Production Guide for Commercial Strawberries

Profitable strawberry production requires careful attention to many cultural practices. Variety, selection, weed control, frost control, and winter protection are of particular importance. Renovation, fertility, and disease and insect control also are important if production is to be profitable. In addition to cultural practices, you must consider potential markets and methods of marketing **before** establishing a strawberry planting. Harvest labor, family or hired, and harvest supervision also need to be considered.

Markets and Marketing

Consideration of potential markets and methods of marketing fruit are the important first steps in deciding whether to begin or expand strawberry production. Potential markets include those available through direct marketing methods such as U-pick or pick-your-own (PYO), roadside stands, and farmers' markets. Direct marketing from the grower to the consumer may be most profitable because intermediary and brokerage fees are eliminated. The volume of fruit that can be sold through direct markets is limited by the traffic flow (consumers) to the site of sale, whereas wholesaling through brokers may move larger volumes of fruit because of sales at many sites.

Match the acreage planted for production to the amount of fruit that can be sold through the desired marketing methods. In the case of acreage for PYO strawberries, Illinois studies have shown that approximately 2,500 people within a 20-mile radius of the point of sale are required to support each acre in production. To determine potential for new acreage or increased acreage in an area, draw a circle with a 20-mile radius around your acreage area and then consider the current number of acres in production and the population within the circle. If there are enough or more acres already in production than the population can support, do not plant any more berries. Also consider existing production outside of but near the 20-mile radius of your proposed production site when making a final decision on whether to plant or not. Successful PYO marketing also requires a good advertising and promotion program.

Consider the availability and ease of acquiring harvest labor along with marketing. The PYO method of marketing eliminates the need for harvest labor, but still requires some labor for harvest supervision, cashiers, etc. Many PYO growers sell some fruit at the PYO site for those consumers wanting farm-fresh fruit, but not willing to pick it themselves. You must charge higher prices for prepicked fruit to pay for the harvest labor.

Fruit for the wholesale market normally must be picked firmer and cooled rapidly to reduce perishability during shipping and ensure a good shelf life. Growers considering growing for the wholesale market should give special consideration to availability of harvest labor, volume of fruit needed to satisfy wholesale buyer demand, appropriate packaging for attractive display, and varieties best adapted to shipping. Discussions with produce buyers or brokers prior to planting are highly recommended since this market is well supplied with a steady volume of produce from large production states and the wholesale market may be difficult to enter with locally grown fruit.

Biology and Culture of Strawberries

Biology

The cultivated strawberry is a hybrid plant between two American species, *Fragaria chiloensis* of western North and South America

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and *Fragaria virginiana* of eastern North America. The botanical name of the common cultivated strawberry is *Fragaria* x ananassa. The hybridization of the two species occurred around 1850 in France and hundreds of varieties have been selected and named since then.

The cultivated strawberry is actually an herbaceous perennial plant. The perennial habit is evident as leaves remain alive and green during the winter in mild climates and under mulch in more severe climates. The cultivated strawberry propagates naturally by the formation of runners that take root to form new plants.

Several cultivated forms of strawberry can be grouped as June bearing, everbearing, and day-neutral. The main distinguishing feature of these different types is the time and manner in which they flower.

June-bearing types account for most of the production in Iowa and are so named because they are harvested in early summer, late May through June. They initiate flower buds during the short days of late summer and continue until frost. Thus, the harvest crop results from flower buds formed the previous fall. The long warm days of summer are responsible for runner development.

Everbearing and day-neutral varieties respond less precisely to day length than the June-bearing varieties. Everbearing types bear crops in both July and late August through September with smaller amounts of production in between. The day-neutral types respond similarly to the everbearers, but tend to flower more or less continuously or in three or more major flushes of flowering and fruiting during the summer. High temperatures tend to favor vegetative development over flowering in the day-neutral varieties, thus flowering and fruiting after periods of high temperatures may be reduced.

Figure 1. Matted-row strawberry production system common in eastern North America.

Site Selection

Sites for planting strawberries should be in areas where adequate air and water drainage occur. Sites lower than surrounding land may be subject to frost damage since cold air is denser than warmer air and settles in low areas.

