AND CARING FOR THE PLANTS

The best results in strawberry growing are obtained only if vigorous plants formed during the previous summer are set out. They should be free from diseases and insects and have a large root system. The crown and the roots should be light brown in color, as a dark color indicates that the plants have been injured by low temperatures or diseases or that they are old. There is evidently no advantage in getting "pedigreed" plants.

SOURCE OF PLANTS

Good plants can be secured from the old patch if it is free from insects, diseases, and winter injury. Only the best plants should be used. One advantage of getting the plants from the old patch is that they can be reset at once. There are such disadvantages as time required to dig them and the destruction of fruiting plants. One good method for the grower who wishes to produce his own plants is to set aside a special patch to be used only for the growing of propagating plants. By this method, he can dig the entire row for plants rather than dig part of the plants and injure the roots of those left for fruiting.

New plants can often be secured from a local nursery or a local grower who makes a specialty of selling plants. Plants from these sources can be set out the same day they are dug, and a good stand can then be expected. Only clean, vigorous plants should be secured.

Some of the larger nurseries grow many acres of strawberries to be used only for sale of new plants. They are experienced plant growers and can usually be depended on to furnish good plants of the desired variety. The plants are not expensive, and if they are packed well, they will arrive in good condition ready for planting.

Plants obtained from northern regions are no more hardy than those secured from other sections. Southern plants, however, are sometimes too far advanced when they arrive in the more northern regions.

WHEN TO GET THE PLANTS

If the new plants are obtained from the old patch or from a neighbor, they should be dug just before they are to be set out. Plants obtained directly from a nursery should be ordered as early as possible, and directions for the date to be delivered should be given. The nursery can take more time with the earlier orders, and the grower can also be surer of getting the varieties that he orders.

The grower who has cold storage facilities may have his plants delivered early in March or as soon as they can be dug. If the plants must be heeled-in or planted at once, they should not arrive until just before they are to be set out.

TABLE 1.—Number of plants required per acre with different planting distances*

Distance apart in row Inches	Distance between rows		
	3 feet	3½ feet	4 feet
9.....	19,360	16,594	14,520
12.....	14,520	12,446	10,890
15.....	11,616	9,956	8,712
18.....	9,680	8,297	7,260
24.....	7,260	6,222	5,445
30.....	5,808	4,978	4,356
36.....	4,840	4,150	3,630

*The number of plants per acre is determined by multiplying the distance between the rows by the distance apart in the row, in feet, and dividing this product into 43,560 (the number of square feet in an acre).

CARE OF PLANTS BEFORE PLANTING

When the strawberry plants arrive from the nursery, they should be unpacked at once, and, if the roots are dry, they should be soaked in water for a few hours or overnight. Then the plants should be set out at once if the soil can be prepared. If not, they can be heeled-in or placed in cold storage temporarily.

HEELING-IN

A well-drained, shaded place should be selected for heeling-in the plants. A trench is dug about 8 inches deep, and each plant is placed separately along the trench. The trench is filled carefully so that the soil settles well around the roots and crowns. The plants are watered well after they are heeled-in, and then the soil is kept moist but not wet. The heeled-in plants should be set out as soon as possible, but if necessary, they can be kept in fairly good condition for 2 to 3 weeks.

COLD STORAGE

The cold storage method has several advantages and is recommended where storage is available. By its use, the plants can be obtained while they are still completely dormant and held in good condition until they can be planted. In this way, a better stand of plants and earlier runner formation can be obtained.

Recent experiments (8, 13) indicate that strawberry plants can be kept in cold storage very successfully for a considerable length of time. According to Haller (8), plants stored at 32° F. for as long as 6 months grew satisfactorily. When a cold storage is available, plants can be obtained as early in the spring as they can be dug, and placed in storage until time to plant.

The temperature of the storage should be between 28 and 34° F. The humidity should be kept high, and the strawberry roots moist. Plants can be left in the packing material, and it can be moistened occasionally. It is not necessary to remove the leaves from the plants when they are stored. The leaves on the stored plants may appear wilted and discolored, but results of experiments have indicated that the plants are just as good as, and sometimes better than, freshly dug plants.

SOIL PREPARATION

An important step in growing a successful strawberry planting is the thorough preparation of the soil. There is no one correct method, but some general suggestions can be given. In the soil preparation are included both the crop rotations used and the immediate preparation for planting.

CROP ROTATIONS

A definite system of rotations should be followed so that the soil will be in the best condition for the strawberry patch. Some different crop is necessary between crops of strawberries in order to build up the soil organic matter and to make possible the destruction of insects and diseases of the berries.

The rotation system depends largely on the type of soil and the requirements of the particular grower. In general, there should be at least 2 years of cropping between plantings of strawberries. The last crop should be a cultivated one, such as vegetables, or an overwintering one, such as rye, which can be plowed down early in the spring. In soils where this cannot be done during many years, the soil should be plowed during the previous fall.

When it is necessary to allow only 1 year between strawberry crops, a fairly good system is to use some summer cover crop, such as soybeans, immediately after harvest, then disk it down in August and plant to a crop of rye or rye and vetch, which is plowed down the following spring. Rye is valuable in preventing erosion during the fall and winter months and makes a good growth early in the spring; nevertheless, there is some objection to rye as a winter crop for strawberry soil because of the difficulty in preparing the soil in the spring to set the plants. The clumps of roots and coarse tops make it difficult to fit the soil so that the plants can be set out where there are no large air spaces around the roots.

A good system is to keep the soil in clover 1 or 2 years, then after plowing in the spring, to grow a cultivated crop, such as vegetables, during the summer. These can be followed with a winter cover crop, which should be plowed under in the late fall, or early spring, where this is satisfactory, before the strawberries are planted. A grower who has plenty of land may wish to allow longer intervals between strawberries. They should never be grown continuously on the same soil.

PREPARATION FOR PLANTING

In order to obtain a good stand of vigorous plants, the soil must be in a good state of tilth before the plants are set out. It is usually necessary to plow, disk, harrow, and sometimes to roll the soil in order to get this desired condition. If the soil is not subject to erosion, it can well be plowed late in the fall. Then the remainder of the preparation can be made the next spring. This plan is most desirable where the soil is often too wet in the early spring to plow well.

PLANTING

TIME OF PLANTING

It is preferable to set out strawberry plants in the early spring in Ohio. They should be planted just as early as the soil can be prepared. The cool cloudy weather at this time helps the plants to become well established. If they can be set out by the first part of April, they should start runner forma-

tion by early June. It is much more difficult to obtain a good stand of plants if they are set out in May or June when the soil dries out quickly and the transpiration rate is high. Runner plants are also delayed, and it is important that new plants be formed early in the season (19).

Strawberry plants set out during the late summer or fall yield little fruit the following spring. Sometimes plants are set out in the fall in order to get the earliest possible growth the next spring, or to avoid the rush of spring planting. This planting is not economical, however, since the plants must be mulched and cared for during the winter, and the mulch must be removed completely early the next spring in order to cultivate the plants. If they are not mulched, there may be much winter injury and heaving of plants. Thus, the plants would need to be mulched two winters before a good crop is produced. In general, only spring planting seems justified in Ohio.

TRAINING SYSTEMS AND PLANTING DISTANCES

The two principal strawberry training systems are the matted row and the hill. There are several modifications of these two systems, but only those best suited to Ohio conditions are discussed here.

MATTED ROW SYSTEM

The matted row system is by far the most common one in Ohio. This method, or a modification of it, has been found to be the one best suited to Ohio conditions and varieties. According to this system, the rows are 3 to 4 feet wide, and the plants are set about 18 inches apart in the row. Runners are allowed to form new plants in all directions, and the width of the row is controlled by cultivation and hoeing. Many varieties form too many plants, especially during good growing seasons, for the highest yield of good quality fruit. Hence, certain modifications of the regular matted row, such as the hedgerow and the spaced row, can be used profitably.

The hedgerow.—This is a modification of the matted row which requires considerable care. It is best suited to varieties which form few but vigorous plants. It is not well suited to commercial plantings, since considerable detailed hand labor is required. The method is very conservative of space, however, and makes it possible to obtain the highest yield of large plants and fruit. The hedgerow method requires the definite spacing of a certain number of runners from each mother plant. For the single hedgerow system, the rows are spaced about 30 inches apart, and the plants are set 18 inches to 2 feet apart in the rows. Each plant is allowed to form two runner plants, and these are made to root in the row in line with, and on each side of, the mother plant. They are placed so that they are equal distances from each other and from the mother plants. All other runners are removed. In the double hedgerow, four runners are set from each mother plant. These are also placed so that they are equal distances apart and equal distances from the original plant. For this system, the rows are usually 3½ feet apart, and the plants are about 2 feet apart in the row, although this distance depends somewhat on the variety and soil.

