Commercial Strawberry Culture in Michigan
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COMMERCIAL STRAWBERRY CULTURE in michigan

COOPERATIVE EXTENSION SERVICE
MICHIGAN STATE UNIVERSITY

The strawberry is one of the most important berry crops grown in Michigan. In 1976, Michigan's 3000 acres of strawberries were worth nearly $6 million. About 62% of the crop was sold to the fresh market. Michigan's climate and soil are generally ideal for producing high-quality strawberries. They can be grown in nearly all parts of the state with Berrien and Van Buren the major commercial production counties. Strawberries are also an important crop in Alpena, Manistee, Houghton and Leelanau counties.

The strawberry is one of the first fresh fruits on the market in spring. It is in great demand locally, for distant markets, for processing, and pick your own customers.

Strawberries can be grown with other crops to reduce the risks involved with one-crop fruit enterprises. Harvest and peak labor requirements occur early in the season before other fruit harvests. Strawberries are harvested about one year after planting. The first crop is usually larger than later crops. However, a planting can be successfully managed for two or three harvest seasons when weeds, insects, and diseases are controlled.

Strawberry plants are very responsive to length of day and temperature. During long days (late spring and summer in Michigan) plants initiate runners and form new plants. When days become shorter (fall season) plants begin to form flowers for next spring's crop. Warm temperatures (above 70° F.) favor runner production, while cooler temperatures cause floral development.

Successful strawberry production depends upon the performance of many timely cultural practices: careful harvest and handling, and prompt marketing. These practices are discussed here.

Table 1 (back cover) gives strawberry production and utilization information for the Michigan strawberry crop for the 1972 through 1976 seasons.

The Planting Site

Since strawberries are a high value cash crop, they should be planted on land best fitted for strawberry production. This land should be well drained and away from wooded areas and other frost pockets. If possible, select land that is fairly level so the soil will not erode, yet with enough slope to provide air and water drainage. The probability of spring frosts in Michigan makes it very desirable to have sprinkler irrigation available.

By Jerome Hull, Jr., James Moulton, and James Flore, Department of Horticulture

Drainage and Slope

Adequate water drainage is essential. After spring growth begins, strawberry roots will not tolerate a saturated soil, even for a few hours. Waterlogging kills the old roots, prevents the development of new ones, and increases the chances of root disease. Thus, avoid water-logged or puddled soils.

Good air drainage is important to prevent frost damage during blossoming. Planting on slightly elevated sites lessens the danger because cold air will move off the slopes to lower areas.

While some slope is important for good water and air drainage, steep slopes tend to erode badly. If the slope exceeds 5 percent, plant on the contour.

If the only land available for growing strawberries is low and poorly drained, plant on slightly raised ridges. Be sure to use varieties resistant to red stele disease.

Soil Type

Strawberries can be grown successfully on nearly any type of soil which contains a good supply of organic matter. However, best yields are most often obtained on deep, fertile, well-drained loams with a high moisture-holding capacity. Clay soils have a high humus content and retain moisture but are often poorly drained. Sandy soils, while sometimes low in moisture, are preferred by growers seeking early fruit. Irrigation is essential for successful strawberry production on sandy soils.

Exposure

A southern exposure is usually warmer earlier in the spring, thereby hastening the bloom and ripen-

Fig. 1 – An excellent stand of strawberry plants trained to the matted-row system of culture.

ing seasons. However, in areas where late spring frosts are rather frequent, a northern exposure that would delay bloom might be more desirable.

Training Systems

Two systems of commercially growing strawberries are commonly used in Michigan — matted-row and spaced-plant. The matted-row system is most common.

Matted-Row

Plants are usually set 24 to 28 inches apart in the row and runners from these plants are allowed to root until the desired width of row is produced. A matted row 15 to 24 inches in width is desirable (Fig. 1). Narrow rows are easier to weed and harvest, produce larger fruit and are usually less infected with foliage diseases and fruit rot than very wide rows.

The chief fault of the matted-row system is development of too many plants. This can result in many small berries and unsatisfactory yields. Some varieties produce runners profusely, and many plants per square foot of matted row. Runner plants produced late in the season are small and have little or no fruiting capacity. Yet, such plants use soil moisture and nutrients, retarding development and fruit production of other runner plants. Four to six plants per square foot is optimal for best fruit production. To prevent the row from becoming too matted with plants, do not crowd plants into the row. Permit runner plants to spread until making desired row width and then cut off surplus runners with disc-hillers or similar attachments on the cultivator.

Spaced-Row

In the spaced-row system, runner plants are arranged by hand until the desired spacing is obtained (Fig. 2). Later-forming runner plants are removed as they appear. The final rows are approximately 2 feet wide with plants spaced 6 to 10 inches apart.

Spacing and thinning runner plants during the summer months usually increases yields and mproves fruit quality. Resulting rows are open and easy to pick. Berries are larger and less likely to be rotted from gray mold since sprays reach the fruit. Berries dry off more rapidly than if they were in a mass of foliage. Pickers can harvest faster because the berries are readily seen and the fruit is larger.

Machines can now be used to remove plants from strawberry rows. Loose runners are mechanically raked to the top of the matted row where they are drawn-up by a specially designed rotary cutter, then chopped and blown out. Thinning runner plants in the strawberry row, either mechanically or by hand, aids in the production of quality fruit.

Experiments indicate that the spaced-row system out-yields the matted-row. However, the matted-row system is adapted to mechanized farming which considerably reduces cost per acre. Thus, increased yields from the spaced-row system are of questionable value when cost difference is compared to the increase in returns. Under conditions of severe drought or severe winters, a sufficient number of plants in the matted-row system usually survive to give a good stand whereas the other system may fail completely.