Strawberries are adapted to a variety of different soil types, provided they are well-drained. Plants usually bloom earlier on lighter soils and thus may increase needs for frost protection. Light or sandy soils are suitable for commercial production when irrigation is available and close attention is paid to nutritional (fertilizer) needs of the crop. Light soils are advantageous because they (1) warm up earlier in the spring than heavier soil types and allow production for the early market; (2) drain well, allowing field work and harvesting sooner after rain than heavier soils; and (3) have fewer root disease problems than heavy soils.

Strawberries also are grown on heavier soils such as loam, silt loam, and silty clay. On heavy clay soils, yields may be reduced due to poor

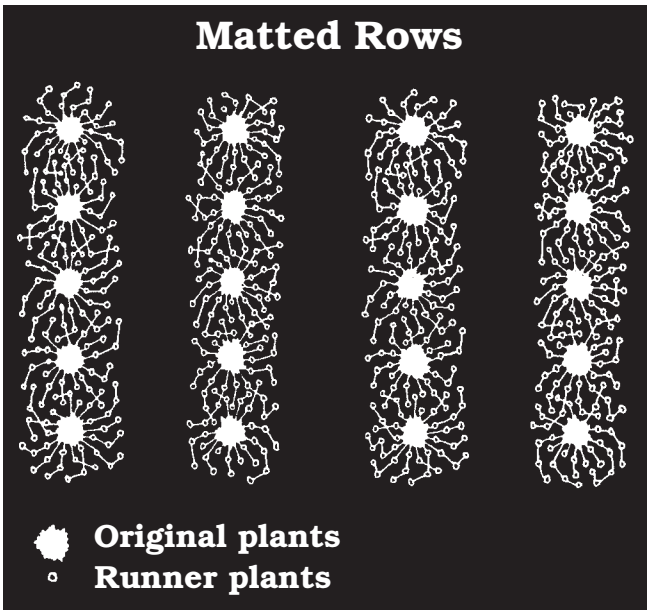

Figure 2. Matted-row system diagram showing original and runner plants.

drainage, root diseases, and the resulting poor root development.

Avoid soils previously planted with Solanaceous crops (tomato, potato, pepper, eggplant) as planting sites unless they can be fumigated. Soils previously planted to Solanaceous crops may contain Verticillium wilt, a persistent fungal organism in the soil. If these sites must be used for planting, soil fumigation or planting of verticillium-resistant varieties is suggested.

Avoid sites recently planted to sod because they may contain large numbers of white grub, which are injurious to strawberry roots. Also, perennial weeds are frequently a problem on sites that have previously been in sod or pasture. Delay planting on these sites for at least 1 year after removal of sod or pasture to reduce white grub populations and achieve control of perennial weeds.

Planting and Training

Strawberries in eastern North America are most commonly grown in the matted (figure 1) or space-matted row production systems. In the matted row system, the mother plants are simply allowed to form runners and spread until a matted row of plants is formed. In the spaced-matted row, the runners are actually spaced to achieve more control of plant density. Plants are maintained in rows by cultivation between rows. In both the matted row and spaced-matted row systems, the original mother plants are planted 18 to 36 inches apart in rows 36 to 48 inches apart (figure 2).

Many growers practice a combination of the matted and spaced-matted row systems, spacing runners to fill in areas where mother plants die and keeping runners trained in the rows. Removal of runners to achieve optimum plant spacing is time consuming and may be too costly and labor intensive for most growers, although some growers have devised mechanical methods to remove excess runners. Optimum plant density, after runnering, in the matted or spaced-matted row systems is six or seven plants per square foot for most varieties.

Plants grown on heavy soils may benefit from slightly raised 3- to 5-inch beds to allow for better root development. Plants grown on raised beds do, however, have higher water requirements and may be subject to increased winter injury unless additional winter mulch is applied to adequately cover the raised bed.

Planting is best done as early in the spring as the ground can be worked. Plant either by hand or with a mechanical transplanter (figure 3) where a large acreage is to be planted. With either planting method, take care to see that

Figure 3. Use mechanical transplanters when large acreages must be planted.

