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Strawberry Growing In Michigan

Michigan State University Extension Service

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STRAWBERRY GROWING IN MICHIGAN

By

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MICHIGAN STATE COLLEGE

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Strawberry Growing in Michigan

I. Strawberry Culture

By R. E. LOREE¹

The strawberry is the most important of the small fruits grown in Michigan. It is grown to some extent, either commercially or in home gardens in every county of the state.

Because of its northern location and nearness to consumer markets, Michigan offers excellent opportunities for commercial strawberry production. The increasing demand for the fruit by local processors for canning and freezing purposes is also an important outlet for the crop. In the northern part of the state where the berries normally begin to ripen after the peak of the southern shipping season, the production of strawberries for late shipping has been found profitable.

YIELDS AND PROFITS

Profits from strawberry growing are proportional to total yield and the quality of fruit produced. These in turn are largely determined by intensity of culture. The average commercial production in Michigan seldom exceeds 2,000 quarts per acre which is far below the yields obtained by better growers in the state. Yields of 3,000 to 4,000 quarts of marketable fruit per acre usually are considered satisfactory, although when plants are grown on good soil and given good care yields as high as 6,000 to 8,000 quarts per acre are not uncommon. Under very intensive methods of culture average yields as high as 14,000 quarts per acre have been produced in the state.

The following cultural directions are intended to help the grower increase the yield and quality and hence the value of his strawberry crop.

SITE AND SOIL

The site for strawberry growing should be fairly level so that the soil will not wash, but there should be enough slope to insure ample air and water drainage. A gentle slope with a fall of two or three feet

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Fig. 1. A field of Dunlap strawberries near Fremont, Mich. Note the gently sloping site which insures good air and water drainage.

in one hundred is usually sufficient for this purpose. Steep slopes should be avoided as they are likely to wash badly and cultivation is more difficult. A site somewhat elevated above the surrounding country, is desirable. Plants on a site with even a slight elevation will often escape injury from frost because of the better air drainage thus provided. Since cold air drains into the lower places, low flat lands are usually more frosty than the higher lands. Despite this fact, however, many strawberries are grown on bottom lands. These lands are usually rich and moist and, where the damage from frost is not severe, may be desirable, especially for growing the everbearing and late spring-bearing varieties. Where early ripening is desired a southern slope should be selected, if available. A site with a southern exposure is warmer and drier, and the season of ripening is often several days earlier than on northern exposures or on bottom lands. For late varieties, northern exposures or well drained bottom lands are preferable since they are cooler, more moist, and, hence, more productive. In sections bordering on Lake Michigan, an exposure toward the moist moderating winds from the lake is always desirable.

Good crops of strawberries may be grown upon almost any type of soil, provided it is retentive of moisture, fairly fertile, and well drained. The ideal soil varies somewhat with the variety and the locality but deep sandy loams with a retentive but not impervious subsoil are generally preferred. These soils do not bake, are easily

handled, and the water supply is most easily controlled. They also allow the development of a greater depth and spread of the root system which is an important factor, especially in time of drouth. Light sandy soils are more likely to be deficient in humus and fertility and, therefore, require heavier applications of manure or the use of green manure crops to restore these deficiencies. A clay soil, especially one that tends to pack and crack, requires more judicious handling in preparing, planting, and caring for the crop. On muck lands, the plants make a rank growth and the fruit is likely to be soft and inferior. Furthermore, these lands are usually low, and there is greater danger of damage from untimely frosts than on the higher lands.

SOIL FERTILITY AND ITS MAINTENANCE

In considering the nutrient supply of the strawberry there are three important requisites: a) good soil texture, b) an abundance of moisture, and c) a readily available supply of mineral nutrients, or plant food.

Good soil texture is of greater importance than the nutrient content. Without it, the desirable chemical and bacterial activities of the soil on the mineral and organic constituents, the movement of water, and the growth of roots as well as the absorption of nutrients are all retarded. It is essential that the plants receive a plentiful supply of moisture at all times during the growing season, but more especially during the few weeks between the time of blooming and the ripening of the fruit. The soil should have a large moisture capacity, and its texture should be such that water will move through it readily in times when an abundance is needed. The presence of humus, or decaying organic matter in the soil, improves its texture, increases its moisture-holding capacity, and provides conditions whereby the movement of water is facilitated and the plant nutrients made more readily available. Soils which lack humus should be built up by the use of farm manures or green manure crops before strawberries are planted on them.

Farm manures are the best general purpose fertilizers for strawberries. They contain large amounts of humus-forming materials, which improve the texture of the soil, and add considerable quantities of those chemical elements readily convertible to an available form. On sands, they increase the water-holding capacity of the soil, and, on clay soils, they tend to prevent the packing and cracking which is

so injurious to the plants. They are also rich in nitrogen which is one of the most essential elements in strawberry production. Unless well decomposed, the manure should not be applied the same season in which the plants are set. Coarse, strawy manure or that which contains many weed seeds should be applied to a cultivated crop preceding the strawberries, or it may be applied in the fall, plowed under, and well worked into the soil so that it will become broken up and partly decomposed before planting time. Well rotted manure may be applied in the spring when the ground is being prepared for planting. It should be spread broadcast over the field after plowing and well incorporated with the soil by harrowing. From 10 to 20 tons per acre is considered sufficient on average soils.

Poultry manure may be used but, because it is richer in quickly available nitrogen, only one-third to one-half as much should be applied per acre. When used as a top-dressing on growing plants, one part of the droppings should be mixed with two or three parts of dry soil or dust to insure an even distribution and to prevent burning the foliage.

Green manure crops are valuable as a means of supplying humus and at least some of the nitrogen that is required. They are economical soil builders where farm manures are not available. The green manure crops that should be used will depend upon the rotation, soil, and time of seeding. Leguminous crops such as clover, vetch, beans, and peas should be used whenever possible as they add some nitrogen as well as humus to the soil. Clover is one of the best crops to use in a rotation with the strawberry. The roots of the clover plant penetrate deeply, and, as a result, the soil is aerated and loosened to a considerable depth. Alfalfa is also a good crop to precede strawberries but it is often difficult to kill out the alfalfa roots after the strawberry plants are set. Sudan grass is also an excellent crop to use in a soil-building program.

Crop Rotations

Where a definite rotation is followed, the land should be kept in clover for one or two years and then plowed in the fall or early spring and planted to some crop which is highly fertilized and one that requires intensive cultivation to subdue grass and weeds.