The spaced row.—The spaced row system was developed because often too many plants are formed in the uncontrolled matted row. This modification of the matted row is the one recommended for most commercial plantings in Ohio. It can be modified to fit the requirements of soil and varietal differences. By

this method, the plants are usually set 18 inches from each other in rows 3½ feet apart. The distance should vary with the variety used. The Dorsett, Fairfax, and Catskill may well be set 2 feet apart in rows 4 feet apart. A less vigorous variety, such as the Howard 17 (Premier), should be set about 18 inches by 40 inches. The runner plants are encouraged to develop as early as possible and until the rows reach the desired width. Meantime, the plants are spaced by some method to keep the rows from becoming too thickly matted. Many experiments have shown that the very thickly matted row is not as productive as the spaced row. Results of spacing tests at Wooster indicate that Premier plants should be 4 to 6 inches apart in the spaced row. More vigorous varieties, such as the Dorsett and Catskill, can be as far as 9 inches apart.

Some tests were recently made to determine the effect of different planting distances and thinning or spacing the plants on the yield of fruit. All treatments were duplicated and set in rows 3½ feet apart. The distances between plants in the row when set were 9 inches and 18 inches apart. One of the 18-inch plots was not thinned at all. In the other, the plants were thinned to about 6 inches apart in August. Of the 9-inch plots, one was thinned to the same number of runner plants as the unthinned 18-inch plot; the other was thinned to the same number of runner plants as in the thinned 18-inch plot. The results in yields of fruit the following June (table 2) show that there was an advantage in thinning the plants in both the 9-inch and the 18-inch settings. The plants set 9 inches apart and then thinned to the same number of runner plants as in the plot set 18 inches apart yielded more berries than those in the unthinned plot, possibly because there was more uniformity in spacing distance between plants.

TABLE 2.—Yields of berries per acre resulting from different planting distances and spacing

Plot No.	Planting distance	Spacing treatment	Original number of plants used	Yield per acre
	<i>Inches</i>			<i>Quarts</i>
1.....	18	Unthinned	250	7,293
2.....	18	6 inches apart.....	250	8,316
3.....	9	Thinned to number of runner plants in plot No. 1.....	500	8,184
4.....	9	Thinned to number of runner plants in plot No. 2.....	500	8,382

It is not often economically profitable for the grower to have his patch spaced by hand to the exact distance between each plant. In a year when many plants were formed, an experiment at Wooster showed that even rough hand spacing of Premier plants to 6 inches apart cost approximately \$50 per acre. It was necessary to go over the plots twice during the late summer to do the job satisfactorily. Much valuable spacing can be done more economically with the hoe during the late summer and early fall. The use of a spike-toothed harrow is a rapid and cheap method of thinning the plants. The harrow is drawn across the rows as often as seems necessary after all the plants desired have set. Some experience will soon indicate the amount of thinning necessary.

Since the early formed runner plants are the most productive (19), an effort should be made to have all plants necessary set during June, July, and early August. Those formed in September and October can be considered as little more valuable than weeds.

With rows $3\frac{1}{2}$ feet apart, the spaced matted row can be allowed to become 18 to 20 inches wide. The patch is more difficult to handle, especially in picking, if the rows are wider. When the rows are farther apart, the matted rows may be slightly wider. In order to obtain the highest production, an effort should be made to have the spaced matted rows as wide as they can be handled well.

HILL SYSTEM

In the method of strawberry plant training called the hill system, only the original plant is allowed to develop; all runners are removed. The mother plants stool out and develop large crowns. Larger fruit can usually be obtained by this method, but in Ohio the total yields are less than in the matted row. By the hill method, the plants are set about 18 inches apart in rows about 30 inches apart. The exact distance depends on the soil and variety used.

COMPARISON OF THE DIFFERENT SYSTEMS

The hill system of strawberry training is used more than the matted row in certain sections of the United States. In Ohio, however, the matted row seems preferable. Plants in the hill system are more likely to be injured by heaving out, and if a plant is destroyed for any reason, it is a relatively greater loss to the row than a plant in the matted row.

One advantage of the hill system is that the plants can be cultivated in both directions throughout the season. More work is required, however, in keeping the runners removed from the plants in the hills.

In general, for the varieties, soil, and weather conditions of Ohio, the matted row or a modification of that system, such as the spaced row, is preferred to the hill system.

MARKING THE ROWS

The strawberry planter will find it worth while to have straight rows and to have the plants equal distances apart. A wire drawn across the patch can mark the rows in a small planting. A homemade hand-drawn marker is one of the best means of marking the rows and spacing for the plants. Sometimes horse- or tractor-drawn markers are used on large plantings. Cross-marking the places to set the plants makes it possible to cultivate in both directions a few times before the runners begin to set.

PREPARING THE PLANTS FOR SETTING

Before the plants are set out, all the large leaves should be removed in order to avoid excessive transpiration, or loss of water from the foliage (fig. 2). Only two or three of the smaller leaves near the crown should be left. It is not so necessary to remove as many leaves early in the season or during cool, cloudy weather. The roots can be pruned back slightly in order to facilitate handling, but there seems to be no other advantage in this practice. The grower should avoid cutting away any more of the root system than necessary. When a transplanting machine is used, more root-pruning is necessary.



Fig. 2.—Plant at right is trimmed correctly and ready to set out.

SETTING THE PLANTS

The strawberry roots and crowns should be fresh and moist when the plants are set. If they appear dry, the plants should be soaked for a few hours before planting. The plants should be protected from drying out while they are being planted; only a few minutes in hot sun will injure the plants and result in a poor stand. A basket can be lined with moss or other packing material, and then the plants with moist roots can be placed in the basket and covered with wet burlap. Another common and good method is to keep the roots in a bucket partly filled with water.

There are several good methods of planting strawberries. Things of major importance to remember are that the roots must be spread out in a moist soil, that the soil must be firmed about the roots and crowns, and that the plants must be at the proper depth. The soil level should be about half-way up the crown, or at the same depth as when the plants were in the nursery row (fig. 3).

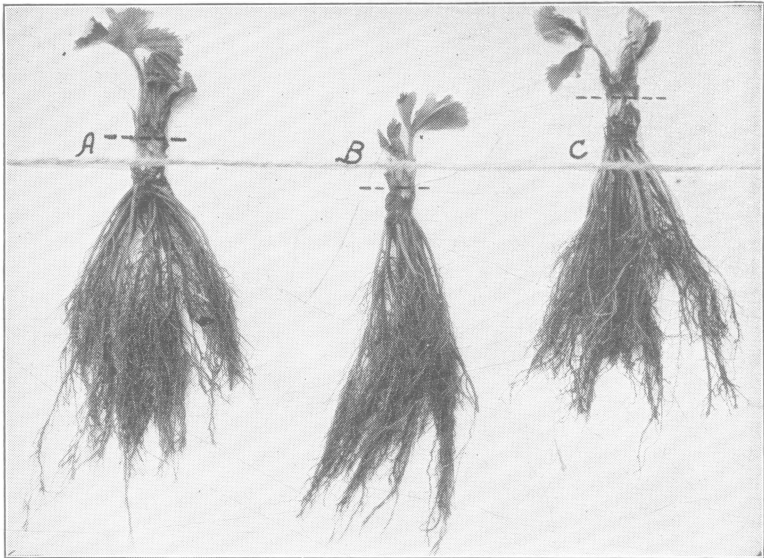


Fig. 3.—Correct depth to set berry plants

Broken lines indicate correct depth. B is too deep. A and C are too shallow.

The spade method is rapid, and if the plants and soil are in good condition, it results in a good stand of plants. The spade is shoved into the ground and pressed forward, making an opening in the soil in which the plant roots are placed. The roots can be spread out quickly in the opening, and the crown placed exactly level with the soil surface. Then the soil is pressed firmly about the roots and crown with the hands or feet. Two persons should work together with this method, and with a little practice, they should soon be able to set 6,000 to 7,000 plants per day.

If one person is to plant alone, he may find the flat dibble or a trowel the most convenient.

The furrow method is used by some growers but cannot be recommended. If both methods are used carefully, the furrow method is no more rapid than the spade system, and the stand of plants is likely to be better when the spade is used. There is probably less drying out with the spade method, and the soil is pressed more firmly about the roots.