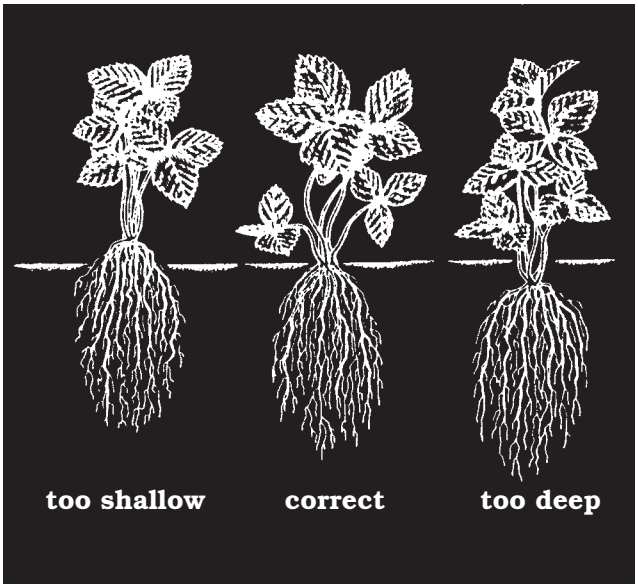

Figure 4. Plant the crown at the proper depth.

plants are planted with the crown set neither too high nor too low. Planting too high exposes roots to the wind and plants die or are poor in performance (figure 4) while too deep planting may cause the crown to rot. Figure 5 illustrates too shallow of a planting depth.

Prior to planting, take a soil test to determine nutrient needs. Apply nitrogen at the rate of 50 pounds actual N per acre and disk in or plow down prior to planting. Apply other nutrients as recommended by the soil test results.

Plants will flower soon after planting, but remove those flowers to promote good plant development and bed establishment. Fruit produced on June bearers during the plant year is seldom of high quality because fruiting occurs before plants are well established.

Varieties

Strawberry varieties recommended for production in Iowa have been thoroughly tested at Iowa State University and proven to be the most consistently high-yielding varieties adapted to Iowa. For a listing of recommended varieties, see Pm 453 *Fruit Cultivars for Iowa* (cost pub).

Varieties differ in many respects. Of these, winter hardiness, disease resistance, fruit firmness, and freezing quality are among the most important.

Figure 5. Strawberry plant planted too shallow exposing roots (arrow) to drying and resulting in poor establishment.

Strawberry varieties tend to be locally adapted and respond strongly to local day length and temperature conditions. Varieties that perform well farther north, south, east, or west of Iowa may not be the best for this region. As new strawberry varieties are introduced throughout the United States, they are placed in Iowa trials to determine which ones are best adapted. As better varieties are found, the list of recommended varieties will change.

Marketing methods employed, in part, determine which varieties to grow. For shipping, grow firmer varieties; for PYO less firm fruit may work out well. PYO growers and consumers prefer large fruit size and open plant habit. Generally, it is desirable to grow at least one early, midseason, and late season variety to spread out the harvest season. Growing varieties with different ripening seasons is also a form of income protection if poor weather conditions prevent a good harvest during the ripening of one variety or another.

Irrigation

The ability to irrigate is highly desirable in commercial strawberry production. First, irrigation maximizes plant growth and yield by ensuring an adequate moisture supply at all times. Second, sprinkler irrigation may be useful as an effective means of frost protection. Third, irrigation may be useful as a means of incorporating and activating certain herbicides. Fourth, some fertilizers and pesticides may be applied through the irrigation system, thus reducing the need and cost to enter the field with equipment.

Sprinkler or overhead irrigation is the most common form of irrigation used on strawberries growing in frost prone areas because of its usefulness for frost protection. Other forms of irrigation, such as drip, are not used in Iowa because they lack frost protection capabilities.

Base irrigation scheduling on plant requirements rather than on the calendar. Tensiometers, gypsum blocks, and data from pan evaporation are used in determining irrigation requirements. Generally, a planting should receive at least 1 inch of water per week during the growing season, either naturally from rainfall or through irrigation.

Fertility Practices

Strawberry fertility practices should be based on soil test information and petiole and leaf analysis results. Strawberries require nitrogen fertilizer application every year beginning the year of planting. Soil phosphorus (P) and potash (K) levels are usually adequate in fields that have been

fertilized for top yields for field or vegetable crops. As an adjunct to the fertility program, plant a winter cover crop of wheat or rye the year before planting strawberries to reduce soil erosion and provide further organic matter. One inch of water applied to one acre is equivalent to 27,154 gallons.

Do not lime strawberries because they prefer a slightly acid pH, from pH 5.5 to 6.5. An exception would be acid soils along Iowa rivers. If lime is required, apply it the year before planting.

Use the following fertilizer guidelines for new and production year plantings.

New Planting—Numbers refer to growth sequence during year.