Varieties

Selection of proper varieties adapted to local climatic conditions is the key to success in any

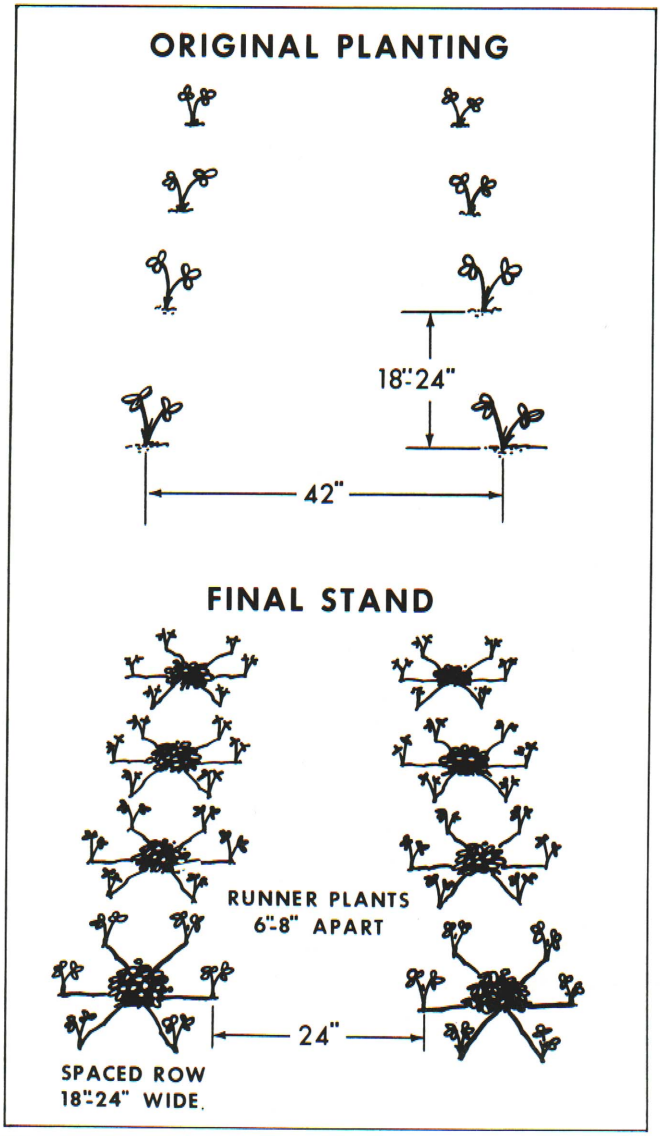

Fig. 2 – Spaced-plant system. Runners are spaced by hand until desired number are rooted and later runners removed as they appear. (Courtesy USDA Photo Service.)

strawberry enterprise. Climate greatly influences the performance of strawberry varieties. When soils contain red stele or Verticillium wilt, plant varieties tolerant to these diseases.

Test new varieties on a small scale to determine the adaptability to your particular conditions before making large commercial plantings. Individual commercial growers and home gardeners have personal preferences, but the following varieties are considered most adapted for Michigan.

Early Season

Sunrise is probably the best early-season variety for Michigan although it varies in productivity and is frequently less productive than desirable. Earliest maturing berries are fairly large, but late ripening berries are often small. The berries are an attractive conic shape, light red and glossy. The flesh is firm, but it is a little light in color for best appearance when frozen. The flavor is good. Sunrise is resistant to Verticillium wilt and red stele root. It is recommended only where earliness is an important factor.

Mid-Season

Midway is the most widely planted variety in Michigan. It has a long harvest season and consistently produces good yields of medium to large berries of fine quality for either fresh use or freezing. Midway is somewhat susceptible to Verticillium wilt and other unidentified root problems. The berries are medium firm, conic in shape, and they have an attractive, bright red exterior with red flesh.

Redchief is a good all-purpose variety that is productive and attractive. The berries are broad conic to conic, firm, and the color is a uniform glossy red. The calyx or cap is difficult to remove from the berry. Primary berries may be split (double) some years, apparently a result of frost injury to the blossoms. The plants are resistant to red stele root rot and moderately resistant to Verticillium wilt.

Guardian ripens late midseason. The plants are vigorous but produce a moderate number of runners. It is notable for resistance to most leaf diseases, red stele root rot and Verticillium wilt. Fruit yield is acceptable but plantings have been less productive than either Midway or Redchief. The fruit is large, but the primary berries are somewhat rough in outline and sometimes have a green tip that detracts from their appearance. Later berries are more symmetrical and attractive. Exterior color of the fruit is light red and glossy. The flesh is firm but light in color, which may not be attractive in a frozen pack.

Raritan, a midseason introduction from New Jersey, is a prominent variety in that area. The berries have a smooth, conic shape and a glossy, red color.

Fig. 3 – An eight-quart carrier of Midway berries. The large, firm, dark red berries are excellent for fresh market and processing.

The fruit is very attractive, firm and good quality for fresh use. Yields have been good, but fruit size has sometimes been small in Michigan trials. The plants are not resistant to either Verticillium wilt or red stele root rot, which could affect performance where these diseases are present.

Late Season

Frequent high temperatures, humidity, and wind in the late season are unfavorable for consistently high yields of good quality berries. Improved varieties are needed in this season. Delite and Marlate have appeared promising in preliminary Michigan trials.

Delite originated in southern Illinois. It is vigorous and produces runners so freely that thinning and removal of late-formed runners may be necessary to prevent plant crowding. Delite has been productive in narrow matted rows. The berries are cone shaped, medium to large size, glassy, bright red, but only moderately firm. The flesh is pink. The plants are resistant to red stele root rot and Verticillium wilt.