If the crop preceding the strawberries is harvested by the middle of August, it may be followed by a cover crop of oats or rye. The latter may be turned under in the fall or very early in the spring in time for

planting strawberries. If corn should precede the strawberries, the cover crop may be seeded between the rows at the time of the last cultivation. Old strawberry beds should be plowed under as soon after harvesting as the condition of the soil will permit, and the land seeded again to clover, which may remain until the end of the following season. If the time available for growing a green manure crop will not permit or for other reasons clover cannot be grown, such crops as oats, rye, vetch, and buckwheat may be used. Rye and vetch are particularly useful when grown preceding strawberries on light sandy soils. They may be grown singly or as a combination crop, using about one bushel of rye and 20 pounds of vetch seed per acre. They may be sown as late as September 1, because though the plants do not make much fall growth, they live over winter and grow rapidly the following spring. In order to obtain the largest amount of organic matter, the crop should not be turned under until the vetch is in full bloom, or later. Considerably more organic matter will be added to the soil if the crop is turned under after it has reached a rather advanced stage of maturity.

Soybeans and cowpeas are also valuable soil-improving crops, and, in localities where they make a good growth, may be useful. They should be drilled in during June or early in July at the rate of 5 pecks per acre.

Commercial Fertilizers

When farm manures are not available the humus of the soil should be maintained by the use of green manure crops and, if necessary the essential plant nutrients may be supplied by the use of commercial fertilizers.

So much depends on the soil type, its physical condition, and previous treatment that no definite advice can be given which will enable the grower to determine when or where fertilizers are certain to prove profitable or the kind and amount that should be applied. *In general, deficiencies in the supply of available nitrogen and phosphorous are more frequently limiting factors than of any other element in Michigan strawberry plantations. Sometimes on light soils, however, potash may be deficient.*

If the supply of nitrogen is limited, the plants grow slowly and the leaves are smaller and of a lighter green color than when plenty of nitrogen is available. In cases of extreme nitrogen starvation, the

foliage may take on a reddish or purplish tinge. This, however, should not be confused with the red coloration often caused by drouth or the leaf spot diseases. Usually any check in growth or any red or purplish coloration other than that which is obviously caused by drouth or disease is an indication of a need for soil nitrogen, and, whenever this condition occurs in the plantation, the use of readily available nitrogen fertilizers may be expected to give beneficial results. If, however, the soil is supporting a vigorous growth of plants and the foliage has a dark green color, it is doubtful if such applications will be beneficial and they might be injurious. An excess of nitrogen particularly near or during the fruiting period may induce an over-vigorous vegetative growth, an uneven ripening of the fruit, and the maturing of soft, poorly flavored berries.

When to Apply Fertilizer

The greatest benefit will be derived from the use of fertilizers when applied during the year that the plants are grown. Many growers prefer to apply most of the fertilizer for crops preceding the strawberries in order that the soil may be brought to a high state of fertility before the plants are set. When superphosphate or the more slowly available forms of nitrogen such as dried blood are used, they should be drilled or broadcast after plowing and should be thoroughly incorporated with the soil before the plants are set.

Quick-acting nitrogen fertilizers such as ammonium nitrate may also be applied at this time, or as a side-dressing along the rows about two weeks after the plants have been set. In some cases, an application of ammonium nitrate made in the summer or fall will be more beneficial than an application in the spring, at planting time. *Fruit bud formation in the June-bearing varieties takes place during August and fall. It depends largely upon the nutrient supply, particularly the supply of available nitrogen, during that period.*

Hence, the plantation should be well cultivated and the plants given good care during this period, and, if there are indications of a need for soil nitrogen, a light or moderate application of readily available nitrogenous fertilizer will be useful. On light sandy soils or those that lack humus, a spring application of nitrogen and one or more applications during the summer and fall will be necessary to provide conditions favorable for fruit bud formation and to obtain the growth of crowns of sufficient size for maximum fruit production.

Sometimes the readily available forms of nitrogen are applied in the spring of the fruiting year. Though some increases in yield have been obtained by this practice, the gain in yield will not be sufficient in many cases to pay for the outlay. Total yield of fruit depends more upon the conditions under which the plants were grown during the preceding summer and fall than upon the soil fertility conditions in the spring or during the fruiting period. Furthermore, the use of readily available nitrogen in the spring tends to make the berries too soft for market purposes. Plants which have been grown under unfavorable conditions the previous fall or those of varieties which naturally make a weak growth are most likely to respond best to this treatment. On light, sandy soils excessive irrigation in the spring of the fruiting year can result in the loss of much available nitrogen by leaching. Under such conditions additional applications of fertilizer may be needed to maintain the size of the berries.

General Fertilizer Recommendations

The following practices are recommended as a basis for the use of commercial fertilizers in Michigan strawberry plantations:

1. Apply superphosphate (0-20-20), 500 to 1000 pounds an acre, in the spring when preparing the soil for planting. If heavy applications of fertilizers have been made on crops preceding the strawberries, this application may be omitted—or the amount used considerably reduced.

2. Apply a starter solution around the roots of the plants at the time of planting. (See page 14.)

3. Apply ammonium nitrate, 150 pounds per acre, as a side-dressing about two weeks after the plants have been set; apply again, 150 pounds per acre, about August 1.

4. If a complete fertilizer is preferred, use a 4-16-4, a 3-12-12, or some other mixture high in phosphorus, at the rate of 500 to 1000 pounds per acre. In southwestern Michigan an 8-8-8 has been widely and successfully used. The fertilizer should be thoroughly incorporated with the soil previous to setting the plants. It may be supplemented by an application of ammonium nitrate, or one of the complete fertilizers, about August 1.

These recommendations should be modified according to the needs of the soil. It is suggested that the grower test the different fertilizers in varying amounts to determine more definitely the needs of his par-

ticular soil. On light sandy soils, the full amount of superphosphate may be needed, but on better soils the amount may be considerably reduced and in many cases none will be needed. Though the importance of nitrogen has been emphasized, the use of commercial nitrogen may not be beneficial on soils that have been well fertilized with farm manures or where the humus has been obtained from leguminous crops. On very light soils which are likely to be deficient in nitrogen, light applications of ammonium nitrate at intervals of 3 or 4 weeks may be necessary to provide a continuous supply of nitrogen throughout the season.

Old beds should be fertilized at the time of renewing after harvest, using one of the mixed fertilizers at the rates recommended in this section.

Lime and Soil Acidity

Use of lime is seldom advisable in preparing land for strawberries unless it is needed to promote the growth of some other crop in the rotation. The plants are highly acid-tolerant and may even prefer an acid soil. Extremely acid soils will undoubtedly be benefited by moderate applications of lime, but as a rule the agricultural soils of the state are rarely so high in acidity that the growth of strawberry plants is inhibited. *Lime, if used, should be applied sparingly, sometime previous to planting, preferably on some crop preceding the strawberries.*

PLANTS AND PLANTING

Soil Preparation

The land should be thoroughly prepared for planting strawberries. Lands that have been well prepared for other cultivated crops may be fitted for immediate use, but, if the land has lain idle for several years or is in sod, it should be devoted to cultivated crops for one or two seasons to rid the soil of white grubs and to eradicate grass and weeds. In the final preparation for planting, the land should be plowed deeply and harrowed several times until thoroughly pulverized and in a fine mellow condition. A well firmed seedbed previous to planting is most important.