1. Spring, before planting—Broadcast and plow down or disk in deeply the following:
• Nitrogen (N)—Most important for plant growth, runner production, and fruit bud formation. Apply 50 pounds N per acre during bed preparation or when turning under the cover crop.
• Phosphorus (P)—According to Iowa State University soil test results.
• Potassium (K)—According to Iowa State University soil test results.

2. At planting—Use a starter high in phosphate, such as 10-34-0 or 10-52-8, etc., in the transplanting water. A common solution is 3 pounds of starter fertilizer to 50 gallons of water. Apply ½ pint of solution to each plant.

3. Runner formation (late May-June)—Loams, silt loams, clay loams—sidedress with 40 to 50 pounds N per acre. Sands, loamy sands, and sandy loams—apply 30 pounds N per acre approximately 2 to 3 weeks after transplanting. Repeat this application 3 weeks later.

4. Mid-August—Apply 30 pounds N per acre to aid in fruit bud formation.

Production or Bearing Year—Numbers refer to growth sequence during year.

1. Spring—Do not apply fertilizer on loams, silt, and clay loam soils. Sands, loamy sands, sandy loams should receive 10 to 20 pounds N per acre. Iowa State University studies suggest that using $Ca(NO_3)_2$ as the N source may help maintain berry firmness during harvest.

2. Renovation (by July 10)—Apply 50 pounds N per acre. On sands, loamy sands, and sandy loams an additional 25 pounds N per acre may be needed in late July. If heavy straw residue was turned under, increase the total N from 50 to 75 pounds per acre.

3. Mid-August—Apply 30 pounds N per acre to aid in fruit bud formation.

No P or K is usually needed during the production year if proper fertilization practices were followed prior to and during the planting year. However, take a soil test to determine fertilizer requirements.

Renovation
Renovation of strawberry plantings controls plant density, maintains plants in manageable beds, and selectively removes older plants. After the first growing season, most strawberry plantings become overcrowded and the plant population becomes too high because of the perennial growth habit and prolific runnering.

Overcrowding reduces quality and yield. Fruit size, quality, and yield decrease when the plant population becomes too great. Only six or seven plants per square foot are needed in the spring for best yields. Disease problems also increase when plantings become too dense, making foliage and fruit slow to dry after rains and more difficult to adequately spray. Renovation practices consist of the following steps.

1. Within 1 week after last picking, mow off strawberry leaves 1 inch above the crown with a rotary mower. If annual and perennial broadleaf weeds are a problem, 2,4-D alkanolamine salts may be applied after the last picking and several days prior to mowing. Do not apply 2,4-D later in the growing season because misshapen fruit may result the following spring.

2. Narrow rows with a cultivator or rototiller and thin plants in the rows by hand hoeing or harrowing across the rows. Narrow and thin rows to various degrees depending on the planting system used. Rows may be narrowed to a strip 6 to 8 inches wide with close 36- to 42-inch rows, whereas a somewhat wider strip (10 to 12 inches) may be left for wider (more than 42 inches) row spacings.

3. Fertilize after renovation.
• Heavy soils—Apply 50 pounds of N per acre.
• Light soils—Apply 50 pounds of N per acre at renovation plus another 25 pounds per acre in late July.

4. Apply herbicides for weed control (see Weed Control section).

5. Irrigate if necessary to stimulate new growth and to activate herbicides.

It is important to renovate as soon as possible, within 7 to 14 days, after the last picking to ensure that the plants recover and have plenty of time to establish new runner plants before fall. Earliest rooted runner plants normally develop the largest number of flower buds for next year's harvest.

Winter Protection
Strawberry plantings must be mulched in the fall for good winter survival and maximum yields. Temperatures as high as 15° to 20°F in strawberry crowns can damage flower buds.

Flower buds are the tissue most susceptible to winter injury followed by the crown itself. When flower bud injury occurs, plants often leaf out but no blossoms appear. Symptoms of crown injury are small, weak, and often deformed leaves in the spring. Plants with severe crown injury often collapse after leafing out. Roots are less susceptible to winter injury because they are well buffered by the soil.

To avoid cold damage to flower buds, mulch plantings when fall temperatures begin to drop into the lower 20s. This may or may not be before the ground freezes, but is usually from the middle to latter part of November in Iowa.

Straw or chopped corn stalks make excellent mulches. Apply mulches so they are 2 to 4 inches deep after settling.