Marlate is a very late-ripening variety. The berries are large, firm, attractive and high quality. They become dark red when fully ripe. The flesh is light colored and the berries are difficult to cap. Marlate might have merit where a very late fresh-market variety is desired.

Sparkle (Paymaster), is an excellent red stele resistant variety that does well throughout Michigan. It is fairly productive, vigorous, and produces runners freely. Fruit is medium size, fairly firm, glassy, dark red with very high quality. Berry size runs small in later pickings if soil moisture is low.

Vesper is a very late ripening variety ideal for extending the season for local sales. Fruit is large, dark red, and soft, with rather rough appearance. Vesper must be harvested more frequently than most varieties. It is not satisfactory for shipping and processing.

Everbearing

Everbearing strawberries are recommended for summer berries in the home garden but not for commercial production except in a limited way for local market. The cost per acre is high with more plants and much more hand labor required.

Virus-Free Plants

Use virus-free plants wherever possible. Viris-free strawberry plants grow more vigorously and tend to produce larger fruit and greater yields than plants that are not virus-free. They are more able to produce under adverse conditions.

Determining Plants Per Acre

Plants required per acre depend upon the spacing system. See Table 2 below, for determining plants per acre. Plants are generally set 2 feet apart in the row in rows 4 feet apart (5,445 plants per acre). When large, well-rooted, virus-free plants are set carefully, the distance between plants in the row may be increased to 28 inches without danger of too many skips in the planting. An extremely important factor affecting maxium yield is missing plants.

Obtaining Planting Stock

Obtain strawberry plants from a reliable nursery. Order early to assure receiving desired varieties and quantities. Specify date of shipment so that plants arrive in ample time for early planting.

It is usually best to obtain plants from a plant nursery marketing virus-free plants. If you intend to produce your own strawberry plants, grow several rows just for that purpose. Keep these rows separate from the main plantings and inspect them periodically throughout the growing season. Remove any weak or abnormal plants. When plants are dug for transplanting, remove soil around the roots so that insects or other infectious materials are not carried along with the plants. Use only those plants with large, light-colored root systems and large crowns.

Table 2. Number of plants needed to plant an acre at various spacings.

PLANT SPACING (FEET)		
In row	**Between rows**	**Plants per acre**
1½	3	9,680[1]
1½	3½	8,296
1½	4	7,260
2	3	7,260
2	3½	6,223
2	4	5,445
2½	3	5,810
2½	3½	4,980
2½	4	4,356

[1] *Can be calculated by multiplying plant spacing in the row by spacing between the row and dividing into 43,560.*

Where to Find Certain Traits

Common varieties grouped according to certain characteristics are:

Traits	Varieties
Early	Sunrise, Premier
Late	Marlate, Vesper, Sparkle, Delite
Good flavor	Redchief, Raritan, Marlate, Sparkle, Catskill
For freezing	Midway, Redchief, Sparkle
Large berries	Guardian, Robinson, Marlate
Resistance to red stele disease	Redchief, Guardian, Sunrise
Resistance to Verticillium disease	Guardian, Redchief, Sunrise, Robinson, Premier, Catskill
Everbearing	Gem (Superfection), Ozark Beauty

Caring for Nursery Plants

Planting dormant stock results in improved plant stand, earlier growth and earlier runner production. Many nurseries dig plants while dormant and hold them until planting time in cold storage at a temperature of about 30°F. and relative humidity of 85 to 90 percent. A little ice formation in the crate is not serious since temperatures around 21° to 23° are necessary to cause serious injury to plant tissue. Storage temperatures above freezing are likely to cause mold, storage rot and drying. When dormant nursery plants arrive, place them in storage immediately and hold them in the dormant condition until planted. A refrigerator or standard cold storage conditions for apples are satisfactory for strawberry plants for a few days.

If planting must be delayed, and cold storage facilities are not available, heel-in the plants in a well-drained location protected from both sun and wind. When plant roots are very dry, soak them in water for several hours before heeling-in. To heel-in plants, separate bundles and place the plants in a V-shaped trench deep enough to spread out the roots when the crowns are at ground level. Pack soil firmly around the roots and leave plants heeled-in until ready for field planting.

Soil Management

Rotations

Grow green manure or row crops on the strawberry site for at least one year before planting strawberries. Raising a cultivated row crop for at least one year before planting strawberries reduces weed and root-feeding insect problems and improves the soil's physical properties. A heavy application of manure is a good substitute for a green manure crop before planting if fairly weed-free manure can be economically obtained.

Quackgrass Control

Control quackgrass by spraying with dalapon at 10-15 pounds per acre for the year before planting. Use the lower rate on light, sandy soils, and the higher rate on heavier soils. Dalapon should be applied in late spring or early summer when the quackgrass is growing vigorously, and is 8-10 inches in height, followed by tillage 7-10 days after application and additional tillage if regrowth occurs. Plant strawberries the following spring after suitably preparing the soil. Do not attempt strawberry growing until quackgrass has been satisfactorily controlled.

Soil Building

Plant green manure crops, or apply manure, on soils lacking organic matter. Green manure crops are: rye (2 bu./A.), buckwheat (5-6 pecks/A.), sudangrass (25 lbs./A.), sudan-sorghum hybrids, or millet. Grown the year before planting strawberries, these crops increase the soil humus content. Fertilize the cover crop to obtain vigorous growth.

Here is a typical soil building program. Prepare the soil early in spring. As soon as danger from frost has passed, harrow or disc the ground to destroy weed seedlings and seed one of the above green manure crops. Fertilize with a complete analyses fertilizer that will furnish 40 to 50 pounds actual N per acre. Disc or plow down the cover crop in mid-summer and sow rye or millet in August. Fertilize this with 30-40 pounds of actual N per acre. In late winter or early spring, topdress with nitrogen (30 pounds actual N per acre) and plow as soon as the ground can be worked. Prepare a firm, fine, plant bed and set your strawberry plants.