The horse- or tractor-drawn transplanter can be used economically only by very large strawberry growers or by large vegetable growers, who have other uses for the transplanter. It can be used fairly well for strawberry setting and is a very rapid method. Care should be taken to spread the roots well and to get the crowns at the proper depth with this method. The main advantages of the horse- or tractor-drawn transplanter are that the plants are watered as they are set and that as much as 5 acres can be set per day.

MANAGING THE PLANTING DURING THE FIRST SUMMER

PREVENTING FRUIT DEVELOPMENT

June-bearing strawberry varieties should not be allowed to develop fruit during their first growing season. Several experiments, including those of Mann and Ball (16), and observations indicate that removal of the blossoms increases the number of runners formed and the general vigor and hardiness of the plants. All flower stalks and flowers should be kept pinched off in order to obtain the most vigorous plants and runner formation. Going over the patch once or twice may be enough for varieties like Dunlap, but others, such as Premier and Chesapeake, require more attention.

Blossoms should be removed from fall, or everbearing, varieties until about July 1; then they can be allowed to develop.

CULTIVATING

The purposes of cultivating strawberry plants are to control weeds, prevent crusting of the soil, improve the aeration of the soil, and make nutrients more available to the plants. Cultivation also aids in controlling the width of the row, and by preventing crusting of the soil, it facilitates rooting of runners.

Cultivation should be continued throughout the first growing season. A thorough cultivation is necessary about every 2 weeks and after every heavy rain. It is usually necessary to cultivate until late summer in order to destroy all weeds, so that the patch will be as clean as possible the next spring when no cultivation can be done.

A broad-toothed or spring-toothed cultivator can be used for the first few cultivations, and fairly deep tillage is suggested. Then the spike-tooth type of cultivator should be used through most of the season, and the cultivation should be made more and more shallow. Each cultivation must be farther and farther from the mother plants as the rows become wider until the desired width is obtained. It is best always to cultivate in the same direction in order to destroy fewer plants as they become rooted.

Several thorough hoeings are usually necessary to destroy weeds near the plants and to aid in spacing the plants in the row. If in the last hoeings the runners which have just rooted and those that are about to root are considered as weeds, much can be done to prevent overcrowding in the row. While hoeing, the grower can also do much to train runners to vacant places in the matted or spaced row.

SPACING THE PLANTS

During the latter part of the growing season when the last cultivation treatments are being made is the time when the larger amount of spacing should be done. The last plants formed are the ones to remove, as they are low yielding and prevent the highest production from the other plants because of their absorption of moisture and nutrients.

WIDTH OF ROW

The width of row most desirable at the end of the first season is 20 to 24 inches. A wider row may sometimes yield more, but it is more difficult to handle, especially in picking. Some growers prefer to set out the original rows only 3 feet apart and allow them to develop into matted rows only 15 to 18 inches wide.

FERTILIZING THE PATCH

FLOWER BUD FORMATION

The time of application of fertilizers should be associated with time of flower bud differentiation, since the number and vigor of fruit buds depend largely on the physiological condition of the plants, which, in turn, depends somewhat on the nutrient content of the soil.

Flower bud differentiation in northern Ohio extends from about the last of August until late in the fall, depending somewhat on the seasonal conditions and the variety. The first, or primary, buds often start differentiation by August 15 in the Premier variety. The time of differentiation extends for several weeks, since the buds at the different positions on the flower stalk differentiate at different times, the primary, first, then the secondary, then the tertiary, and so on. The time of differentiation also depends on the age of the plant. Plants rooting in September must form flower buds later than those that root in June and July. Evidently, however, the late runner plants form flower buds at a younger age than the earlier plants. Darrow (4) has shown that regardless of the temperature, short days encourage flower bud production and tend to inhibit runner production. He also indicated that the development of flower buds requires shorter day lengths at the higher, than at lower, temperatures.

PLANT VIGOR

Plant vigor is determined by size and number of strawberry leaves, size of crown, number and distribution of roots, and number of runner plants per original plant. These are all, to some extent, associated with soil fertility. Many experiments and observations show that vigorous plants are directly associated with high yields of berries. The possible berry crop is determined largely by the leaf area during the previous fall (21). A larger leaf area is directly related to a potentially large crop. One reason for this relationship is that the crop is associated with the extent of flower bud formation, which is associated with the number of leaves per plant. Thus the cultural and fertilizer practices in the fall should be planned to get the largest possible number of leaves per plant. Results in Maryland (22) showed that a complete fertilizer applied in August and September was effective in increasing the dry matter of both crowns and roots. Long and Murneek (15), working in Missouri, found that the strawberry plant stores organic foods during the late summer and fall and depletes them during the spring of the next year. These results show how necessary it is that the plants be well grown in the late summer and fall.

The application of fertilizers, especially nitrogen, is sometimes necessary in the spring of the year the plants are set out in order to stimulate runner formation. Again, the general vigor of the plant is involved.

DISTRIBUTION OF STRAWBERRY ROOTS

Strawberries are more deeply rooted than is usually realized. The writer has already reported (11) finding strawberry roots to a depth of about 30 inches in Canfield silt loam at Wooster. In these studies it was found that where plants were set out in rows 3½ feet apart and had formed a matted row 14 to 16 inches wide, the roots usually met between the rows.

In 1941, a detailed study of the root distribution of Premier strawberries in Wooster silt loam was made at the Experiment Station at Wooster. The observations were made soon after the first fruiting season was over. Three typical positions in the matted rows were selected, and the soil was removed to a depth of about 2 feet around a column of soil 12 inches square. With the aid of a corn knife, the successive 2-inch and 4-inch layers of soil were cut off and removed. The soil was washed away from the roots through a fine screen. The roots from each level at the three locations were weighed fresh and again after drying to constant weight at 60° C. The data presented (table 3) represent the average of the results obtained at the three locations, which were all within 30 feet of each other.

The results (table 3) show that there is a gradual reduction in the weight of the roots as a greater depth is reached. The first 6 inches contain 62.0 per cent of the total fresh weight and 72.2 per cent of the dry weight of roots in the upper 22 inches. The weight of roots below 22 inches was very small and varied considerably with the particular location examined. On a dry-weight basis, the amount of roots below 14 inches was relatively smaller than when the fresh-weight basis was used (table 3), because the roots below that depth were younger and composed of a higher percentage of moisture, as shown in the last column of the table. The roots containing the least moisture were found near the surface, in the 2 to 4-inch level.

TABLE 3.—Relative amounts and moisture contents of strawberry roots at different depths

Variety, Premier; area of soil sample, 12 inches by 12 inches

Depth of soil sample <i>Inches</i>	Fresh weight of roots		Dry weight of roots		Amount of moisture in roots <i>Per cent</i>
	<i>Grams</i>	<i>Per cent</i>	<i>Grams</i>	<i>Per cent</i>	
0-2.....	104.4	27.7	24.6	32.0	76.4
2-4.....	72.7	19.3	18.8	24.5	74.1
4-6.....	56.6	15.0	12.1	15.7	78.6
6-8.....	37.5	9.9	7.8	10.2	79.2
8-10.....	24.8	6.6	4.9	6.4	80.2
10-14.....	36.8	9.8	5.3	6.9	85.6
14-18.....	27.8	7.4	2.0	2.6	92.8
18-22.....	16.5	4.4	1.3	1.7	92.1

Studies of strawberry root distribution under matted and thinned rows were recently made in Maryland (18). Determinations of the dry weight of roots from 3-inch cubes of soil in four soil layers to a depth of 12 inches showed that matted rows of Blakemores developed more roots in the upper layers than spaced plants. Where the plants were 7 and 11 inches apart, the roots did not fill the entire zone between the plants, but they did develop a greater percentage of roots in the lower soil layers than did the matted rows. It was concluded that more roots in matted rows make for crowded conditions before fruiting and, hence, smaller fruit.

USE OF MANURE AND OTHER ORGANIC MATERIALS

Barnyard manure is one of the most common and satisfactory materials to use for strawberry soil. It provides organic matter, in addition to nitrogen, phosphorus, and potassium in slowly available forms. For soils which are fairly low in fertility, manure may well be applied at the rate of 20 to 30 tons per acre; ordinarily, 20 tons per acre is enough. Unless the manure is well rotted and free from weed seeds, it is well to apply it to the soil about a year before the strawberry plants are set. A good garden soil well supplied with manure for several years makes an exceptionally good strawberry planting. Unfortunately, manure is not always available, and cover crops and commercial fertilizers must then be used.

