Diseases

Fruit Rots

Gray Mold (*Botrytis cinerea*): Symptoms of gray mold include light brown areas on fruit; a powdery gray growth produced on rotted fruit and leaf tissue; and whole rotted berries that retain their general shape but become tough and dry.

Gray mold is a serious problem because it often attacks other living plant parts in addition to developing and harvested fruit. The fungus overwinters in living plant tissue and proliferates in the spring as leaves die. Favored by cool, wet weather, the fungus establishes itself on dead or aging leaves, moving to healthy tissue as more and more spores are produced. Petals and other parts of older flowers are likely to be attacked first. These infections may destroy developing fruit immediately or become dormant until the fruit begins to ripen. Secondary infections may occur when spores that cling to ripening fruit germinate in moist packaging conditions after the fruit is harvested, causing uncontrollable storage rots.

Management: It is important to maintain proper spacing between plants and also narrow plant rows to allow good air circulation. This will promote rapid drying of foliage, blossoms, and fruit during periods of high humidity, rain, irrigation, or dew and lessen the chance of *Botrytis* spores germinating on plant surfaces. Beds that become too crowded are likely to promote *Botrytis* fruit rot. Heavy nitrogen applications, particularly early spring applications, also promote *Botrytis* development.

If *Botrytis* is a chronic serious problem or in years with a lot of rainfall during bloom, fungicides should be applied during the bloom period. See pest management schedule below for recommended materials and timing.

Leather Rot (*Phytophthora cactorum*): Symptoms include: fruit with dull and lifeless appearance; infected areas of immature fruit are brown to dark brown, while infected areas on ripe fruit appear bleached to lilac to normal in color; infected fruit is tough and has a bitter taste. After harvest white fuzzy growth may appear under moist packaging conditions.

This fungus is a common soil inhabitant that attacks many species of trees, shrubs, and perennial or annual herbs. The leather rot organism also causes a serious crown rot. Rainy weather promotes infection by splashing the fungus spores along with soil particles onto flowers or fruit. Maturing fruit in contact with wet soil may also become infected. Frequent fog or morning dew may supply adequate moisture for the "swimming" spores to cause infection. Fruits may be affected at all stages from blossom to maturity.

Management: Proper plant spacing and weed control for good aeration to promote rapid drying of plant surfaces. Clean straw mulch placed under plants and between rows keeps maturing fruit from getting rain-splashed soil on the surface. (Note: plastic mulch may "puddle" and actually make leather rot worse.) When conditions are very wet, and leather rot has occurred in a field, fungicides may be needed. See pest management schedule below for recommended fungicides and spray timing.

Anthracnose (*Colletotrichum* spp.): Symptoms of this disease include circular, sunken, water-soaked tan to brown lesions on both green and ripe fruit. In wet or humid weather, creamy pink to salmon colored spore masses occur in the centers of these lesions, and the fungus can produce fluffy white growth at the border of the lesion and healthy tissue. Under dry conditions, or if secondary organisms do not cause soft rots, the fruit may become mummified and black.

This fungus had not previously been reported to cause fruit rot in New England but is an extremely important pathogen of strawberries in the Southeast. In addition to fruit, this fungus may also attack stolons, petioles, and strawberry crown tissues. The same fungus has been reported to cause fruit rots of crops such as apples, blueberries, raspberries, grapes, peppers and tomatoes.

The incidence of anthracnose fruit rot may be directly related to unusually warm weather in spring. Spore production, germination, and host infection are all favored by warm, humid environmental conditions. Spread of the fungus from infected tissues to uninfected fruit and crowns occurs primarily by splash dispersal and is aided by wind-driven rain. However, spread may also occur on runners and by the movement of people or equipment through the field, especially in wet weather.

Management: Control of strawberry anthracnose is difficult, especially under warm, wet conditions. Initial planting of uninfected crowns is

important, and rotation out of strawberries for a period of time before replanting may be helpful, as the fungus overwinters on infected plant tissues or infested debris in the soil. Fungicides may be helpful in reducing infection, but may be less effective in hot, humid weather. Overhead irrigation of fields with infected plants or fruit and the movement of people or equipment through wet fields can increase spread of the pathogen. However, the retention of a straw mulch between rows will help reduce splash dispersal of the fungus. See pest management schedule below for recommended materials and timing.

Foliar Diseases

Bacterial Angular Leaf Spot (*Xanthomonas fragariae*): Angular leaf spot is a bacterial disease caused by *Xanthomonas fragariae*. Relatively little is known about the disease. It is not thought to be a consistent annual problem. Rather, it has only recently appeared in New England. Early symptoms on the leaves are tiny, water-soaked areas. When viewed against a bright light, lesions are translucent, but when viewed against a normal or dark background, the lesion areas are dark green. As the disease progresses, it may develop symptoms which are similar to common leaf spot, leaf scorch and Phomopsis leaf blight. Chlorotic halos will form, areas of tissue will appear red, and the lesions on leaves and petioles will join together into large, irregularly shaped areas. The most severe problem, from a marketing perspective, is that the calyx of the berries may become infected, darkening it and making the berries less attractive. To date in Massachusetts, the disease has damaged plants, limiting growth, but has not caused plant mortality. Reports from California indicate that infections can become systemic and will occasionally kill plants.