Fertilization

Rapid growth of newly placed plants and early runner plant development is necessary for strong, fruitful plants. Maximum production is greatly influenced by plant growth achieved in the first 60 days after transplanting. Organic matter increases the fertility and moisture-holding capacity of sandy soils. Subsequent fertilization programs should be used to promote rapid, early-season plant growth.

Type of soil and previous treatment influence the need for fertilizer in the strawberry planting. Soil test to determine fertilizer needs. If a green manure crop has been grown the previous year, and heavily fertilized, additional fertilizer is not usually required. If a soil building program does not precede planting, apply a 1-1-1 ratio fertilizer to supply 30 lbs. of actual N per acre, and work it into the soil at least 10 days before planting.

Side-dress plants having weak growth with nitrogen one month after planting. This can be repeated one month later if plant growth is still weak. Strawberries require plenty of nitrogen early in the first year for maximum growth. Strong plants are needed by late summer and early fall to form blossom buds for next year's crop. When nitrogen supply is limited, plants grow slowly and leaves are small and light green in color. Extreme nitrogen starvation causes foliage to develop a reddish color.

Many growers apply about 25 pounds of actual N per acre in early August just prior to the period of flower bud initiation. When liberally-fertilized cover crops precede strawberry plantings, or plantings are adequately fertilized during the early part of the growing season, this nitrogen application is not necessary.

Apply fertilizer when plant foliage is dry and brush it off immediately to avoid serious foliage injury or burning — particularly if ammonium nitrate is used. Fertilizer can be removed from the foliage by dragging a bundle of fine brush, burlap sacks or a heavy rope over the rows. There is little danger of foliage injury if a pellet form of nitrogen is applied.

Do not apply nitrogen fertilizer in the spring of the fruiting year, unless plants are quite weak. Nitrogen applications at this time can be extremely detrimental and result in tall, dense, dark-green foliage and softer fruit. Fruit rot is much more serious under these conditions, especially when wet weather prevails during harvest. Likewise, nitrogen applications in early spring of the fruiting year tend to retard fruit ripening.

If the strawberry plants show a need for nitrogen in the spring of a fruiting year, do not apply more than 10 pounds of actual N per acre. A quick response at this time may be obtained by using a urea spray of 5 pounds in 100 gallons of water at 200 gallons per acre.

When plantings are to be fruited another season, apply fertilizer immediately after harvest to furnish 50 pounds of actual N. Additional fertilizer applications should not be necessary until after harvest the following season.

Preparing the Plant Bed

Thoroughly prepare the land for strawberry plantings. If not plowed the previous fall, turn the soil early in the spring and work into a fine, mellow condition the full depth of the furrow slice. Pulverize the soil thoroughly just before setting the strawberry plants.

Planting

Transplant strawberries as early in the spring as the ground can be prepared. Usually, there are several weeks of cool, damp, cloudy weather during the early spring season which enable plants to become well-established before arrival of hot weather. Early-set plants produce early runners. These bear more fruit the following spring than runner plants formed late in the season. It is difficult to obtain a good stand when plants are set in May or after warm, dry weather unless irrigation is available and plants are dormant.

Fall planting is not suggested for commercial growers. Plants set in the fall require extra weed control care and an extra winter of mulching to prevent injury from winter heaving. Also, weather and soil conditions are generally more favorable for plant growth in the spring than in the fall.

Except for small plantings, use mechanical planters wherever feasible. Such equipment supplies water to plants during transplanting and packs soil firmly against the roots. Set plants at the correct depth, with the crown flush with ground level (Fig. 4). Plants set too deep are likely to smother and die, while plants set too shallow will dry out. Avoid exposure of roots or covering the plant crown. Depth of the planter shoes should be sufficient to avoid bending roots at a right angle to the planting trench.

For most satisfactory results with a mechanical transplanter, use plants relatively uniform in size, arranged in one direction in the holders. Plant roots should be straight and trimmed. An experienced crew can set three to four acres per day. It is advisable to have someone trail the transplanter to reset plants which are not at the correct depth or firmly planted. Some strawberry growers go over the field immediately after transplanting with a cultipacker to pack the soil around plant roots and crown and keep soil from drying out before plants become rooted in the soil.

Water plants when they are set, unless the soil is moist and the plants are in extremely good condition. Irrigating the field immediately after transplanting firms the soil around the plants and avoids damage from drying. Starter solutions may be used at manufacturer's directions when plants are set very early in the spring on heavier soils. Generally, they are not necessary, and under dry conditions may cause injury, especially on light, sandy soils.

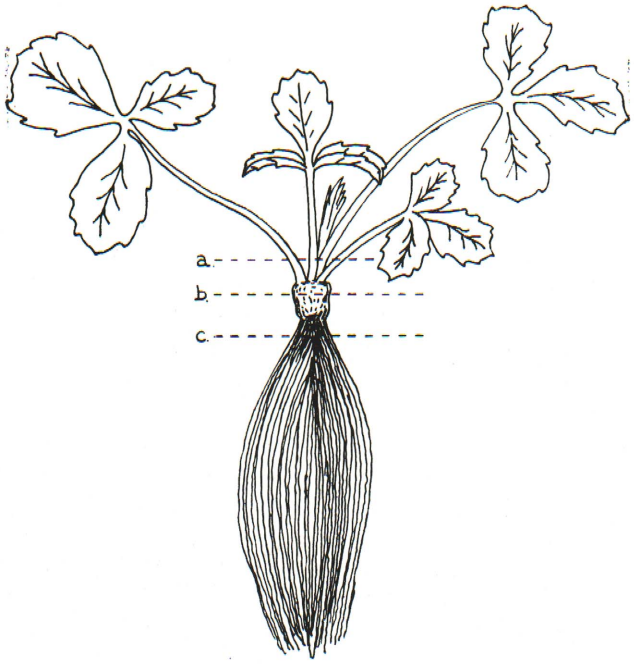

Fig. 4 – Strawberry planting depths. Broken line "b" illustrates proper depth; line "a" – set too deeply; and line "c" – set too shallow.