Strawberries are particularly sensitive to the physical condition of the soil. Hence, a system of rotation should be designed to keep the soil well supplied with decomposing organic matter. Organic matter is also necessary to supply the plants with the largest possible amount of available moisture throughout the season (12). It is not so necessary to grow large cover crops before every crop of strawberries when large amounts of manure are available. Cover crops are especially valuable for light sandy soils and for the very heavy, or clay, soil types.

In 1936, plots were laid out to determine the effect of large amounts of organic matter on yields of strawberries at the Ohio Station. The treatments, each replicated three times, were as follows: (a) chopped corn stover at 1,600 pounds per acre, plowed under; (b) manure, 15 tons per acre, plowed in; (c) muriate of potash, 100 pounds, and superphosphate, 300 pounds per acre, disked in, and ammonium sulfate, 500 pounds per acre, applied in spring and in late summer in equal amounts. The soil used was the Canfield silt loam, which is considered fairly good strawberry soil.

The resulting yields in 1937 in quarts per acre were as follows: treatment a, 8,715; treatment b, 8,798; treatment c, 8,051. Although the yields are all high, the large amounts of organic matter supplied by the manure and the corn stover seem to have been of some advantage.

USE OF COMMERCIAL FERTILIZERS

The results of considerable experimental work in different parts of the Country are available on the use of various types of commercial fertilizers. There is much disagreement between these results and those observed in different parts of the same state. Some general suggestions can be made for certain soil types under definite climatic conditions, but every farm and every patch are specific problems and should be treated as such. A careful observer will soon learn to judge by the appearance of the plants and by the yields of berries obtained, whether the addition of a commercial fertilizer should be tried in his patch. On the soils of some plantings, there is no advantage in adding any type of commercial fertilizer. Such soils are usually those which are high in native fertility or which have been built up well by the use of such materials as manure and cover crops (11).

The elements usually considered most likely to be lacking for crops in Ohio soils are phosphorus, potassium, and nitrogen. The fertilizing of strawberry soil is, therefore, concerned mainly with these elements and with the reaction of the plants to each of them in different amounts and proportions,

also with the time and method of application of these elements and their effects on the growth of the plants and the yields and composition of the fruits.

PHOSPHORUS

Experiments on Long Island (9) showed no response to phosphorus broadcast just before the strawberry plants were set, even though the soil used requires large applications of phosphorus for many vegetable crops. Applications of phosphorus under New Hampshire conditions (14) did not prove harmful to the plants, and there was some evidence of slight benefit, especially when phosphorus was used in combination with nitrogen and manure. Recent tests at Wooster showed no benefit from the use of phosphorus applied at the rate of 300 pounds of superphosphate per acre before the plants were set and disked well into the soil. The same result was obtained when phosphorus was used alone or in combination with potash and nitrogen.

POTASSIUM

There is little evidence that additions of potassium to Ohio soils would be of value in strawberry growing. In some cases, added potassium might prove harmful. Applications of potassium chloride seemed to be injurious to strawberry plants in New Hampshire (14). There, the potassium did not prove beneficial when used alone or in combination with nitrogen. Potash as muriate of potash, at 200 pounds per acre, has been used at Wooster over a period of 3 years, applied alone and in combination with sulfate of ammonia and superphosphate. It has never been of any significant value as judged by the plant growth and yields although the soils used at the Experiment Station tested low in available potassium. There may be places in Ohio where the application of potassium would be of value for strawberry soil, but evidently they are not at all common. When potassium is applied, it should be broadcast before the soil is disked in preparation for setting the plants.

NITROGEN

The element which it is usually most necessary to add in order to secure the highest possible yields of fruit crops is nitrogen. It is most often applied in the form of ammonium sulfate, sodium nitrate, or cyanamide.

On Long Island (9), the application of 53 pounds of nitrogen (approximately 265 pounds of ammonium sulfate) per acre around strawberry plants, either in April or in September or in divided applications, failed to result in increased yields. In Massachusetts (23), on a loam soil of medium fertility, nitrogen was applied at the rate of 300 pounds of sodium nitrate per acre, or its equivalent, during the spring, summer, and fall of the year before the plants fruited. None of these nitrogen applications resulted in significant differences in yields of fruit. There was no evidence of damage from any of these applications, however. In Maryland (24), it was found that early runners were stimulated by applications of nitrogen at time of planting. In these Maryland experiments, it was found that the application of a "complete" fertilizer in the spring of the first year resulted in little increase in yield, but that applications in the late summer and fall resulted in slightly greater increases. None of the yield differences was great, however. In certain Ohio (19) and other experiments (5, 24), the application of nitrogen during the first year the plants were set resulted in increases in yields the next year.

The application of nitrogen, either alone or in combination with phosphorus and potassium, has usually not resulted in increases in yields when made in the spring of the first fruiting year (14, 20). Experiments (19, 24) and observations have indicated, however, that nitrogen should often be applied during the renewal process just after the first fruiting season.

About a month after setting, the nitrogen fertilizer can be applied in a ring about each plant (fig. 4). In the late summer or just after fruiting, it can be added with a grain drill or broadcast. If the material remains in contact with the foliage very long, burning will likely result. A broom or a burlap sack should be used to brush the fertilizer off the foliage.

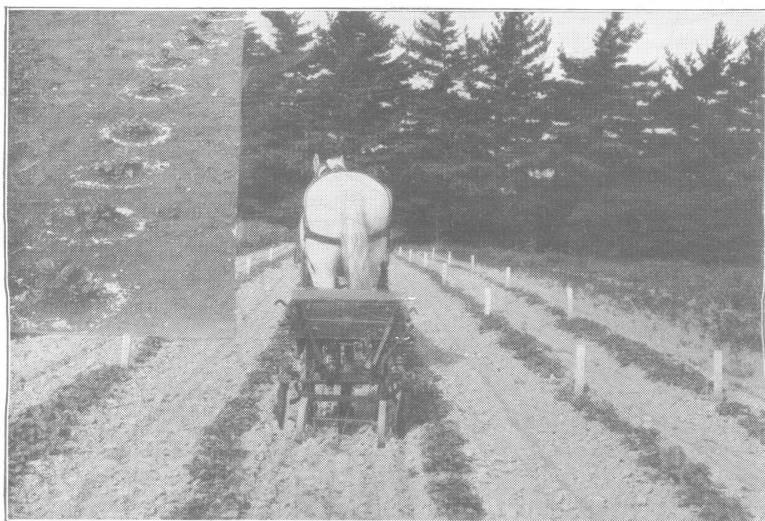


Fig. 4.—Fertilizing strawberries with a drill. Only the outside spouts are open. Inset at upper left shows fertilizer applied by hand around each plant.

FERTILIZERS IN RELATION TO FIRMNESS AND COMPOSITION OF THE BERRIES

It is often stated that certain fertilizers affect the firmness and chemical composition of strawberry fruits. The Maryland Experiment Station (6) found that potassium and phosphate fertilization failed to improve the shipping or keeping qualities of strawberries over a 3-year period. In these Maryland studies, nitrate fertilization had no effect on keeping quality except as it affected the size of the berries and excessive plant growth, which favor field rot development. The total sugars was increased slightly by nitrate, which was applied at the rate of 200 pounds per acre in March of the first fruiting season.

The Ohio Experiment Station (20) found that the berries were slightly softer following spring application of nitrogen but that there were no significant differences in moisture content or shipping quality.

Culpepper et al (3) have concluded that the chemical composition of strawberry fruits is determined throughout the season by the absorption of water and the accumulation of sugar. These two processes are usually affected in their relative activity more by weather conditions than by type and amount of fertilizers.

CONCLUSIONS ON FERTILIZATION

It can be concluded from experiments and observations on strawberry fertilizers that each location presents a different fertilizer problem. A good garden soil that has been kept fertile by the use of manure and cover crops may not require any type of fertilization for strawberries. In some Ohio soils, it may be necessary to add phosphorus and potassium, but these additions are not often profitable. When they seem necessary, they can be broadcast at the rate of about 300 pounds of superphosphate and 100 pounds of muriate of potash per acre just before the plants are set out.

If runner formation is poor and the foliage is light yellow, available nitrogen may be lacking. About 200 pounds of a nitrogen fertilizer, such as ammonium sulfate, should then be applied about a month after planting. An equal amount can also be applied in August. If only one application is made, it should be made in August. The late summer application is sometimes valuable in increasing the size of the crowns and the number of flower buds.

Applications of fertilizers in the spring of the fruiting year are not recommended. When the patch is renewed, the addition of a nitrogen fertilizer, such as sodium nitrate, at the rate of 300 pounds per acre is suggested.

For best growth and production, the organic matter content of the soil should be kept as high as practical by the use of cover crops and manure. Plowing them under several months before planting time is preferable.