Time of Planting

Early spring is the ideal time for setting the plants. They should be set as soon as the soil can be prepared properly in the spring—late March or early April, if possible. Summer or fall planting is not advisable.

The Plants

Certified plants should be obtained from reliable nurserymen, or taken from young plantings known to be disease and insect-free. Commercial growers will often find it cheaper and more satisfactory to propagate their own plants, rather than purchasing all of them from nurseries.

When a considerable number are needed, it is best to set aside one particular bed—or one or more rows of good plants—for propagation purposes. Do this instead of digging the plants here and there from the fruiting rows. By so doing, any damage to the fruiting rows which can result from a disturbing of the roots is avoided. Moreover, digging the entire propagation row affords an opportunity to cull the plants, saving only the best for setting.

When selecting plants, give preference to those with medium-sized crowns and large, light-colored, healthy roots. The old mother plants with blackened roots should not be set, nor any other plants which may have dark, discolored roots. It is particularly important that the plants be healthy and vigorous; for this reason, they should be taken from new plantations which have not yet fruited. Plants from old beds weakened by fruit-bearing, or crowding, or disease, lack vigor—and therefore are not desirable for planting purposes.

Systems of Training

Strawberries are grown according to the hill, the hedgerow and the matted-row systems of training. The matted-row system is most widely used. In this, the rows are spaced from 3 to 4 feet apart and the plants set at intervals of 18 to 30 inches in the row depending on the tendency of the variety to produce runners. The common practice is to space the rows 4 feet with the plants at intervals of 2 feet in the row, the runners being allowed to form a solid mat of plants 20 to 24 inches in width.

The hill and the hedgerow systems are suitable for the home garden and for growers who practice very intensive culture for special or

fancy market berries. In the hill system, the plants are set 12 to 15 inches apart and no runners allowed to develop. The rows are from 2 to 3 feet apart, depending on the method of cultivation employed. The usual planting distance is 15 by 30 inches. In the single hedgerow system, the rows are 3 feet apart. The plants are set 2 feet apart in the rows, and each plant is allowed to produce two runners. These are set in the row, one on each side of the original plant and allowed to root about 8 inches from it. After the row is formed, all other runners are removed. This results in a single row of strong plants, evenly spaced about 8 inches apart. Sometimes four additional runners are set from each mother plant to form a new row on each side of the original row. This is known as the triple hedge or more commonly as the double hedgerow system. In this system, the rows should be spaced $3\frac{1}{2}$ feet apart.

Plants in hills or hedgerows produce larger and better berries, and harvesting and weeding are easier under these systems. These advantages are considerably counterbalanced by the great labor necessary for removing surplus runners and for proper spacing of the plants. Furthermore, the larger number of plants required is an important item in the hill system. At the distances recommended, about 14,000 plants are required for setting an acre in hills and from 6,000 to 7,000 plants for the matted-row and the hedgerow systems. The number of plants required per acre for any planting distance may easily be obtained by multiplying the distance between plants by the distance between rows and dividing this sum into the number of square feet in an acre (43,560). When purchasing plants, it is advisable to order a few more than are needed for planting the field to allow for any which may be culled out and for replacing those that do not make a good start.

Care of Plants

Plants obtained from a nursery should be unpacked as soon as received and either planted at once or heeled in until they are needed. For this purpose, a moist, well-drained spot somewhat protected from the sun and wind should be selected, the bundles opened, and the plants well spread out in a shallow trench with the crowns even with the level of the ground. The trench is then filled in carefully to avoid covering the crowns, and the soil is well firmed so that it will come in close contact with all of the roots. If the roots are warm and dry when received, they should be dipped in water and the plants then kept in

a cool place for a few hours before being heeled in. In case the plants are very dry, it may be necessary to keep them well watered and heeled in for several days before they are set in the field. When properly heeled in, the plants may be kept in good condition for two or three weeks or longer if necessary while the field is being fitted for planting. Usually, however, the sooner they are transplanted permanently in the field the better the results will be.

Plant Storage

Better results will be obtained by setting strictly dormant plants, rather than those which have started growth. To insure dormant plants for setting, obtain them very early before growth starts, and hold them in cold storage until planting time.

The storage temperature should be kept at about freezing, or slightly below (26° to 34° F.). If the temperature is much above freezing, trouble is likely to occur from the growth of crowns, molds, storage rots, or drying. The relative humidity should be high (85 to 90 percent). Standard cold storage conditions for apples are usually satisfactory for strawberry plants as well.

Place the plants in storage immediately on arrival, and keep the roots and packing material moist—but not wet—during the storage period. The more dormant the plants, the better they will keep in storage.

Transplanting

Strawberries are not difficult to transplant successfully. The soil should be moist but not wet, and a cool cloudy day or a period just before a rain is an ideal time to set as the roots are very susceptible to injury from heat and dryness. The plants should never be exposed to the sun or wind longer than is necessary. They may be carried to the rows in shallow boxes, trays, or pails and covered with wet burlap or damp packing material until immediately before setting. Previous to planting, any blossom buds or old runner cords and all but two or three inside leaves should be removed and the roots shortened if necessary for convenience in handling.

When setting the plants it is important that the roots be well spread and the soil pressed firmly against them. There is little danger of making the soil too firm unless it is wet. Loose setting is a frequent cause of failure. A little loose soil should finally be left over the surface as

a mulch. After the soil has settled, the crowns of the plants should be even with the surface. If a plant is set too deeply, especially on heavy soils, the crown becomes covered and rots. If not set deep enough, the roots become exposed and dry out.

The use of transplanting or starter solutions is now recommended for strawberries. These are mixtures of soluble fertilizers added to water, applied around the roots while setting the plants in the field. The mixture may be dissolved in the water used in the transplanting machines; or in small plantings the solution can be applied by hand after the plants are set.

A 10-54-17 mixture is quite commonly used for the purpose. Four pounds should be dissolved in 50 gallons of water, and applied at the rate of 100 gallons of solution per acre. Several other mixtures which may be used are sold in Michigan under their trade names. They should be used according to the manufacturer's directions.

CARE DURING FIRST SEASON

Cultivation and Runner Control

Frequent shallow cultivation and hand hoeings to maintain a fine surface mulch are important. Cultivation should be started immediately after transplanting and repeated at intervals of 10 days to 2 weeks or after every rain until freezing weather occurs in the fall. The field should be absolutely free from weeds at that time. Late cultivation is necessary to destroy small weeds, which otherwise will continue to grow in the fall and start quickly in the spring. Frequent hand hoeings to loosen the soil immediately about and between the plants, to remove weeds, and to space the young plants in the rows, should supplement the cultivations. A common cause of small berries with the matted-row system is the practice of allowing the plants to mat too closely in the rows. They should be spaced at least 4 to 6 inches apart. If this thinning is done while the runners are forming, it will save much labor later on in removing rooted plants.