Care After Planting

Blossom Removal

Some of the buds within the crowns of newly set plants are flower buds formed the preceding fall. When the plants begin growth, these buds push out stems that terminate in flower clusters. Carefully pinch off all flower stocks as they appear (Fig. 5). Otherwise, development of flowers and fruit decreases plant vigor and retards early runner production. Removal of flower stems as soon as they appear strengthens the plant and increases the number of early runner plants. This is important since early formed runner plants bear the most fruit the following season.

Some strawberry varieties produce only one flower cluster per plant, while others produce several blossom clusters per plant. Generally, it is necessary to go over the planting two or three times to remove all flower clusters.

Cultivation

Begin cultivation as soon as possible after planting. This destroys weeds which would take moisture and nutrients from the plants, and maintains

a fine surface mulch (Fig. 6). Unless chemicals are used for weed control, cultivate every 10 days to 2 weeks, or after every heavy rain until fall.

The first cultivation might be somewhat deeper than usual to loosen soil packed during planting. Uncover at once any young plants covered by the cultivator or they will be weak plants even though they might live through the season. Cultivate increasingly shallow as the season progresses and also farther from the original plants each time until the rows are of the desired width. Do not cultivate deeper than one or two inches near the plants after the first cultivation. Cultivate the rows in the same direction each time so that runner plants already trailed into position are not disturbed. Hoeing is necessary to destroy weeds which cannot be reached with a cultivator.

Chemical Weed Control

Herbicides can be successfully used with tillage to control weeds in strawberry plantings. Proper selection and application of these herbicides can reduce labor costs for weed control (Fig. 7). Several chemicals are available for controlling weeds in strawberry plantings. The chemical or chemicals you may want to select will depend upon (1) soil type, (2) weed species present, (3) season of the year you intend to make application and (4) whether it will be a pre- or post-emergence treatment. Consult MSU Extension Bulletin E-433 or E-154 for information on herbicides available for both bearing and non-bearing strawberry plantings.

Specialized Tillage Equipment

Many types of tillage equipment are available for cultivating strawberries (Fig. 8). Self-propelled power hoes and rotary-type tillers reduce hand labor requirements (Fig's 9,10). While quite expensive, this equipment pays for itself on large operations. Since it is designed for row crops in general, it can often be used on other crops.

Successful herbicide programs have supplemented special tillage equipment and tend to make extensive hand hoeing impractical.

Irrigation

About 75% of the strawberry roots are in the top three inches of soil and 90% in the top six inches. Consequently, the top six-inch soil layer supplies most of the plant's water and nutrients. Therefore, irrigation is an important production practice for strawberry growing, especially immediately after transplanting during blossom bud development, fruit development, harvest (Fig. 11) and immediately after renovation (see page 12). Irrigation is especially beneficial when dry weather occurs

Fig. 5 – Remove strawberry blossoms during the summer following planting. Fruiting the first year weakens the plants and reduces production the following spring. For everbearing varieties, do not remove blossoms developing after early July. (Photo courtesy Ohio Agr. Exp. Stat.)

Fig. 6 – Thorough cultivation early during the year of planting controls weeds and results in favorable soil conditions for rooting of runner plants.

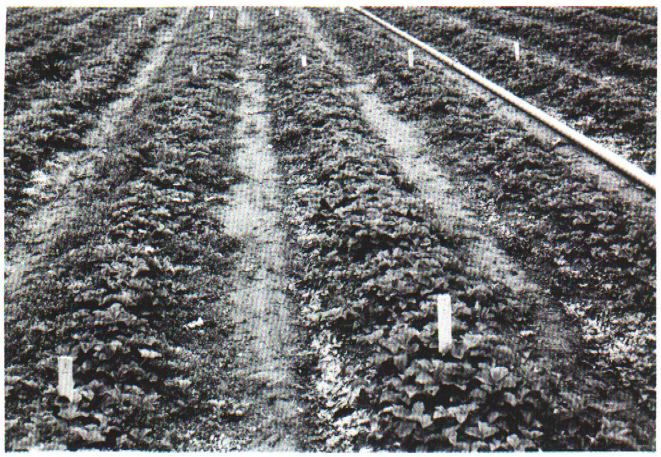

Fig. 7 – Chemicals can simplify strawberry weed control problems. A fall application controlled chickweed in the rows on the right. Non-treated row on left shows results of uncontrolled chickweed growth.

Fig. 8 – A 'wiggle hoe' drawn behind a tractor-mounted cultivator. Rider moves (wiggles) cultivator shovels around strawberry plants to cultivate in the row between plants.

Fig. 9 – A type of power hoe used in some Michigan strawberry fields.

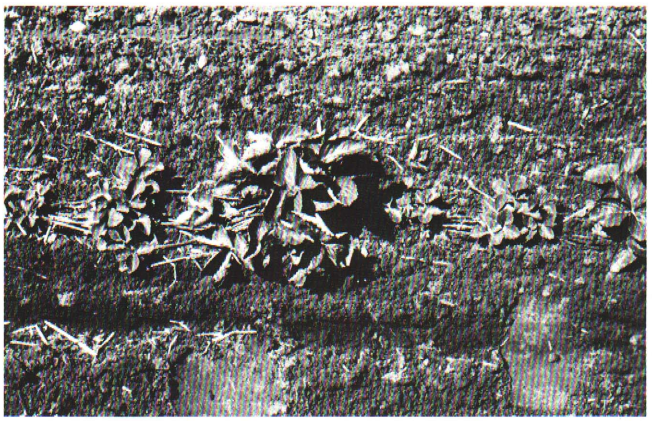

Fig. 10 – Power hoe draws runners into plant row resulting in plant crowding. Cultivating in same direction is less likely to disturb rooted runner plants.

while plants are establishing themselves in the summer, or in the spring from bloom through harvest. During dry seasons, irrigation has markedly increased yields.