MULCHING THE PLANTING

Regardless of the purpose for which strawberries are grown, they should be mulched every winter. This is an important phase of strawberry growing and should be given more attention, especially by the home gardener in Ohio. Since the benefits of mulching are not recognized easily, they are too often not realized.

VALUE OF MULCH

The mulch aids in protecting the plants from direct winter injury to the roots and crowns (fig. 5) and it also prevents heaving of plants. In the early spring, mulch retards plant development and thus often helps prevent injury of flower buds from spring frosts. Other advantages of mulch are the controlling of weeds, keeping berries clean, and conserving moisture.

Much damage has been done to strawberry crowns and roots by low winter temperature before the mulch was applied. The result of this type of injury usually is not noticed until during the ripening season, and even then it is often mistaken for something else, such as the result of dry weather or hot sun. Winter-injured plants are more subject to injury by drouth and by a hot, dry atmosphere.

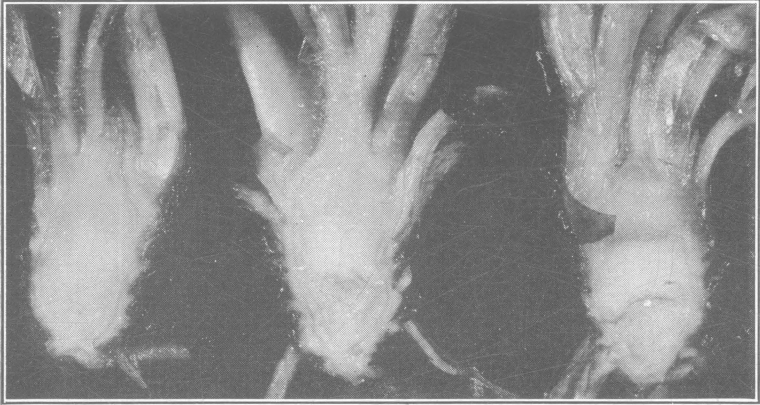


Fig. 5.—Crowns of strawberry plants. The two plants on the right show mild winter injury as evidenced by the dark color in the lower crowns.

MULCHING MATERIALS

Clean wheat straw is probably the best mulching material available to Ohio growers. Baled straw can be used if it is well torn apart and spread evenly over the plants. Any coarse vegetable material that does not pack tightly over the plants and does not contain weed seeds can be used. Such materials as pine needles and sawdust are not desirable, since they pack too tightly and cause the plants to be smothered. Oat, rye, or timothy straw, or



Fig. 6.—Oats planted between the strawberry rows sometimes supply all or a part of mulch material. The oat crop competes with the strawberries for moisture and nutrients, however, and is usually not sufficient for a mulch. It is not often recommended.

even shredded cornstalks can be used if clean wheat straw is not available. Although leaves do not make the best type of mulch, they can be used if they are not allowed to pack over the plants and if they are removed promptly early in the spring. Straw manure is sometimes used, but it too often contains weed seeds. Many weeds in the planting reduce the yield and make renewal for another year more difficult.

Oats are sometimes grown between the strawberry rows to be used as mulch the following winter (fig. 6). This system is not very satisfactory, since the oats compete with the berry plants for water and nutrients in the late summer when the plants require relatively large amounts of these materials. Usually, as shown in the illustration, this procedure results in poor growth of both the oats and strawberries.

Methods of mulching strawberries with various types of paper have been suggested, and several kinds of paper have been tried at Wooster. None of them has been satisfactory. The scarcity of good clean wheat straw in some localities makes a substitute desirable, but as yet a perfectly satisfactory one for Ohio growers is not known.

APPLYING THE MULCH

The mulch should be applied to the strawberry planting before the first hard freeze. In Ohio it seems best to apply it during the last of November or first of December in order to avoid danger of winter injury. Much winter injury to crowns has been the result of applying the mulch too late or applying it in too small amounts. It has been demonstrated, however, that if strawberry plants are covered too early in the fall, they may fail to harden properly and incur severe losses (2). Evidently the plants should be exposed to several early season frosts before being covered. It has been found (1) that cold resistance of strawberry plants is developed in light but not in darkness, that more hardiness is developed in dry than wet soil, and that hardiness is obtained by exposure to approximately freezing temperatures.

Three to four tons per acre of wheat straw or enough to cover the plants about 3 inches deep is recommended. It should be applied uniformly over the patch.

The everbearing varieties should be mulched lightly around the plants in the late summer just before they start fruiting to avoid dirty fruit. This mulching also aids in conservation of moisture and in controlling weeds.

REMOVING THE MULCH

Strawberry mulch should be taken off when the plants begin to grow beneath it and the danger of late frost is past. The mulch usually can be removed about the middle of April at Wooster. If there is danger of injury to flower buds by a frost after the mulch has been taken off, it can quickly be raked back over the rows. It should be removed again as soon as possible, however.

In 1940 at the Experiment Station, part of the mulch was removed from a patch on April 10 and the rest, April 25. This difference of 15 days in time of removing the wheat straw resulted in no significant differences in yield of berries. No frost injury occurred. The berries started ripening at the same time with both treatments, and there was little, if any, difference in length of season. The plants from which the mulch was removed last ripened slightly

more of their fruits during the latter part of the season. In 1940, the season in general was later than usual, and the late season may explain the lack of effect of time of mulch removal.

In 1941, the mulch was removed from a Premier planting at three successive periods: from one plot on April 10, another on April 19, and the last on April 30. The season in general was earlier than that of 1940. The yield of berries was significantly greater from the plants first uncovered, but there was little difference in the total yields from the other two plots (table 4). The most striking results were those showing the effect of time of removing the mulch on the yields at different dates. The time of removing the mulch did not affect the time of the first or last picking dates. The season extended from June 9 to June 26 inclusive on all plots. The treatments did, however, influence the yields at different periods of the season. The height of the picking season was extended by the later removal of the mulch. Only 13.3 per

TABLE 4.—Effects of removing mulch at different dates during spring of 1941. Premier variety

Date mulch was removed	Total yields per acre	Yields per acre after June 20	
		Quarts	Per cent
April 10	6,852	912	13.3
April 19	5,244	1,068	20.4
April 30	5,196	1,440	27.7

cent of the berries ripened after June 20 from the plot uncovered April 10, whereas that uncovered April 19 yielded 20.4 per cent, and that uncovered April 30 yielded 27.7 per cent, of their total crops after that date (table 4). There were no significant differences between the size and quality of the berries.

In Michigan, Eggert (7) found that a difference of 20 days in time of removal of the mulch resulted in a delay of only approximately 3 days in beginning of the picking season; it retarded the dates of largest pickings 7 to 10 days, however. The date of last picking was delayed 4 to 5 days in the variety used, the Dunlap.



Fig. 7.—Strawberry experimental planting at Wooster, 1941. The straw mulch was removed shortly before this photograph was made.

The time of mulch removal influences the ripening season, and the extent of this influence depends on the weather conditions of the particular season. Most of the effect of delayed removal is in delaying the time of largest pickings, and, to a lesser extent, the length of the season.

The mulch should be raked back off the rows into the middles and tramped down. It is not necessary or desirable that all the straw be taken off the plants. Leaving a small amount in the rows near the plants is helpful in conserving moisture and keeping the berries clean. The leaves will readily grow up through a small amount of straw. The mulching material is removed from the field after harvest only if the patch is to be renewed.

IRRIGATION OF THE PLANTING

The most desirable situation would be for every strawberry grower in Ohio to have an irrigation system. Of course, in many cases, an irrigation system is too expensive to be practical. Irrigation has proved extremely profitable for many growers, however, and some have been able to pay for the installation of a system with 1 or 2 years' crops of berries following or during a dry season.

It is sometimes profitable to irrigate the patch during the first growing season. At this time, a good supply of moisture results in increased leaf surface, larger crowns, and more and larger flower buds for the crop the next June.

Just before, and during, the fruiting season, the plants require large amounts of water. During some seasons there is no advantage in irrigation, but often the yields can be increased considerably by even one or two applications of water. Sometimes irrigation means the difference between crop success and failure. A thorough irrigation at the beginning of the picking season will often increase the size and quality of the late-ripening berries.

IRRIGATION SYSTEMS

There are two general or common systems of irrigation for strawberries in Ohio, the overhead and the surface.

THE OVERHEAD SYSTEM

The overhead system (fig. 8) has several merits. It adds a uniform supply of water to the soil; it can be used on ununiform soil or slopes; and it does not pack the soil. The greatest objection to this method is that it is relatively expensive. Furthermore, considerable pressure is required for long lines. Once the overhead system is installed, it is fairly permanent, and its upkeep is relatively small.