In the spring, remove the mulch when the danger of injurious temperatures is past or when plants begin to show signs of growth from the crown. The earlier mulches are removed, the earlier the plants will bloom. To prevent possible spring frost damage to blossoms, it may be wise to leave the mulch on until the plants show signs of growth. Mulch is best removed by raking it into centers where it makes a clean bed for pickers and provides a clean surface for developing fruit to lie on.

Frost Protection
Strawberries frequently bloom in the spring before the danger of late spring frosts is over. Open blossoms are injured at 30°F (-1.1°C) and lower. Injured blossoms can be identified by discoloration of the flower parts. Partially injured blossoms may form deformed fruit, while severely injured blossoms will abort. Spring frosts can severely reduce yields because the first flowers are more likely to be injured and they are the ones that form the largest fruit.

The best cultural technique that will reduce frost problems is to avoid planting strawberries in low areas where cool temperatures settle and frosts occur first. Planting several varieties with slightly different bloom periods will also help reduce changes of all varieties having complete damage. Early removal of winter mulch results in earlier flowering. Leaving mulch on longer will delay bloom and chances of frost damage.

Sprinkler irrigation is the most commonly used means of protection. Turn on sprinklers when temperature drops to 34°F and leave on until the temperature rises and the ice melts. Sprinkler heads that apply ⅒ inch of water per hour are normally used for frost protection purposes. As the water freezes and ice forms, heat is released and the plants will be protected to temperatures as low as 20°F. Sprinklers should remain on after the ice begins to form for protection to occur.

Weed Control

Good weed control is one of the most important cultural practices a strawberry grower must master to achieve high production. Competition from weeds for light, water, and nutrients reduces plant establishment, plant density, fruit size, and flower bud initiation. The strawberry is a relatively shallow-rooted plant and cannot be expected to achieve high yields when competing with deeper-rooted and more competitive weed species. In addition, presence of weeds in the planting makes picking difficult and is unattractive to pickers. Studies have repeatedly shown that PYO customers pick less and do not return to weedy strawberry planting.

Weed control is best achieved through a combination of cultivation and the use of herbicides. Selection of the appropriate herbicides along with proper timing and rates of application are critical factors determining effectiveness of a weed control program. A single herbicide is often not effective in controlling all weed species present. Therefore, broad spectrum control will require using more than one herbicide during the season. Also, the use of a single herbicide for long periods will result in increasing numbers of certain types of resistant weed species, thus necessitating changing herbicides. Using more than one type of herbicide in a growing season will help reduce the build-up of resistant weed species.

Current weed control recommendations for strawberries are given in PM 1375 *Iowa Commercial Small Fruit and Grape Spray Guide* (cost pub). This is an annual publication that keeps current with pesticide regulations as they pertain to strawberries and other small fruit crops. It also provides information on the effectiveness of herbicides on various weed species. The publication NCR 281 *Weeds of the North Central States* (cost pub) will help you identify problem weeds you may encounter.

In selecting and using herbicides, remember that improperly used herbicides have the potential to do considerable damage to strawberry plants. Read the product label carefully before using a product, and calibrate your herbicide spray to apply the proper amount of product per acre. Information on spray equipment and calibration is available in NCR 520 *Chemical Applications in Agriculture, Methods and Equipment for Field Sprayers* (cost pub).

Disease and Insect Pest Control

Several diseases and insects must be controlled in strawberry production. Failure to maintain a high level of control can quickly decrease yields and reduce marketability of fruit. A detailed spray schedule for insects and diseases is provided in Pm 1375 *Iowa Commercial Small Fruit and Grape Spray Guide* (cost pub).

The following diseases are likely to occur in many strawberry plantings during certain years. Disease problems will generally be most serious in years with rainfall levels above normal.

Foliage Diseases

Powdery mildew—White patches of fungus occur on the undersides of leaves. These patches can gradually enlarge until entire lower surfaces are covered. The disease causes the leaf edges to roll upward, exposing the whitened, fungus-covered lower surfaces. Purple to reddish blotches can also appear on the undersides. Occasionally, leaf petioles, flowers, and fruits may also be attacked by the powdery mildew fungus.

Because the powdery mildew fungus apparently survives the winter on living leaves, removing leaves that appear infected before flowering begins may help reduce disease severity. Many widely available commercial cultivars are highly resistant to powdery mildew. Applying fungicides at regular intervals from the early flower period through the growing season also can control the disease and limits its carryover from one growing season to the next. However, use of fungicides to control powdery mildew on the foliage has not significantly increased yields, even for highly susceptible cultivars.