Irrigate strawberry plants before they show symptons of water deficiency. Frequency of irrigation depends on prevailing temperatures and natural rainfall. Irrigate if rainfall is not sufficient. Apply sufficient water to penetrate 6 to 8 inches. Sandy soils require more frequent applications of water than heavier soils because they hold less available water.

Light Harvest Irrigation

Maintain sufficient soil moisture during bloom and until development of pink fruit color. But, application of large amounts of water during fruit maturation and harvest can cause soft fruit. Frequent, light applications of water only during the heat of the day will prevent the adverse effects of heavy watering during fruit harvest.

The quantity of water to apply to the maturing crop depends upon rainfall and amount of water applied for frost protection. Soils retaining much moisture from rainfall or frost protection applications probably need little additional water unless temperatures are above 90°F and relative humidity below 50% at mid-day.

If frost protection irrigation is not necessary and no rainfall occurs, irrigate during early fruit development, thoroughly wetting the soil 8 to 10 inches deep. Then, a low application rate (sprinkler output less than 0.1 inch per hour) applied during the high temperatures of the day will prevent moisture stress from developing in the plant. Such an irrigation rate during a dry season would supply 1/4 to 1/2 inch of water daily between 10:00 or 11:00 a.m. and 1:00 to 3:00 p.m. and reduce evaporation. Developing fruit will benefit considerably by a 10 to 15°F reduction in temperature during the time of

Fig. 11 – Irrigation is very helpful for establishing strawberry plantings and producing maximum yields. (Photo courtesy Ontario Dept. of Agr.)

application. The fruit will lose less water, develop larger size, and brighter finish. Vary the length of application according to the temperature and relative humidity. Use the maximum application on days above 90°F with relative humidity below 50%, and no water if temperatures are below 80°F and humidity above 65%.

When irrigating for a beneficial cooling effect, select a sprinkler nozzle size and spacing that will prevent application of large quantities of water. It is desirable to adjust amount of water applied for cooling to 0.3 to 0.5 inch per day. Small nozzle sizes (under 1/8 inch) will help reduce application rate but are easily plugged by dirt in the water supply. Selection of pipe size depends upon length of the irrigation line and the amount of water it must carry. Use aluminum or plastic pipe of adequate size.

Fig. 13 – Sprinkler irrigation to protect strawberry bloom from frost injury. Heat is released as water turns to ice to protect plants. Continue to sprinkle until all ice melts from plants.

Frost Prevention

Strawberries are extremely susceptible to late spring frost damage. Plants bloom during a two to three week period and the first flowers are most likely to be injured by late spring frost. This is unfortunate since the first flowers will develop the largest berries. Their loss can result in significant yield reductions. Frost injury is usually confined to the flower pistils, which turn black (Fig. 12). The stamens and petals are not injured and the blossom looks normal until examined closely. If blossom is only partially injured, misshapen berries are produced.

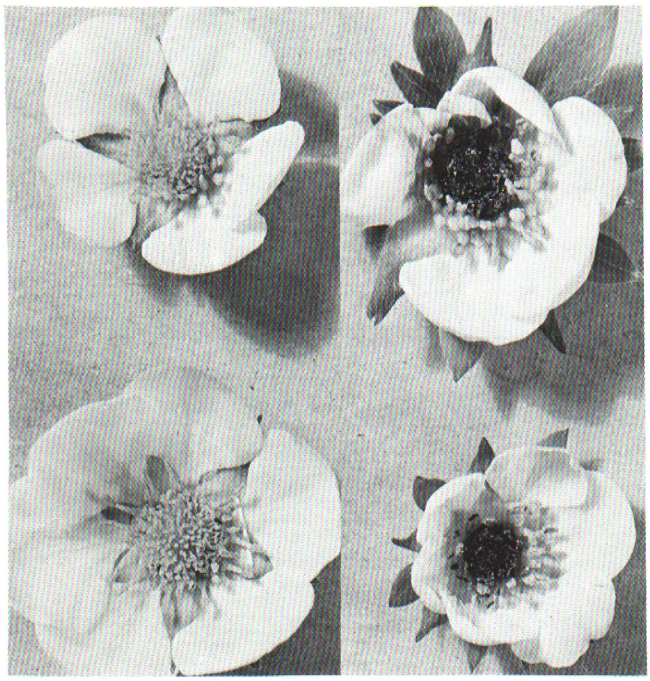

Fig. 12 – Strawberry Blossoms on right are frost-injured. The pistils (female flower parts) are darkened and killed while the stamens (male parts) and rest of the flower show no injury. (Photo courtesy Ontario Dept. of Agr.)

Sprinkler irrigation can protect blossoms against temperatures as low as 20°F. Position irrigation systems in the field and test them prior to need for frost protection. Begin sprinkling as soon as the temperature at plant level drops to 34°. Continue irrigation until the temperature the following morning rises again to 34° and all ice is melted from the plants.

When using an irrigation system for frost protection, select a nozzle size and spacing that will apply about 0.1 inch of water per hour. Very low temperatures may require slightly higher rates of application. Use 5 to 10 psi more pressure for frost protection than for the same sprinkler-nozzle size combination for irrigation. The sprinklers may be spaced farther apart than for normal irrigation. A triangular spacing results in better coverage at the wider spacing. Sprinklers should make a complete revolution in approximately one minute or less. The system should operate continuously while the temperature is below freezing. *Do not stop* sprinkling when ice begins to form on the plants. *An accurate thermometer* is essential and should be located at ground level. A temperature alarm is also helpful.