The cost of having the overhead system installed is approximately \$300 per acre. This cost can be considerably reduced, however, if secondhand pipes are used and the regular farm labor is employed. There are temporary overhead systems which can be put up and moved over the patch as needed. This type is much less expensive to install.

The overhead system is used extensively where strawberries are grown with vegetables. Here the system is usually permanent, and often especially profitable, since it can be used also for the vegetables that are rotated with the berries.

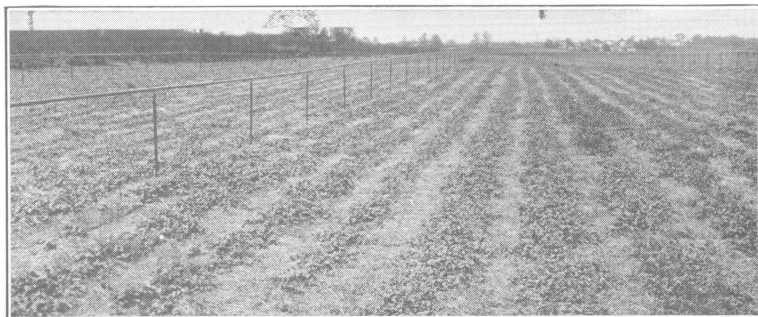


Fig. 8.—An overhead irrigation system is used in this strawberry planting.

The spray or overhead system can be turned on during periods of frost danger to afford some protection. If the temperature drops more than 2 to 3 degrees below the danger point, however, and stays down long, the flower buds will be injured regardless of the sprinkling system. Although some growers have reported striking results, this advantage of the overhead system should be a minor consideration.

The best time of day to run the overhead system is early in the morning. Some growers prefer to turn the irrigation on at night. It is preferable not to sprinkle during the hottest part of the day. The fruit and foliage should not be wet longer than necessary, as water on them encourages rot and diseases.

THE SURFACE SYSTEM

For successful use of a surface method of irrigation of strawberries, the land should slope uniformly, and there should be a relatively large supply of water. The soil should be fairly heavy, and the rows not more than 350 feet in length.

The most simple surface method is to train the water down the middles on alleys between the rows. The water can be supplied by a well, artificial lake, natural lake, or some other similar source.

The porous canvas hose method is used by several good strawberry growers in Ohio (fig. 9). This method is relatively inexpensive to install and operate. Another important advantage is that the fruit and foliage can be kept dry during irrigation. It can be used well only where the slope is fairly uniform and where there is considerable water pressure, especially for rows more than 100 feet long. The hose is placed on the ground along each row, and water is turned into one end under pressure. The water oozes out through the canvas. As soon as the hose is filled with water, the pressure can be regulated so that the soil will absorb the water as rapidly as it seeps out. When one row is well watered, the hose is moved to the next, and so on. Canvas hose can be secured from several commercial concerns, or it can be prepared at home from thick canvas duck. The weight of the material used should depend on the water pressure, the slope, and the type of soil. If the water pressure is low, the soil sandy, and the slope gradual, the canvas should be relatively heavy so that the water will seep out slowly. Couplings and other equipment for this method can usually be purchased from the porous or ooze hose manu-

facturers. The canvas is treated with a preservative to lengthen its life. After each season's use, it should be cleaned well and dried out to lengthen its usefulness.



Fig. 9.—The porous hose system of irrigating strawberries, a satisfactory method where the slope is uniform

FREEZING INJURY TO FLOWER BUDS

The flower buds and flowers of the strawberry are often injured to some extent by late spring freezes in Ohio. Sometimes the amount of injury is serious, especially in low sites or where air drainage is poor. The growth habit of the plants, the stage of development of the flowers, and the resistance of the variety are all concerned in the amount of damage resulting from any particular temperature.

The freeze of May 12, 1938, offered an unusual opportunity to secure information on the amount of damage to a large number of varieties at Wooster. The minimum temperature recorded about 5 feet above the ground was 29° F., but it was probably lower than that immediately around the berry plants. A detailed study was made of the results of this freeze (10). The varieties varied considerably in their resistance. There were many different types of injury (fig. 10). All types were, as a whole, most severe in the earliest flowers of any variety.

As the season advanced following the frost and many berries failed to develop because of the destruction of the ovules or embryos, the resistance of Premier became evident. Apparently, although the receptacle, or fleshy part of the fruit, of this variety is no more resistant to low temperatures than that of many varieties, the embryos of the seeds are more resistant. Furthermore, Premier berries seemed more likely than those of most varieties to develop into marketable fruits in spite of some embryo injury. Although the yield of

Premier at the Experiment Station and in many other parts of the State was reduced considerably by the frost, this variety should still be considered in first place as a commercial berry for most parts of Ohio. Under the conditions of this test, the Wayzata and Gem varieties seemed especially hardy to frost, but they are of the everbearing type, and the commercial value of this type of strawberry in Ohio is limited.

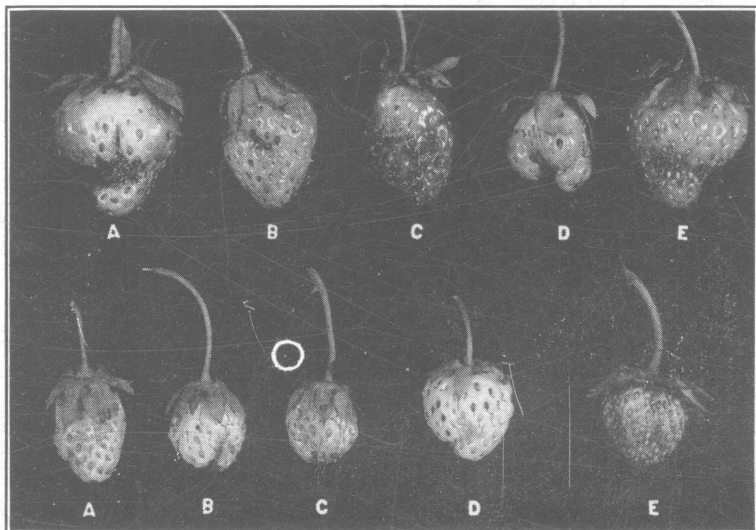


Fig. 10.—Results of frost injury to strawberry flowers, variety Premier

The use of smudge pots for frost protection of strawberries in Ohio has not been worth while. In very few cases is the frost of such nature that the berries can be saved by the heat from the smudge pots. The use of resistant varieties, such as Premier, planting on a high site, and re-covering with the mulching material when there is frost danger are the most practical means of avoiding injury.

HARVESTING AND MARKETING

The strawberry fruiting season begins the middle of May in Lawrence County in Southern Ohio and extends to the first of July in the northern counties. The competition with other fruits is mainly with those shipped from the southern states and with storage apples in Ohio. Cherries start ripening in Ohio during the latter part of the strawberry season; otherwise, there is little competition with other fresh fruits from Ohio.

TIME OF PICKING

The exact stage of ripeness to which the strawberry should be allowed to develop depends somewhat on the market used. If the berries are picked for home use or for local retail trade, they should be picked only after they are completely ripe. The highest quality can be obtained only by this means.

When the berries do not travel so directly from the producer to the consumer, they must be picked slightly before they are thoroughly ripe. At least 75 per cent of the red color should always be present, however, in such a variety as Premier (Howard 17). The exact ripeness must depend largely on the distance the berries go to market and the average length of time they are held before reaching the consumer. A general rule is that berries about one-half red will stand 24-hour shipment, that those with full color but firm can stand 12-hour shipment.

Strawberries should be picked only when they are cool. Many good growers have their berries picked only during the morning hours. During the middle of the season, however, the pickers must usually work the entire day. Sometimes the plants need picking over every day, but more often every other day is sufficient. They should not be picked during, or just after, a rain, as wet berries rot easily. Varieties differ in the frequency that they should be picked; some require picking every day.

METHOD OF PICKING

Strawberries bruise and crush easily, and it is especially necessary that they be handled carefully. Pickers should be warned to pick rather than to pull or snap off the fruit. The best method is to pinch the stem in two with the thumb and forefinger so that the berry comes off with both the calyx (or hull) and a short piece of the stem. Some pickers hold too many berries in their hands before placing them in the baskets. Bruised berries turn dark and decay rapidly. Overripe, injured, or otherwise unmarketable berries should always be picked from the plants as soon as found in order to facilitate locating the good berries in later pickings. Some growers have their pickers use two containers, one for the firm berries, the other for the thoroughly ripe but usable berries.