Leaf Scorch—Despite the common name "scorch," this disease is caused by a fungus rather than by physiological stress. The earlier symptom is the appearance of numerous small, 1 to 5 mm diameter, purplish, irregularly-shaped blotches on leaves (figure 6). The centers of these blotches become brownish, not white or gray as in common leaf spot. When blotches are numerous they will coalesce, and the entire leaf blade turns purplish or reddish. These discolored leaves later dry up and their margins curl up, giving a scorched or burned appearance. When conditions are particularly favorable for disease development, plants of susceptible cultivars can become seriously weakened and defoliated by late summer. In such situations, disease symptoms can appear on petioles, fruit peduncles, pedicels, calyxes, flowers, and fruits as well as leaves. Scorched calyxes ("dead cap" or "dead burr") can cause fruit to receive a lower market grade. Furthermore, leaf scorch can become progressively more damaging to perennial plantings of susceptible cultivars each year; yields may be severely reduced by the second year after the disease initially appeared.

Use of varieties resistant to leaf scorch can reduce severity of outbreaks. Starting with disease-free plants and renewing strawberry plots frequently can also help prevent losses. Applying fungicides before the onset of fruiting may control the disease satisfactorily.

Leaf Spot—The earliest symptoms of this fungal disease on leaves are small, deep purple, rounded to variably-shaped spots on the upper leaf surfaces (figure 7). As the spots enlarge to 3 to 6 mm in diameter, their centers become brown, then grayish, then white (older leaves) or light brown (younger leaves). Lesions on undersides of leaves are less intensely colored. Spots may coalesce and kill individual leaves, producing a "scorch"-like appearance. Symptom expression varies with susceptibility of the cultivar; the centers of rapidly spreading spots on leaves of susceptible cultivars may remain light brown instead of becoming white. Spots resembling those on upper leaf surfaces can also develop on petioles, calyxes, runners, and fruit trusses. Infections appear as shallow black spots, known as "black seed disease."

Leaf spot infections spread most rapidly under high rainfall and moderate temperature conditions. To control leaf spot, use resistant cultivars when practical. Plant only pathogen-free nursery

plants. If necessary, supplement these controls with application of appropriate fungicides at appropriate times. The need for a fungicide application program will probably be greater if susceptible rather than resistant cultivars are planted.

Root Diseases

Black Root Rot—Symptoms of this disease include blackening and death of feeder rootlets, deterioration and blackening of structural roots, and reduced plant vigor and productivity.

Black root rot does not have one specific cause. It can be induced by physiological stresses (such as waterlogging or freezing of soil), by a range of soil borne fungal pathogens, or by root-lesion nematodes. Often, these factors act in combination. Black root rot is most common on soils with a high clay content.

Measures such as improvement of soil aeration and/or planting on well-drained sites may help to reduce losses due to black root rot.

Verticillium Wilt—Plants are most severely infected during the first year after planting. The outer leaves show interveinal browning and ultimately collapse (figure 8). Inner leaves are stunted but remain green until the plant dies. Initial symptoms appear rapidly in late spring, especially in conjunction with periods of environmental stress, such as drought and/or onset of high temperatures. Symptoms may continue through summer and fall, although disease spread from plant to plant during a growing season is probably minimal. The disease may affect plants in clusters of varying size, with healthy plants and diseased ones often interspersed.

A number of cultivars are moderately to highly resistant to verticillium wilt. Satisfactory chemical control has been obtained by preplant soil fumigation or by preplant soil drenches with several types of compounds.

Red Stele—Plants with severely infected root systems are often stunted in above ground growth. Young leaves may sometimes be bluish-green and older leaves may be red, orange, or yellow. Less severely infected plants may show no above ground symptoms except reduction in growth rate, production of runners, and size of fruit. As with verticillium wilt, symptomatic plants tend to be distributed in irregular patches and the disease is often most severe where the soil is wettest.

The soil borne fungus that causes red stele attacks the roots. Young roots rot first at the tip. Above the tip, the stele turns red. As the disease progresses the lateral roots are killed, giving the main roots a “rattail” appearance. Eventually the crowns may also take on a red discoloration. The fungus reduces future productivity of plants most when soils are

Figure 6. Early leaf scorch symptoms.

Figure 7. Leaf spot symptoms.