Water sprinkling during frost is a method of heating. While a little heat is given up by the water as it cools to the freezing point, the main effect comes from the heat released as water turns to ice. Because of this heat of fusion, the temperature of a blossom or leaf on which the water is continually freezing remains at or near 32°F and is not damaged.

To maintain this safety margin, water must be continually freezing on the plant (Fig. 13). If all the water freezes and only ice is present, the tempera-

Fig. 14 – Mulching protects strawberry plants from low temperature injury during the winter and from freezing and thawing resulting from fluctuating temperatures. (Photo courtesy Ontario Dept. of Agr.)

ture can fall rapidly to the danger level. Therefore, the more severe the frost, the greater the application rate needed for protection.

Mulching

Mulch strawberry plants for protection against winter damage (Fig. 14). Low winter temperatures may kill flower buds and cause considerable winter injury to the roots and crowns of unprotected plants. Mulching protects plants from rapid freezing that causes serious crown damage. Alternate freezing and thawing of the soil heaves the plants out of the ground or breaks their roots. Mulching also results in cleaner berries and more satisfactory harvest conditions.

Apply mulch in late fall or early winter after plants have become hardened. Exposure to temperatures of 20°F or lower sufficiently hardens the plants for mulching. A mulch about 2 inches in thickness when settled gives ample protection (Fig. 15). This requires about 3 tons of straw per acre if applied both over and between the rows. Generally, heavy clay soils are more subject to heaving and need slightly heavier mulching than lighter type soils. One and one-half tons of straw per acre are satisfactory for light soils.

Wheat straw is an ideal mulch material. However, most straw contains some grain seed which grows and becomes troublesome the following spring. Obtaining mulch material a year in advance and exposing it to sun and rain forces any grain to germinate and die. When using fresh straw, distribute the bales over the patch in early fall and break them open for thorough rain soaking. In this way, grain seeds in the straw will germinate before it is spread. Soaking stacked straw will cause seed to sprout before it is spread. Applying an herbicide prior to mulching will control germinating grain and weed seeds.

Fig. 15 – Specially constructed equipment readily deposits mulch over strawberry row. (Photo courtesy USDA Photo Service.)

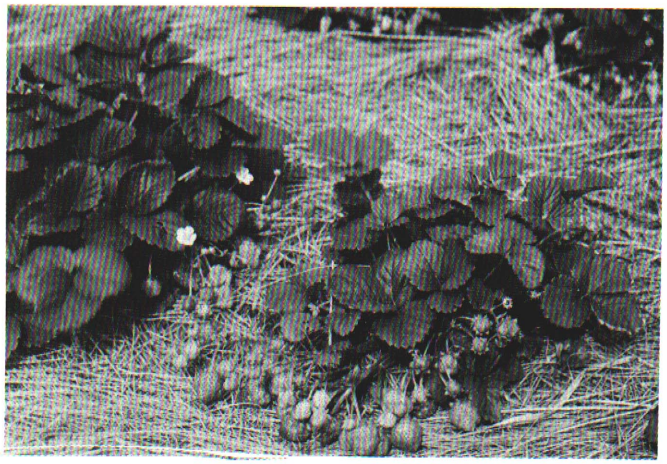

Fig. 16 – A good mulch, properly placed insures clean, bright berries and aids in controlling fruit rot.

Rye can be grown specifically for strawberry mulch and cut when in bloom so no seed forms. This eliminates the possibility of any grain germinating in the strawberry planting after mulching. Sudangrass, cut when it is beginning to head, and run through a crusher, makes satisfactory mulch.

Remove mulch from the plants in the spring when new leaf growth begins and foliage starts to get light yellow. Leave 1/3 to 1/2 of the mulch over the bed for the plants to grow up through. This will suppress weed growth and keep the berries clean during harvest (Fig. 16). Place excess mulch in the row middles. It can be used to recover the plants if frost conditions threaten. Mulch, if not removed too early in the spring, delays blossoming and thus affords some protection against a late spring frost. If mulching is delayed until spring on sandy soils, apply one ton per acre as soon as the first blossoms set fruit. A mulched field is usually more susceptible to frosts during blossoming than one that was not mulched.

Harvesting

Harvest generally begins in late May, early June in southern Michigan and extends through June and early July. Length of harvest in any specific production area varies with the season and varieties grown. The picking season will be short if hot weather occurs, but with cool weather and abundant rainfall, picking will continue over a longer period of time. Generally, the first mature berries appear about 30 days after the first blossoms have opened.

Hire sufficient pickers to go over the planting at east once during each two-day period. Many of the pickers will be needed for only a relatively short period of time about 6 to 9 pickers are needed per acre — depending upon efficiency, fruit yield and rate of fruit ripening. More pickers are needed when berries are capped at harvest for processing.

Carefully instruct pickers on the proper stage of maturity to pick the berries, the best technique of picking and care and handling of the fruit. Also, show how to pick with the most speed and least damage to the fruit and plants and what to do with small or rotten berries. Supervise them carefully, placing a competent foreman in charge of each large group.

Most pickers are paid according to the number of quarts picked. Some growers pay a bonus of ½ to 1 cent per quart to pickers who remain throughout the entire harvest. Others retain ½ or 1 cent a quart until the harvest is over.

Some operators pay the picker each time he delivers a carrier of berries to the field shed. Other growers issue tags which may be punched to keep a record of the number of quart of berries the picker harvested.