HANDLING THE PICKERS

An important item in growing strawberries is the availability and cost of labor for picking the crop. Women who have done much outdoor work make good berry pickers. Boys and girls over 12 years of age can be used if they are closely supervised (fig. 11). It requires 6 to 8 pickers per acre, depending on their experience and the yield of the crop. The grower should hire enough to get over the patch at least every other day. Some prefer to hire more than needed to pick the berries and then use them partly for other work when weather is not favorable for strawberry picking.

Dependable supervision of the pickers is important. The pickers must have in mind from the beginning the stage of ripeness desired, the importance of clean berries, the way to pick, how to sort the berries as they are picked, and how to avoid crushing the plants and the berries.

Most growers pay the pickers by the quart, from 2 to 4 cents, depending on the price received for the berries, local labor rates, and yield of the crop. In general, about one-fifth of the price received for the berries can be paid for picking. Often growers pay more to the pickers who remain throughout the season. A bonus of about one-half cent per quart may be paid at the end of the season to those who remain all season. Some prefer to pay the pickers by the hour, and there are some advantages in each method.

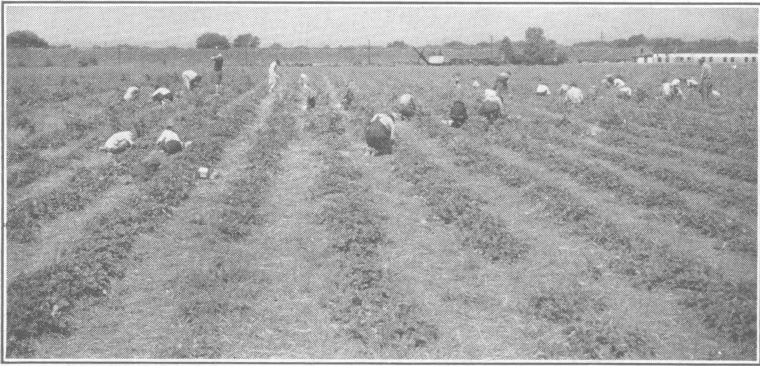


Fig. 11.—Many pickers and close supervision are both necessary when the berries are ripe.

The pickers usually take their carriers or trays to the shelter shed and there get credit for the amount picked. A good systematic method of keeping account of amount picked and payment is necessary for a large planting. The punch-card system is one of the best. Some growers prefer to pay cash; others use a check; others, a record book. All systems have certain advantages and disadvantages. There is an advantage in keeping records in such a way that the work of each picker can be checked.

PROTECTING THE FRUIT

Strawberries must never be left in the sun after they are picked. They should be placed in some cool place at once. It is especially necessary that berries picked late in the morning or in the afternoon be moved to a cool place immediately. A cold storage or even a cool cellar may aid much in removing some of the heat from the fruits. The length of time that the fruit will remain firm after it has been picked depends on (a) the variety, (b) stage of ripeness, (c) temperature of berries, and (d) the care with which the fruit is handled.

Experiments (5) have shown that for each rise in temperature of 15° F., the life of the berry is decreased one-half; that is, if the strawberry will keep for 8 days at a temperature of 40° F., it will keep for only 4 days at 55° F., only 2 days at 70°, and 1 day at 85° F. If the berries are picked in the early morning when they are relatively cool and put in the shade at once, they will keep much better. They will also have a more attractive appearance on the market than if picked at midday, when the fruits are at a higher temperature.

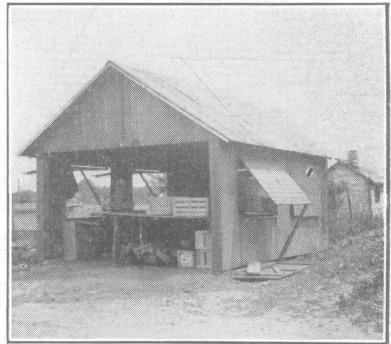


Fig. 12.—An inexpensive sorting and packing shed in a strawberry patch

Note arrangement for thorough ventilation.

A conveniently located shelter shed is a valuable asset in a commercial strawberry patch (fig. 12). It need not be expensive or large, but it should be built so that it can be used for the protection of the berries, especially from the sun and rain, as soon as they are picked. Some growers use it as a grading house also. Where there is a refrigerated storage on the farm, it may well be used to remove the field heat from the berries before they are placed on the market.

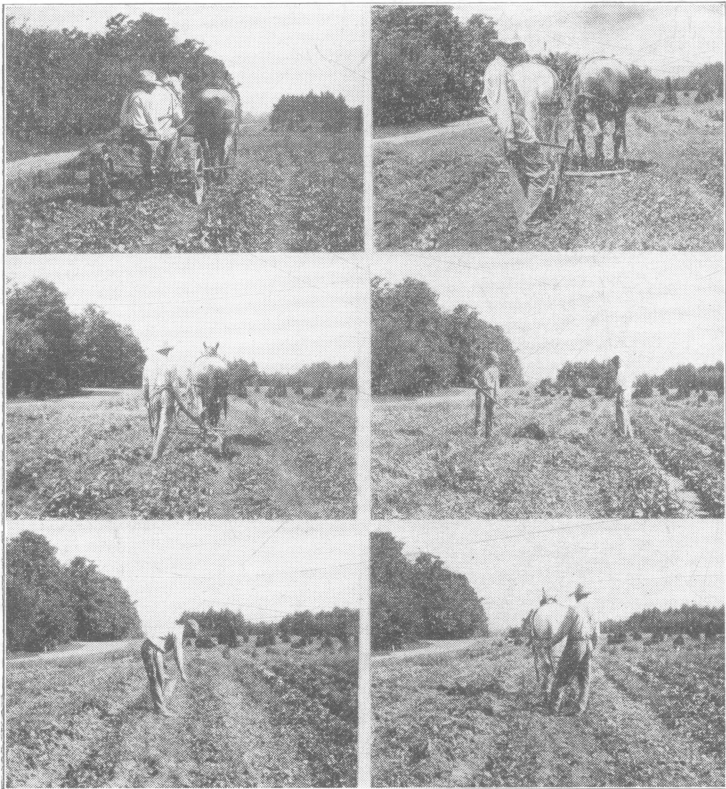


Fig. 13.—Steps in renewing the strawberry bed

Left to right from top: mowing, narrowing rows with plow, narrowing rows with grape hoe, shaping out and removing surplus plants, fertilizing, cultivating

GRADING AND PACKING THE FRUIT

It is often profitable to grade strawberries by some method before they are placed on the market. Grading can be done in the field by placing the berries in different baskets on the basis of size and color, or the berries can be "pan" graded after they reach the packing shed. In Ohio, very little grading is done except in a rather rough way as the berries are picked. The practice of field-sorting or grading has the advantage of little handling of the berries,

but it does require close supervision or experienced and dependable pickers. Sometimes strawberry boxes are faced so that none of the stems of the top layer are showing. This top layer should, however, not be different in size and color from the layers below.

The 24-quart slat crate is the one most used in Ohio. The 16-quart and the 32-quart crates are sometimes used, however. There are some new types of corrugated crates being used by some growers now, and they are well worthy of trial. Some growers have built up reputations for their fruit by stamping their names and sometimes the name of the variety on each package.

In any type of packing, it is important that the berries at the top of the container be representative of all the rest. It is never wise to attempt deception in packing. It should be remembered that some settling of the fruits occurs in hauling, and that the baskets should be well filled in the field or packing shed. Some settling can be avoided by arranging the berries in the baskets before they leave the packing shed.

MARKETING IN OHIO

By far the greater part of the Ohio strawberry crop is marketed relatively near where it is grown. These local markets are at the patch itself, the roadside market, through retail stores, through hucksters, or in other such ways. There are usually not enough berries grown in Ohio to meet the demand completely, and there are often some shipped from neighboring states.

Local demand can often be extended through such means as advertisements in local papers, letters or cards to prospective buyers, displays, sample berries, and roadside signs. Stamping the container with the grower's name and address is also helpful.

RENEWING THE PLANTING

By renewal of the strawberry planting is meant the preparation of the patch for the highest possible yield the next year after it has fruited at least once. A patch should never be allowed to fruit year after year without a careful renewal process after each picking season (fig. 13). The main purpose of renewal is to clean out the old and most unproductive plants and to encourage development of the younger plants and formation of early runner plants.

Whether or not to renew a strawberry bed depends on the variety grown and the condition of the patch as to insects and diseases. A variety that produces many and vigorous plants is worthy of renewal more often than a weak grower. If the soil lacks fertility, if there are many weeds, or if there are many insects, such as the crown borer or leaf roller, probably the patch should not be renewed at all.