The first cultivation should be rather deep to loosen the soil that has been packed in setting. In the matted-row and hedgerow systems, the cultivator may be run in both directions and close to the original plants until the runners start. After this, the space cultivated is gradually narrowed to allow the runners to root. The ground should be kept mellow to encourage rooting and every subsequent cultivation should be in the same direction in each row as the previous one. The

matted-row may then be controlled by the width of the strip cultivated. A better spacing of the plants will be obtained if the row is allowed to spread rapidly instead of throwing the runners back towards the center of the row. When the rows become too wide the surplus runners may be cut off with the hoe or by means of rolling cutters attached to each side of the cultivator. In the hill system of culture, the runners should be removed whenever they appear. A sharp hoe may be used for this purpose or if the work is done before the cords become tough they are easily pinched or pulled. They are most conveniently removed with a circular cutter about 8 or 10 inches in diameter which is dropped over the plant and cuts the runners on all sides of the plant at once.

Rototillers and the rotary hoe are used by some growers as supplementary tools for cultivation. The rototiller is a very good implement for cutting off runners, and controlling the width of the row during the growing season. The rotary hoe is sometimes used in new planting to kill germinating weed seeds. Growers report best results when the rotary hoe is pulled at a speed of 12 to 14 miles per hour across the field. Each cultivation should be in the same direction as the preceding one.

Geese will forage on grasses in strawberry plantings to provide an economical means of weed control. They are most effective in controlling grasses in renewed plantations. In fruiting plantations, geese can be left in the field until the earliest berries turn white, without danger of damaging the crop.

The following points should be considered before geese are employed. The field will need a fence around it; some shade should be provided; and water and some additional feed—such as shelled corn or stale bread—will be needed. Goslings the size of pigeons and larger will forage well, if properly fed and watered. About 6 to 8 geese to an acre of strawberries are sufficient.

CHEMICAL WEED CONTROL

Chemical weed killers now can be used to eliminate many weeds in strawberry plantings, but always keep in mind that they must be applied correctly for the best results. If properly used, these chemicals will reduce the cost of hand labor by 65 to 80 percent, but will not eliminate all cultivations. Two important rules to follow in the use

of weed sprays are: First, use them as recommended; second, use when the weeds are small, or germinating.

The following methods and procedures for chemical weed control are suggested:

2,4-D. The amine salt of 2,4-D should be applied at not more than 1 pint to an acre (1 pint of a 40-percent commercial product). For small scale spraying this will amount to 2 teaspoons per gallon. The first year, 2,4-D can be used 3 weeks after the plants are set. The second year, early in the spring before flowering, and again after harvesting. The third year, early in the spring before flowering and after harvesting.

Simple tractor-mounted sprayers operated from the power take-off are very efficient in strawberry spraying. The volume of spray solution applied may vary from 10 to 25 gallons. Trial runs should be made with water alone before actual spraying, so that not more than 1 pint of 2,4-D is applied to 1 acre of strawberries. For small-area spraying, a knapsack or hand sprayer is satisfactory.

EH 1. This is a new chemical which has proved very satisfactory in 3-year tests. EH 1 kills only the germinating weed seeds and seedlings. It should be applied to the soil one week after setting the plants, and again after cultivating. The material can be sprayed directly over the plants at the rate per acre of 3 pounds in 50 gallons of water. Since EH 1 is new, only limited quantities will be available at first. Growers should spray only a part of their acreage until more is known about this material, and more is available.

IPC. Common chickweed, which often infests strawberry plantings, is controlled with 7 pounds of IPC per acre. When applied as a row spray, 7 pounds of IPC in 50 to 75 gallons of water will cover 2 acres of strawberries. The spray should be applied in the fall, any time from September 1 to December 15.

CAUTION: In using chemicals, avoid skin contact and the inhaling of chemical fumes or dusts. Always wear gloves. When dusts are used, always wear a mask over the nose and mouth. Confine sprays to the area required, by spraying on a calm day, since grapes and certain vegetables are very sensitive. Clean the equipment well after each usage. *Do not use the same sprayer for insect and disease control.*

Removal of Flower Stems

Soon after the plants are set in the field, flower stems are usually produced. These should be removed as they appear, preferably before the blossoms open. The production of flowers and fruit at this stage of development will decrease the vigor of the plants and the production of runners. With fall-bearing varieties, the blossoms are removed until about July 1st after which time the plants are allowed to fruit.

MULCHING

Strawberry plants should be mulched before hard freezing weather in the fall; not later than November 15. The functions of the mulch are to protect the plants from winter-injury, which results from the alternate freezing and thawing of the soil, and to conserve moisture, smother weeds, and keep the berries clean during the fruiting season. It also retards the time of blossoming and the period of ripening of the fruits and may be used to protect the plants from frost during the blossoming season.

Any coarse vegetable material that does not pack so tightly over the plants as to smother them and that does not contain many weed seeds may be used. Marsh hay makes an ideal mulching material. A covering of wheat, oat, or rye straw is most commonly used and is usually satisfactory if the straw is free from grain and weed seeds. Most kinds of straw contain some grain which is likely to grow and become troublesome in the spring. For this reason, old straw is preferable. If new straw is used, it should be well shaken out before applying as a mulch.

When applying the mulch, it should be well shaken out and spread uniformly over the field. However, if there is a scarcity of material the tops of the rows should be mulched rather than the spaces. The thickness of the mulch will depend upon the type of soil and the system of training employed. On sandy soils, a lighter mulch is necessary than on clay soils. Likewise, plants grown in matted-rows require less protection than those in hills or hedgerows. Usually a mulch 2 inches in thickness will afford ample protection. This will require about 2 tons of straw or marsh hay per acre.

When to Remove the Mulch

The mulch should be opened over the plants as soon as growth commences in the spring to allow them to grow through and prevent

smothering. If the mulch is loose and not more than an inch or so in thickness it may not need to be disturbed, but if it is several inches in thickness it should be parted or opened over the plants, and any surplus material removed and pushed into the alleys between the rows. This mulch should be left on the patch until the end of the harvesting season.

When removing the mulch from over the plants, leave as much as possible around the base of the plants to keep the berries clean and conserve moisture. Opening of the mulch should be delayed as long as possible in the spring to help retard blossoming, and thus prevent possible damage from late frost, and to smother weeds. However, severe damage may result if the mulch is left too long. The plants should be examined frequently, especially if the weather is warm, and as soon as growth commences or the leaves show evidence of bleaching the mulch should be opened to admit air and sunlight regardless of the season.