Strawberries are generally harvested into quart boxes which the picker carries in a light tray or carrier. Trays holding four to eight quart boxes are most satisfactory.

Harvest only those berries that are red or at least pink all over. Berries still showing white should be left for the next picking. Do not save over-ripe or sunburned fruit. Harvest and throw to one side or remove during the grading procedure such fruit and any berries with soft spots. Harvest fruit to be shipped to distant markets slightly ahead of full maturity so it will be firm enough to stand handling and yet not be overripe when purchased by the consumer.

For most efficient harvest, the picker should place his carrier within easy reach just ahead of himself, between the rows. Leaves should be pushed aside or parted with the hands to avoid missing berries ready for harvest.

Harvest strawberries by grasping the stem just above the berry with thumb and forefinger and pulling with a slight twisting motion (Fig. 17). This will break the stem about one-half inch from the berry. Allow the first fruit to roll into the palm of your hand and pick another one using your thumb and forefinger as before. Repeat these operations using both hands at the same time until your hands contain all the fruit they can hold without crushing. Place these berries in the boxes and repeat the picking process.

Pick all the ripe fruit in the row as you proceed. Otherwise, they will be overripe by the next picking, making the subsequent picking more difficult.

Strawberries are usually harvested every other day. If the weather is hot and berries are ripening rapidly, it may be necessary to pick the same field every day.

Pick berries early in the morning while they are cool. However, during the peak of harvest it may be necessary to pick throughout most of the day to keep pace with fruit ripening and prevent serious losses.

Fig. 17 – Pick strawberries for fresh market by pinching and twisting the stems rather than pulling the fruit, then let the fruit roll into the palm of your hand.

Generally, morning dew does not seriously interfere with the 'keeping' quality of the berries. However, berries picked on rainy days do not ship and keep very well. Regardless of when strawberries are picked, do not leave them in the sun after harvest. Place them in a cool location. Temporary sheds are often built near the fields so fruit can be placed in the shed immediately after each carrier is filled. Such a shed need not be elaborate but should be placed where it will be convenient for the pickers and easily reached by truck.

Grade berries to receive premium prices. Experienced pickers can satisfactorily grade berries during harvesting, but fruit is most commonly graded in the packing shed. Grading is usually done by carefully pouring berries from one quart to another, discarding all overripe, green, small or misshapen fruit. A more rapid method involves emptying one box of fruit at a time into a triangular pan removing all the inferior berries and then pouring the remaining desirable fruit back into the box. Always handle the fruit as gently as possible.

One-quart veneer boxes are widely used in Michigan. These are usually packed in ventilated slatted crates that hold 16-quart boxes (Fig. 18). Some growers use 8-quart cardboard flats. Fiber board quart boxes are usually used with this container. Pint containers are also utilized and are preferred by some buyers.

Market life of fresh strawberries can be extended by placing them in cold storage. If they are to be held for a day or longer, store at 32° to 35°F. If held for a period of only a few hours, keep them at about 45°F.

Fig. 18 – Sixteen-quart slatted crates have been widely utilized for shipping berries to fresh market. Graded berries bring premium prices.

Fig. 19 – Renovating field after harvest with a rotary-type tiller. Row width of plant is adjusted by removing teeth from the center of the tiller drum.

Renovation

Some strawberry growers fruit their planting only once and plow it under after harvest. In many cases, the plantings are retained for harvest of a second crop. Ordinarily, the cost of renewing a planting is less than that for establishing a new field.

Plantings to be renovated should be free of heavy infestations of difficult-to-control weeds, such as white clover, perennial grasses, quackgrass and sorrel. If these weed problems have not been controlled, plow the planting after harvest. It is best to start a new field if serious disease infestations are present in the old planting.

Renovate promptly and properly fields to be retained and fruited another season. Unless the plantings are free of insects and diseases, mow the old foliage immediately after the last picking. Mow as close to the ground as possible without injuring plant crowns. If renovation is not completed immediately after harvest, do not mow the foliage when fields are renovated.

After mowing, broadcast a complete fertilizer over the field to supply about 50 pounds of actual N per acre.

Narrow the rows to 8 to 12 inches in width. This may be accomplished with a cultivator or plow. Using a rotary-type cultivator with some of the teeth removed will leave a narrow strip of plants in the row center (Fig. 19).

Thin the remaining plants six to eight inches apart. This may be done by hoeing or dragging a spike-tooth harrow once or twice across the rows and once down the rows. Irrigate if soil moisture is deficient. This is especially important on light textured soils. Handle the field the remainder of the season as outlined for newly-planted strawberry fields.

Table 1. Acreage, Yield Utilization, and Value of Michigan Strawberry Crop for the Seasons 1972 through 1976.[1]

Crop Year	Acres	lbs./A[2]	Price/lb. paid to grower (cents)	FRESH BERRIES 1,000 lb.	FRESH BERRIES cents per lb.	PROCESSING BERRIES 1,000 lb.	PROCESSING BERRIES cents per lb.
1972	4,200	5,300	24.6	13,300	28.3	7,900	18.4
1973	3,600	4,400	31.5	9,600	33.9	5,400	27.2
1974	3,300	5,700	31.1	12,400	33.9	5,300	24.5
1975	3,100	5,500	32.1	11,000	36.1	5,500	24.1
1976	3,000	6,000	33.3	10,000	36.0	7,400	29.7

[1] *Data of the Michigan Crop Reporting Service.*
[2] *A quart of strawberries weighs about 1.5 pounds.*

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Insect and disease control are important for the successful commercial production of strawberries. Registration of chemicals for the control of these problems changes periodically. The MSU Fruit Pesticide Handbook E-154 is revised annually and lists pesticides currently available for strawberry insect and disease control. Copies can be purchased from your local Cooperative Extension Service Office.