Many of the best commercial berry growers in Ohio fruit their patch only once and then plow it up. They must then set out a new planting every year, but they feel that this practice pays, for they have found that the yield and size of berries are best the first year. The yield for the second fruiting year must be expected to be about 75 per cent of what a patch fruiting for the first time would produce under similar conditions. The fruit is usually smaller, and the insects and diseases are usually worse the second season. On the other hand, renewal makes it possible to reduce the production cost of the crop.

Some plantings can be renewed profitably, but the tendency among the best growers is to fruit the patch only once, especially where space is not a prime consideration. Rarely should more than two crops be produced by any one planting.

There is a temptation, especially among small growers, to fruit the strawberry patch just as long as it produces berries. They often fail to realize that after the first year, with occasional exceptions due to weather conditions, the number of small berries and the insect and disease problems increase each season.

TIME TO RENEW

Renewal should be started as soon as the last picking is made, during the first part of July at Wooster. It is necessary to renew the patch as early as possible in order to encourage the setting of early runners, which are the most productive.

METHOD OF RENEWAL

There are several methods for renewing the patch, but the one suggested here seems preferable in general. Modifications in detail are often necessary to suit the individual situation.

CLEANING UP THE PATCH

Mowing the foliage.—As soon as the harvest season is over, the old leaves and weeds can be cut off with a scythe or a mowing machine with the cutter bar set high. Mowing does not seem to affect the plants materially and is helpful in the destruction of insects and diseases. Mowing is not necessary, however, in many plantings, and if the plants are vigorous and healthy, it is even doubtful whether mowing should be done.

Removing the mulch and leaves.—If the mulch between strawberry rows is heavy, it should be taken from the field. After the foliage is mowed, the leaves must also be removed. After the leaves are dry, they can be raked up with the straw and taken from the patch. Sometimes the dead leaves are raked into the middles with the straw, and the patch is burned over. Burning should be done only when the ground is wet and on a windy day so that the crowns are not injured. The mulch and leaves should be dry so that they will burn rapidly. In general, the removal of the leaves and straw is preferable to burning over the patch, and burning should never be done unless conditions are perfect for it, for otherwise the plants will be damaged. Burning over the planting aids in destroying some insects and diseases, but the patch should probably not be renewed if it is necessary to give it such a drastic treatment as burning.

THINNING OUT THE PLANTS

Narrowing the rows.—The principal object in narrowing the rows or thinning the plants is to leave only the most vigorous of the new plants to produce runners during the summer and fruit the following spring. In a small planting, a hoe can be used to cut out all old or weak plants and leave the most desirable ones about 14 inches apart.

In a large planting, some such implement as a plow or grape hoe can be used to narrow the rows. There are two general methods suggested. One side of each row can be systematically plowed up to leave a narrow row along the same side of each row 8 to 10 inches wide. If this method is used, the

younger plants remain, since they are most likely to be along the edge of the row. Another method of leaving only the younger plants is to plow up or in some way destroy the plants in the center of the row and leave both edges of the matted row.

A horse-drawn grape hoe can be used to narrow the berry rows. A little more than half of each row, and always the same side of each row, is cut off. This hoe cuts into the soil to a depth of 1 to 2 inches and deposits the plants in the middles in such a way that they can be raked up more easily than with the plow method. The soil is then in good condition for cultivation.

A common method is to turn under one side of each row with a plow and then use a cultivator or a harrow to tear out the partly covered plants. It is important that the old mother plants be removed, and to do this, it is necessary to cut off a little more than half of each row.

A special shovel-shaped plow is necessary to work up the centers of each matted row and leave the two edges. This method is not so satisfactory as removing the edges because of the difficulty in cultivating and caring for the remaining plants. From the standpoint of leaving as many as possible of the most desirable plants, it has some merit if it is done so that only a narrow strip is removed in the center and the other plants are not covered in the process.

Thinning out the plants in the row.—It is usually necessary to use a hand hoe to thin the plants after the rows have been narrowed. Only the best plants should be left, and they should be evenly spaced. It is preferable to leave the plants slightly closer together than the mother plants were set. The hand hoe is necessary to shape up the rows so that they are straight and even in width, and so that the weak plants are removed from along the edge and in the row.

CULTIVATING AND FERTILIZING THE PATCH

As soon as the plants have been thinned sufficiently, the middles should be leveled and thoroughly cultivated. Several additional cultivations will be needed during the season. Thinning the runner plants with the hoe or by some other method as described for the first-year planting is recommended.

The patch should be fertilized as soon as it is renewed. The kind and amount of fertilizer to use depend on the condition of the planting, the variety, and the soil. Ammonium sulfate at the rate of 250 pounds per acre has usually given the best results. If the soil has been given an application of a complete fertilizer within the last 2 years, it is not often necessary to add phosphorus and potassium at this time. If none has been added recently, it is sometimes worth while to apply 250 pounds of superphosphate and 100 pounds of muriate of potash per acre in addition to the nitrogen. Some prefer a complete commercial fertilizer mixture and have found by trial the amount that gives the best results for their particular soil.

The fertilizer can be drilled in along the edges of the new row, or it can be applied by hand. If the ammonium sulfate or sodium nitrate is left on the foliage, it will likely cause burning, but it can be brushed off easily with a broom or burlap sack. It is preferable to apply the superphosphate and potash before the final cultivation in the renewal process unless they are applied with a drill.

COMPANION CROPS AND INTERCROPPING

Home gardeners who must secure the greatest return for their space often grow vegetables with strawberries. These companion crops can be used successfully only during the first summer after the berries are set out. Almost any vegetable desired can be used, but some compete less with the berries than others. A vegetable crop which requires a large amount of cultivation is most desirable, since the cultivation is needed for berries. Onions or radishes can be grown early in the season in the row with the strawberries. Other crops, such as peas, carrots, beets, spinach, and lettuce, can be grown in the middles between the rows. The plan is that these early vegetables will be used before the strawberries require the space for production of runners and new plants. Longer-season vegetable crops, such as beans, potatoes, and cabbage, are not so desirable with strawberries. They can be used, however, if the berry rows are 4 to 6 feet apart and there is only one row of vegetables between each strawberry row. Such crops as tomatoes and sweet corn should not be used.



Fig. 14.—Use of strawberries as an intercrop in an orchard

Sometimes strawberries are planted in young orchards (fig. 14). The principal advantage is that there can be an income from the land before the trees come into bearing. There are some disadvantages, too. The land cannot be cultivated until the berries are harvested. It is necessary to cultivate the strawberries, whereas it is often desirable to grow a cover crop or a sod in the orchard. Also, the berries require later cultivation and fertilization than is best for the fruit trees. When strawberries are used as an intercrop, only a row or two should be planted in the middles between the tree rows, and they should be allowed to remain in the orchard only 2, or at most 3, years.

GROWING FALL, OR EVERBEARING, STRAWBERRIES IN OHIO

Some special directions are necessary for the production of fall-bearing strawberry varieties. These varieties bear a fall crop the year they are set; then they bear again during the following June with the standard varieties, and then through the following summer, with a peak in September.

Fall, or everbearing, varieties are not recommended for commercial planting in Ohio except under special conditions. For a home garden, however, they are of much more value, since the production of berries out of season is often an advantage, or at least a satisfaction. The low yield and long ripening season, together with the special care required, result in few commercial plantings.

One of the principal advantages of the everbearing type is that a crop is produced the same season that the plants are set out. In order for the crop to be profitable, however, there are several requirements. The soil should be especially fertile and well supplied with organic matter. Irrigation is more necessary than with the ordinary June-bearing varieties. There must be such a demand for the crop that a substantial premium will be paid for the fall berries and make their growing successful commercially.

The everbearing plants should be set out at the same time as the other varieties. They are cultivated and otherwise treated as the June bearers during the first growing season, except that the flowers are allowed to set after the first of July. In sharp contrast to the June bearers, the everbearers form flower buds during the long days of summer. Even if there is a severe frost which kills all the flowers early in the spring, the everbearers will form others and bear a summer and fall crop. A light mulch of straw around the plants is desirable just before the fruiting season in order to protect the fruit. Everbearing varieties require mulching again in the late fall for winter protection. The treatment over winter and during the second year is similar to that for other varieties. They can be renewed for bearing the following fall, but further renewal is not recommended. It is especially necessary that the fall-bearing varieties be well fertilized and have a continuous water supply in order to produce well. Many growers have been disappointed in the low yields from them.

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