Growing a Mulch Crop

Where a crop is grown especially for mulching, millet and sudan grass have been found very satisfactory. On moist soil, they produce a large amount of dry material suitable for mulching. For this purpose, the crop should be cut when the seed heads begin to form and before any seeds have matured. In some fields, a mulch crop of oats is grown between the rows during the late fall. The oats are sown about September 1 at the rate of 2 or more bushels per acre. Under favorable conditions they make enough growth before they are killed by frost to afford considerable protection for the plants.

Usually, however, it is best to supplement this mulch with a light covering of straw over the rows. The chief objection to growing a mulch crop in this manner is that it absorbs large amounts of moisture and nutrients at a time when they are likely to be most needed by the strawberries. For this reason, it is recommended as a special practice only for localities where mulching materials are expensive and difficult to obtain—and then only under conditions where the plants have made a strong vigorous growth earlier in the season.

Spring Tillage

When no winter mulch is used, spring tillage of moderate depth should be practiced. Deep cultivation at this time, especially near the

plants, may cause serious injury through the cutting of many surface roots. Whatever practice is followed during the spring of the fruiting year, a large percentage of first-class berries will be produced only in fields which are kept free from weeds and grass and in which the humus in the soil and the mulch are sufficient to maintain an adequate supply of moisture during the production and the ripening of the berries.

IRRIGATION

Almost every year, yield and quality of the strawberry crop are diminished to a greater or less extent by periods of drouth previous to or during the fruiting season. One or more irrigations will prevent much of this loss. Many commercial growers would no longer consider growing strawberries without supplemental irrigation. Irrigation will also help in the establishment and the growth of the young plants and the development of runners during the growing season. Some growers have also found a sprinkling outfit useful for warding off light frosts during the blossoming season.

The sprinkler system is most commonly used. This system has the advantage that it can be used on either level or sloping land, and as the water is delivered in the form of a fine spray or mist it does not pack or puddle the soil. A cheap and abundant supply of water is necessary, and the plants must be grown under intensive cultivation if irrigation is to be profitable. Profits will vary from season to season according to the weather. In some seasons, little or no benefit will be derived from irrigation, while the yields obtained in other seasons may be several times greater than those obtained on a similar soil without irrigation.

When the cost of installing a permanent system is prohibitive, a portable system consisting of one or more nozzle lines which may be carried from one part of the field to another may be used, or if the area is not large a small automatic sprinkling outfit can be used.

Some of the basic principles governing the use of irrigation on strawberries are as follows:

1. Irrigation should be started *before* the plants show evidence of suffering from drouth. The use of the Bouyoucos moisture blocks is the best means of determining the proper time to start irrigation.
2. Strawberry plants should receive about an acre-inch of water each week during critical growing and harvesting periods. If rainfall

does not equal 1 inch, the difference should be made up with supplemental irrigation.

3. The plants should receive at least 1 inch of water, but not more than 1½ inches, at any one setting.

4. Most sandy soils can absorb an inch of water in about an hour-and-a-quarter without excessive run-off.

5. The rate of application on heavy soils should be reduced to a point where there is not excessive run-off. Some heavy soils may require 2 hours to absorb an inch of water.

6. The soil texture and organic content will vary from field to field, and even within a single field. Every grower needs to work out an irrigation method which will fit his soil, and the crop he is growing.

Recent studies in a number of Michigan strawberry fields show that the use of a sprinkler system is one of the best means of preventing frost damage to the blossoms. Following are suggestions on how and when to irrigate for frost control:

1. Use small-capacity sprinklers, but cover all areas of the field.
2. Start irrigating when the temperature gets down to 34° F.
3. Continue to apply water until the temperature has risen above 32° F. It is not necessary to apply water until the ice coating is all melted.
4. Water from either a well or a lake may be used. Temperature of the water has little or no effect on frost prevention.

HARVESTING

The fields should be picked over at least every other day and, if the weather is hot and the berries are ripening rapidly, it may be necessary to pick daily. Unless this is done and the rows are picked clean, each subsequent picking will contain many over-ripe berries. A few soft over-ripe berries will ruin the appearance of a box, and one poor box may spoil the appearance of an entire crate. The berries will ship and keep better if picked during the early part of the day while they are still firm and cool but for shipping it is better not to pick them when wet.

Method of Picking

For the fresh fruit market, the fruit should be picked—not pulled or stripped from the plants. This means that the berries should be

grasped by the stem, which is pinched off about half-an-inch from the berry. They should be carefully placed in the box, rather than dropped or thrown. Care should be taken that pickers do not crush or bruise the fruit by holding too many berries in the hand at one time. Damaged berries, and berries without hulls, do not carry well to the market. Neither should be allowed in the boxes.

For commercial processing, "field de-capping" has become an accepted commercial practice (removing the berries from the plant without the hulls attached). This method of harvesting allows the processor to handle many more berries than when they are delivered to him with hulls attached. From 50 to 100 percent more pickers will be required to harvest the crop when field de-capping is practiced. Also, pickers are usually paid 2 or 3 cents more per quart when it is practiced.

Care After Picking

The boxes are carried by the pickers in light trays or carriers, which should be built so that the boxes fit snugly. Those holding four to eight boxes are most satisfactory. Larger carriers are inconvenient to handle, and unless provided with legs they cannot be placed on the ground without crushing unpicked berries. After the berries have been picked, they should be placed at once in a cool, shaded place. They should never be exposed to the sun longer than necessary. Temporary packing sheds are frequently built near the field to which the fruit is immediately carried by the pickers as each carrier is filled. After the crates are packed, they should be placed in as cool a storage as is available. The quicker the berries are cooled the better they will ship. Berries should not be held in rooms where temperature is lower than 40° to 50° F.

Packages

Michigan strawberries are usually marketed in crates containing 16 quart boxes. In some local markets, 24-quart crates and occasionally 32-quart crates are used. The 16-quart Hallock is the standard package used in the southwestern part of the state, while the American ventilated crates and boxes are more commonly used in other sections. Pint boxes are most suitable for long-distance shipping or for very early or fancy berries when prices are high. The 12-quart flat is becoming a popular package for marketing strawberries, and is desirable for handling processing berries.

RENEWING THE PLANTATION

Life of Plantation

The length of time that a plantation can profitably be maintained depends largely upon the prevalence of weeds, insect pests, diseases, and the comparative cost of renewing an old plantation and establishing a new one. It also depends to some extent on the variety, the system of training, and the preparation of the soil previous to planting. Plants grown in hills and hedgerows are usually kept longer than those in matted rows. The common practice is to renew the old patch and keep it over until a second crop is harvested. When the stand of plants the first season is poor or when the plantation has been well maintained, the second crop may even exceed the first.

If the land has been thoroughly prepared by the use of farm manures or green manure crops, the plantation may be maintained for four or five years or even longer, depending on the care. Only those plantations which have been given good care can be profitably renewed. If the patch has become weedy and grassy, it may cost more to renew it than to set a new one, and, unless the old plants are exceptionally vigorous, the younger plantation will yield a larger and better crop.