Figure 8. Verticillium wilt.

wet following the fruiting period, because new adventitious roots are normally produced at this time.

Symptoms typically appear a year after planting. However, when plants are severely infected before being planted or where soil conditions strongly favor the disease, symptoms can appear during the first growing season.

Improving soil drainage and reducing soil compaction will help control red stele. Plant stock that has been tested and certified free of the red stele fungus. Select resistant cultivars. Applying appropriate soil fungicides after the fruiting period ends can protect the development of new roots during the post-fruiting period.

Fruit Rots

Several types of diseases can cause strawberry fruit rots. Information on the most common fruit rot diseases is in table 1.

Insects

Several insects injure strawberries in Iowa either directly by attacking the fruit or indirectly by reducing plant vigor. Unless control measures are followed, damage may be severe enough to drastically reduce yields and fruit quality. The most common insect pests and the damage symptoms follows.

Tarnished Plant Bug—This insect prevents normal fruit development by feeding on sap from developing berries. Fruit fails to develop in the area where feeding occurs and "button berries" or berries with apical seediness develop (figure 9).

Mites—Mites feed on undersides of leaves causing leaf mottling and eventual coppery bronze discoloration. Fine silken webbing may be present. Plants that are weakened may die.

White Grubs—These are the larval stage of the June beetles or masked chafers that weaken plants by feeding on roots. Damage may be severe where strawberries follow recently plowed sod.

Strawberry leafrollers—These insects do their damage by leaf feeding. A larva folds the leaflet and feeds inside the enclosure, eventually causing the entire leaflet to turn brown and die.

More detailed information on strawberry diseases and insect pests is available in B 861 *Midwest Small Fruit Pest Management Handbook* (cost pub).

Figure 9. Button berries that result from the feeding of the tarnished plant bug.

Table 1. Strawberry fruit rots.

	Symptoms			Control	
Disease	**Berry color**	**Berry consistency**	**Other**	**Cultural**	**Chemical**
Gray mold fruit rot	Turns light brown; no sharp border with healthy tissue. Becomes covered by velvety gray growth.	Firm; becomes tough and dry.		Space plants properly. Avoid fertilizing in spring. Mulch. Minimize cultivation until harvest.	Spray with mix of systemic and protectant fungicides from bloom until harvest.
Anthracnose fruit rots (black spot)	Tan to light brown lesions; become circular, tan to dark brown, compact, shrunken. Pink to buff spore masses in humid weather.	Firm, dry; may become mummified.	Attacks ripe or green fruits.	Mulch. Remove plant debris. Some resistant cultivars.	Protective fungicides from bloom until harvest.

Table 1. Strawberry fruit rots, continued.

	Symptoms			Control	
Disease	**Berry color**	**Berry consistency**	**Other**	**Cultural**	**Chemical**
Rhizopus rot (leak)	Gradually turns light brown. White, fluffy fungal growth with black spore bodies (pinhead size) in humid weather.	Rapid softening, collapse, leakage.	Mostly a postharvest problem; sometimes in field on ripe fruit.	Cool fruit rapidly after harvest. Store fruit below 43°F.	Protectant broad-spectrum fungicides or mixtures during ripening.
Rhizoctonia fruit rot (hard rot)	Soil adheres to infected area. Infected area brown.	Hard.	Only ripe berries are attacked. Rot occurs on side of fruit touching soil.	Mulch.	Protectant fungicides when disease appears on fruits grown through plastic mulch.
Powdery mildew	Immature berries—won't ripen. Ripe berries—white fungal growth on surface.	Hard.	Attacks blossoms and leaves also.	Resistant cultivars. Plant in areas with full sun and good air drainage.	Protectant and systemic fungicides during growing season in places where powdery mildew is a problem.
Stem-end rot	Discoloration at calyx end; distinct line between healthy and diseased tissue.			Resistant cultivars. Field clean-up at renovation time. (Weeds favor this disease).	Spray as for gray mold fruit rot.
	Small green fruits—don't ripen; browning. Large green fruits—pale red or brownish.	Hard.			
	Ripe fruits—little color change.	Soft, watery.			
Leather rot	Dull, lifeless. Green fruits—infected areas brown to dark brown. Maturing fruits—infected areas bleached to light purple.	Infected areas tough; edges slightly softened.	Bitter taste.	Mulch.	Mixture of systemic and protectant fungicides.

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