Method of Renewal

In renewing a plantation, the first operation is usually to mow over the patch with a scythe or mowing machine. This should be done as soon as possible after the crop is harvested. When a mowing machine is used the cutter bar should be set rather high to cut all weeds and most of the strawberry foliage without injuring the crowns. If the mulch is heavy and a rototiller is not available, enough of the mulch may be raked off to permit the renewal of the patch with other implements. The field should not be renewed during a period of drouth, unless irrigation is available.

When the plants are grown in matted rows, it is necessary to reduce the number of old plants to make room for the development and rooting of new runner plants. This is accomplished by narrowing the rows with a plow or cultivator, leaving only a very narrow continuous strip of the youngest and most vigorous plants along the corresponding edge of each row. The plants that remain along this strip are then thinned by removing the old ones and thinning the others to about 6 or 8 inches apart. After the soil has been worked down by cultivation,

the treatment during the rest of the season is the same as with a new plantation.

When using a rototiller to renew the patch by straddling the rows, some growers make a practice of removing the center teeth and plowing guards to protect the row.

VARIETIES

The variety selected should be adapted to the purpose for which the fruit is to be grown—whether for sale on distant or nearby fresh fruit markets, for canning or freezing, or for home use. Varieties for the commercial grower should be highly productive, and the fruit fairly large, well formed, firm and attractively colored. Firmness of berry is very important for long-distance shipping, but for local or nearby markets some of the high quality varieties which may be too soft for shipping may be selected. For the home garden, yield and firmness are not so important as high quality and suitability for freezing, preserving and table use.

As a general rule, it is best to plant those varieties most largely grown in the locality because they are probably best adapted to the climatic, soil, and market conditions of that particular section. It is also well to limit the number of varieties grown to as few as will meet the market requirements. Often only one variety is grown, and as a rule, not more than three varieties are desirable. Growers dealing with a local market and home gardeners desiring to extend their season from extra early to very late may require a larger number of varieties.

Standard June-bearing Varieties

Premier—This has stood for many years at the head of the list of commercial varieties for Michigan. It succeeds well in most parts of the state and, in addition to its earliness, productiveness, and long fruiting season, it has unusual frost resistance which makes it extremely valuable for the North. Plants are healthy, very productive, and sufficiently vigorous to produce a good fruiting row. Berries are medium to large in size, conical or wedge-shaped, with a bright red flesh which is moderately firm and of good quality. Fruit ripens over a long period and the size of the berries usually holds up well until the end of the harvesting season. It is a very dependable variety and is highly recommended either for the home garden or commercial planting.

Robinson—Begins to ripen a few days later than Premier. Berries very large, bright red, attractive; flesh firm, white at center. Plants very vigorous and productive. Somewhat susceptible to leaf blight and stem-end rot. While one of the best for the fresh fruit market, it is not a first class berry for freezing.

Dunlap—An old early to mid-season variety which is still extensively grown in the state. The berries are medium to large in size, conical and often slightly necked, dark crimson with a deep red flesh. Quality very good. Plants usually very hardy and vigorous, producing many runners. Very productive. The berries are slightly soft for shipping and for this reason should be grown chiefly for home use and for nearby markets. One of the best for canning and preserving. Thrives under neglect better than most varieties, but unless given good culture, many berries are small by the end of the harvesting season.

Catskill—Berries very large, medium firm and good in quality. Color bright red which does not darken as the berries become ripe; very attractive. Ripens in mid-season. Plants large, making plenty of runners for a good fruiting bed. Very hardy and productive. Not so high in quality as Dorsett and Fairfax but more productive. Recommended for home use and local markets. A good variety to plant with Premier.

Fairland—About the same season as Premier. Very resistant to red stele root-rot. Can be grown in place of other varieties susceptible to that disease, or on soils seriously infected with red stele. Susceptible to stem-end rot, however. **Sparkle** and **Temple** have shown resistance to red stele, but do not possess as good commercial qualities as Fairland. Sparkle is an excellent variety for freezing.

It is impossible to determine small amounts of infection in the new red-stele tolerant varieties—such as Temple, Fairland and Sparkle.

As a result, if these so-called “resistant” varieties carrying hidden infection are planted on clean soil, wholesale infection of that soil may result. The present red-stele resistant varieties are not superior to our old standard varieties.

Growers having disease-free soil should use the well established standard varieties. It is suggested that Temple, Fairland, and Sparkle be used only on soil already contaminated with the red stele fungus.

Dorsett and Fairfax—Both are high quality varieties desirable for the home garden. Generally, they are not recommended for planting in Michigan.

Everbearing or Fall-bearing Strawberries

Everbearing strawberries differ from the standard or June-bearing varieties in their bearing fruit more or less continuously throughout the summer and fall instead of maturing the entire crop within a period of three or four weeks. They are especially desirable for the home garden and under favorable conditions may be profitably grown as a commercial crop. However, the everbearers are not recommended for general commercial planting in the state. More care and better culture are required, and the costs of growing and harvesting, quart for quart, are considerably greater than for the ordinary varieties. They require a more fertile soil and more moisture and, unless they are grown on rich moist bottom lands, it is usually necessary to supply water by means of some system of irrigation to sustain the growth and fruiting of the plants during a dry summer and fall.

The chief advantage of the everbearers is that a crop of fruit is obtained from the plants during the same season they are set whereas the ordinary varieties do not bear until the following spring. The fact that the fruit is produced during the summer and fall enables one to extend the season so that strawberries may be had from early June until freezing weather in the fall. They are also valuable for planting where there is likely to be serious injury from late spring frosts for when the first blossoms are killed another crop is soon produced.

In commercial plantations, the everbearers are commonly grown as an annual crop. Under favorable conditions, some varieties bear a good crop in the fall of the first year and a medium-sized crop the following spring, but the berries are usually smaller and the yields lighter than those produced by the June-bearing varieties. Good fall crops are sometimes obtained in the fall of the second year, provided the plants are not allowed to bear too heavily in the spring.

Of the varieties which are now offered by nurserymen, the **Gem**, **Mastodon**, and **Superfection** are recommended for Michigan.

Gem—Plants of this variety are rather small but are very hardy, vigorous and productive, producing many runner plants. The berries are somewhat flat but regular in shape, light red in color, and rather tart in flavor. Usually sell well. Grow well either in hills or in matted

rows. Many late berries are produced on the young runner plants. A good commercial everbearer.

Mastodon—Plants large, vigorous and usually very productive. Does not produce runners so freely as does the Gem. Berries large, often somewhat irregular in shape, light red in color, moderately firm and good in quality. Does best when grown in hills. Also does well in matted rows when conditions are favorable for runner production.

Superfection—Similar to Gem, but better, a more vigorous grower and generally more productive. The berries are large and roundish in shape. Flesh is dark red in color and very good in quality. This is one of the best everbearers.

II. Strawberry Insects

By RAY HUTSON²

Numerous insects may be found on the strawberry. Aside from white grubs, leaf rollers, and weevils, however, it is seldom that any of them warrant spraying or other special measures for their control.

Where leaf rollers are prevalent, regular spraying may be necessary. But in most plantations the use of preventive measures—such as mowing and burning after harvesting, clean tillage, the removal of weeds and rubbish from the borders of the plantation; together with the use of healthy planting stock, short rotations, and proper management methods—is more effective than spraying for control of strawberry pests.

WHITE GRUBS

These are the most troublesome and destructive insects attacking the strawberry. They feed on the large roots and in the crowns, causing the plants to wilt and die. The grubs are the larvae of the common May-beetles or June-bugs and they live and feed in the ground two or more years. They are most abundant in land that has been in sod for several years. Hence, such lands should be devoted to some other cultivated crop for several seasons before planting strawberries. When young plants are infested, there is no remedy except to dig out and destroy the grubs and then replant.

Ten pounds of lead arsenate mixed into each thousand square feet of soil will protect strawberries against white grubs. To insure even distribution, the arsenical is commonly mixed with sand and scattered over the surface, then worked into the soil and the plants set. This will pay in small patches but is not practicable commercially.

For small patches, a strip or band of soil about one foot wide is usually treated and the strawberry plants set in this strip. One pound of lead arsenate by this method will treat 100 feet of row.

STRAWBERRY LEAF ROLLER

This is a small greyish or greenish caterpillar with a brown head. It draws the leaflet together with a silken thread and feeds on the

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leaflet from within, causing it to turn brown and die. The adult is a small moth that lays its eggs on the undersurface of the leaves in early spring. Spraying in early spring, using 2 pounds of arsenate of lead to 50 gallons of water, will prove effective if applied just before the young larvae begin to fold the leaves. Spraying after the leaves are folded will do little or no good. Mowing and burning the leaves after the crop is harvested will destroy the larvae and pupae in the folded leaves. Old beds that are to be abandoned should be plowed under immediately after picking the last crop. Spraying newly set plants with cryolite or fluosilicate, 4 pounds plus 2 quarts of summer oil emulsion, is an excellent method of avoiding a building-up of leaf roller. Cryolite and fluosilicates do not mix with bordeaux. Parathion, used according to directions given below for spittle bug, is also an effective means of controlling this insect.

STRAWBERRY WEEVIL

Though this insect has never been a serious pest in Michigan, in some localities it is becoming abundant. The insect is a small, black or reddish brown snout-beetle, which appears just as the strawberry buds begin to open. The injury is caused mainly by the adult females which puncture the unopened buds and then almost sever the stalk some distance below the injured bud. This causes the bud to wilt, dry up, and fall to the ground. Dusting the vines with 3 or 5 percent DDT just as the beetles begin to damage the buds has been found to be one of the most effective means of control. Rotenone dusts when available are effective against this insect. Clean cultivation and the planting of imperfect or pistillate varieties for the main crop will also aid in their control.

SPITTLE BUG

Spittle bug infestation is readily apparent from the foamy spittle-like wet masses on the plants. Lindane, $\frac{1}{4}$ pound (4 ounces) per 100 gallons, applied at the rate of 200 gallons an acre has given excellent control. However, applications after strawberries are $\frac{3}{8}$ inch in diameter may result in a bad residual odor and taste.

Parathion, 1 pound of the 15 percent mixture in 100 gallons of spray, or as a 1-percent dust, can be used against the spittle bug if applied 21 days before harvest.

ROOT APHIDS

To control root aphids, many growers dip the strawberry plants in a nicotine sulfate solution before setting. Use 1 pint of nicotine sulfate to 50 gallons of water containing a spreader, such as one of the commonly used household detergents ("soapless soaps"). Two ounces of the detergent to each 50 gallons will give the proper amount of spreader.

III. Strawberry Diseases

By DONALD CATION³

LEAF SPOT

Three different fungi cause leaf spots on strawberry leaves. When present and severe, lesions may also occur on the leaf stalks and fruit stems, sometimes girdling them and causing the death of the flowers and young fruit. The spots caused by the leaf spot fungus, *Mycosphaerella fragariae*, are characterized by their white center and purplish border. The spots caused by the leaf scorch fungus, *Diplocarpon earliana*, are dark purplish spots about $\frac{1}{4}$ inch in diameter without white centers. The leaf blight fungus, *Dendrophoma obscurans*, results in the formation of spots or areas which are much larger, of light brown to red color and often triangular, being limited to the leaf tissue between two veins. It also attacks the stem end of fruits.

These diseases reduce the vigor of the plants and in very severe attacks seriously reduce the yield. In past years spray controls were not considered necessary except in case of severe infection. However, *Dendrophoma obscurans* has recently caused severe damage to fruit stems, calyx lobes and stem ends of fruits. In fruiting plantations, spray with 8-12-100 bordeaux⁴ before blossoming and repeat 10 days or 2 weeks later. Young plantations, or those which are not producing fruit, should be sprayed whenever necessary to keep the disease under control. Mowing and burning the old leaves after harvesting and the removal of diseased leaves before the plants are set are also methods of control. The frequent renewal of plantations as generally practiced in Michigan and the fact that the prevalent varieties are somewhat resistant keep these diseases at a minimum.

NON-INFECTIOUS VARIEGATION

This disease, also known as June Yellows or Blakemore Yellows, is not infectious but is evidently an hereditary character present in

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⁴To make small amounts of bordeaux 8-12-100, dissolve $2\frac{1}{2}$ ounces of copper sulfate in one gallon of water; dissolve 4 ounces of spray lime (hydrated lime, chemical grade) in another gallon of water. Pour these two solutions together into a third container and mix thoroughly. The mixture is now ready to use as a spray. The material should be stirred or shaken occasionally while spraying. Always use freshly mixed spray for best results.

certain varieties such as Blakemore and Premier which have a tendency to "sport". The leaves become variously mottled and streaked with yellow and green; some of the leaves become entirely golden yellow. Affected plants do not recover, are less productive, and may die although they frequently live several years. Growers using Blakemore and Premier varieties are advised to plant the so-called green strains which do not show the yellowing tendency.

SPRING DWARF

Spring dwarf is a strawberry disease caused by a species of nematodes or eelworms of microscopic size which live between the tightly folded leaves. The symptoms are apparent in the early spring by the absence of blossom buds and the characteristic, small, narrow, twisted and glossy leaves developing from the infested buds. Infested plants bear little if any fruit. The plants appear to recover vitality during the summer and develop into good plants with normal appearing runners. The runners, however, are also infested with nematodes and will show symptoms the following year.

Spring dwarf is thought to be relatively rare in Michigan, having been found in but one nursery field set with imported plants. The disease is controlled by setting clean, uninfested plants and not resetting infested fields for several years. An inspection made soon after strawberry plants start growth in the spring is necessary before certifying for freedom from spring dwarf.

ROOT DISEASES

Black Root

Black root or root rot is common in Michigan strawberry fields. Plants affected with the disease are low in vitality, usually more or less stunted and have a tendency to wilt and dry up in hot sunny weather. The symptoms are most pronounced in periods of dry weather and particularly during the picking season. On hot days, the plants may wilt and then recover during the night; but, if the dry weather continues, the plants die with the berries hanging green and shriveled on the stems.

Black root may be caused by several different soil-inhabiting fungi which invade the root tissues. Winter injury, drouth, fertilizer injury, or other conditions which will predispose the roots to the attacks of



(Photograph—Bureau of Plant Industry, U. S. Dept. of Agriculture)

Fig. 2. Healthy and diseased strawberry plants. Left, healthy plant. Right, plant showing effects of the red stele disease. Note the absence of small feeding roots as compared with the normal root system.

fungi are frequently contributing factors. Rotation with some of the grain or forage crops, the use of healthy plants with clean white roots for starting new plantations, sufficient mulching material to protect the plants from winter injury, and adequate soil drainage are some of the measures suggested for control.

Black root or ordinary root rot should not be confused with the red stele disease. In black root the outer portion of the root turns black with the inner core or stele remaining white.

RED STELE ROOT ROT

From the standpoint of losses incurred and difficulties in control, red stele root rot is the most serious strawberry disease in Michigan. The disease is relatively new to strawberry production. It was first noticed in Scotland in 1920 and is now widely established in northern and eastern United States. The disease is caused by a fungus, *Phytophthora fragariae*, which grows most favorably under cool, wet conditions of late fall and early spring. It spreads from root to root, plant to plant, and over the entire field in drainage and flood waters by means of swimming spores. For that reason, the disease is most prevalent in the lower portions of the field or in soil pockets that hold water for considerable periods.

Effect of the disease is most evident in the spring just before fruiting time when the roots of infested plants are so completely rotted that there is not enough root tissue to absorb the moisture demanded by the leaves and fruit. The result of the disease is noticeable in the late spring by the death of the outer and older leaves, the reduced yield of small-sized berries, and frequently the death of many of the plants. Because the fungus does not thrive under warm soil temperatures, the plants send out a new clean root system and show considerable recovery during the summer only to be attacked with more serious losses late in the following fall and the next spring.

The fungus also forms thick-walled resting spores which remain dormant during the summer and serve to carry the fungus over in the soil for a long period of years. Soils are known to carry the disease organisms for 8 to 10 years even when crops other than strawberries are grown. The fungus is not known, however, to attack other crops.

Strawberry plants affected by red stele disease show a reduced growth and set fewer runners. The older and outer leaves turn brown and dry up, actually making the plant appear to grow smaller as the spring season progresses. The center or younger leaves are smaller,



Fig. 3. Strawberry roots showing symptoms of the red stele disease. A. Diseased roots showing dead, discolored root tips. B. Diseased roots split lengthwise to show the reddened core extending into the white portion of the root; confirmatory symptoms. C. Normal roots split lengthwise, to show the absence of the red center.

with shorter stems which makes the plant appear "to hug" the ground. Frequently the center leaves show a deeper blue metallic color.

The disease is readily differentiated from all other strawberry troubles if one digs the entire plant and examines the roots. The roots show many different degrees of rotting, but the first stage frequently concerns the loss of the many small, fibrous, secondary feeding roots with the half dozen or more primary roots left bare and white like a group of so many "rat tails". Some or all of these primary roots may show progressive rot beginning at the tips. If these larger roots are split open lengthwise with a knife or the thumbnail some of them will show a red core or center extending for some distance into the otherwise white root. When the core or center, (also known as the stele) of the root is brownish or red in color, the trouble can be definitely considered as red stele. This symptom is known for no other disease.

Such practices as rotation, spraying, soil disinfection, and dipping plants in disinfecting solutions are of no practical value in controlling red stele disease. The only control methods known at present are to set disease-free plants on clean soil and use resistant varieties.

Our well established standard varieties are all susceptible to the disease. However, Sparkle, Temple, and Fairland are more recent red-stele resistant introductions. Of these, Fairland seems to possess good commercial qualities. (See page 24.)

A word of caution: It is impossible to determine small amounts of infection in the newer red-stele tolerant varieties such as Temple, Fairland and Sparkle. If these so-called "resistant" varieties carrying hidden infection are planted on clean soil, wholesale infection of that soil may result. The present red-stele resistant varieties are not superior to our old standard varieties.

Growers having disease-free soil should use the well established standard varieties. It is suggested that Temple, Fairland, and Sparkle be used only on soil already contaminated with the red stele fungus.

Therefore, growers who have disease-free plantings should not obtain new varieties, nor replenish their strains from outside sources, unless absolutely certain through authorized inspection that the new source of plants is free of red stele root rot.

Growers who have red stele in their plantings should find a new disease-free source of plants, and set on fields new to strawberry production. Those fields should not receive surface drainage from acreage previously planted to strawberries suspected of having the red stele disease. Use of completely disease-free plants in new plantings is

essential, because the fungus can spread from a few infected plants to ruin an entire field.

ROOT KNOT

The root knot nematode infests the roots, causing enlargements or small galls or swellings, especially on the tips of smaller roots. This eelworm which is more common in the South attacks a wide variety of plants, with the general exception of grains and grasses. It is frequently introduced into fields on tomato plants or other bed-propagated plants imported for resetting. Nursery plantings showing the presence of nematodes are condemned for sale. The infestation in a field may be reduced to a negligible amount by a rotation with grain or grass crops.

FRUIT ROTS

There are a number of different types of fruit rot caused by soil-inhabiting fungi, and known from their typical symptoms on the fruit such as gray mold, tan rot, hard rot and leather rot. Mulching with straw, which prevents the direct contact of berries and soil is a preventative in many instances. Gray mold and other field rots may continue to develop while the berries are being taken to market. Rotted berries should be culled. The common black mold, *Rhizopus nigricans*, also, attacks strawberries, causing collapse of the berry with loss of juice, or "leak". The spores of black mold are common in the air. They enter the berries only through wounds, and the fungus grows very slowly below a temperature of 50° F. Careful handling to prevent wounds, picking in the morning while the berries are cool and holding the berries at low temperatures are measures which prevent destructive losses in transit.

Stem-end Rot

Dendrophoma obscurans previously considered of minor importance as a leaf blight fungus has recently caused severe yield reductions as a stem-end rot. It also kills pedicels and calyx lobes before the fruit is fully developed. The full import of the disease is not well established. Spray controls are in the process of investigation. Protection by bordeaux sprays, just before blooming and two weeks later are suggested.