Inoculum for the first lesions in the spring comes from infected dead leaves. The bacteria are very resistant to drying and other harsh conditions, and may survive for a long time in the old leaves or in buried plant tissue in the soil. The pathogen does not move in the soil, or survive free in the soil. The bacteria may move from new lesions to other plants. It can be spread by rain or irrigation, or carried from plant to plant when fields are being worked. Wet, cool weather in the spring encourages the bacteria to build up to damaging levels. Long periods of rain, or frequent irrigation at times when the day temperatures are around 65½ F, and night temperatures near 35½ F, will encourage growth and spread of this disease.

Management: In general, antibiotics (streptomycin or oxytetracycline) or copper-containing pesticides are used to treat bacterial plant diseases. While some sources say these treatments will protect against angular leaf spot, field tests have shown only moderate success at best. Copper applications can damage strawberry plants.

In the absence of any better information, it is best to take a two-pronged approach where angular leaf spot has been a problem. First, in fields with a history of this disease, inoculum should be reduced by removing as much leaf debris as possible from the field at renovation. Rotate out of severely infested fields for at least a year. Second, begin scouting fields with a history of this disease as soon as buds extend from the crown. Continue scouting until bloom. If symptoms are observed, discontinue irrigation unless needed for frost protection or when excellent drying conditions prevail. Minimize the time leaf and blossom tissue is wet. Also, avoid worsening the problem by working in the field when the leaves are wet.

Leaf Spots

Fungal diseases of the leaf may occur as soon as the first leaves unfold in early spring until dormancy in the late fall. Generally, these diseases do not exceed an economic threshold that calls for chemical control. The primary damage of leaf diseases is a loss of vigor through reduced leaf area that is needed to support the plant. If outbreaks of these leaf diseases become significant, the plants will become weakened during winter dormancy and become more susceptible to root diseases and winter injury.

The three major leaf fungal pathogens have a similar life cycle. Leaf spot, leaf scorch, and leaf blight all overwinter in infected dead or living leaves, producing spores and new infections during moist, warm conditions.

Leaf Spot (*Mycosphaerella fragariae*): Symptoms of leaf spot first appear as circular, deep purple spots. The spots enlarge and the centers turn grayish to white on older leaves and light brown on young leaves. A definite reddish purple to rusty brown border surrounds the spot.

Spores overwinter in lesions on living leaves.

More spores are produced in early summer in spots on the upper and lower leaf surface, and are spread by splashing rain. Middle-aged leaves are most susceptible. Lesions also develop on fruit, stems, petioles and runners.

Leaf Scorch (*Diplocarpon earliana*): Symptoms of this disease consist of numerous small, irregular, purplish spots on leaves. The center of the blotches becomes brownish. Blotches may coalesce, covering the leaflet which then appears purplish to reddish to brown.

Fruiting structures are produced in the spring on lower leaf surfaces of dead leaves. Spores are produced most abundantly in midsummer. Oldest and middle-aged leaves are infected more readily than young ones.

Leaf Blight (*Phomopsis obscurans*): Symptoms of leaf blight infections begin as one to six circular reddish-purple spots on a leaflet. Spots enlarge to V-shaped lesions with a light brown inner zone and dark brown outer zone. Lesions follow major veins progressing inward. The whole leaflet may turn brown. In severe cases, stolons, fruit trusses and petioles may become infected which may girdle and kill the stem.

The fungus overwinters as mycelium or fruiting structures on the old leaves that remain attached to the plant. Spores are spread by rain splash early in the spring. Leaf blight is most destructive to older leaves
in the late summer. Calyxes and fruit may also be infected.

Management: Leaf scorch and leaf spot are mainly controlled by use of resistant varieties. (See chart of disease resistant varieties.) No resistant varieties to leaf blight are known. Cultural practices and fungicides recommended for controlling fruit rots are also beneficial for managing leaf spot diseases, e.g. proper plant and row spacing for good air drainage and plant vigor. Mowing or removing the tops and old leaves at renovation has benefits for managing leaf diseases. But, this practice is only effective for this purpose if the mowings are removed from the field or thoroughly incorporated into the soil by tilling. Leaves less than 3 weeks old are susceptible to infection by leaf spot; older leaves are resistant. See pest management schedule below for recommended materials and timing.

Powdery Mildew (*Sphaerotheca macularis*): Symptoms include white powdery growth on the lower leaf surface, causing the leaf edges to roll upward. (Note: Some herbicides will cause leaf rolling on certain varieties.) Infected flowers and ripe fruit may also become covered with white growth; and infected green fruit may fail to ripen and will remain hard.

This fungus overwinters on living infected leaves. Infection periods are favored by dry weather and temperatures between 58½ and 68½F. Thus, if a severe foliar infection occurs, it does so late in the season. Controlling these foliar infections with fungicides does not apparently increase yields. However, by controlling foliar infections, the amount of inoculum available to infect the spring growth is reduced. Crop losses occur as a result of flower and fruit infections.

Management: See pest management schedule for recommended materials and timing, and variety selection chart for resistant varieties.

Root Rots

The strawberry root system is composed of three types of roots: the perennial and structural roots that originate from the crown, and the transient feeder rootlets that originate from the perennial or structural roots. The structural roots are light in color with a well developed cortex. The perennial roots are dark due to the sloughed cortex surrounding woody secondary growth and are more or less permanent. They store food reserves to maintain the plant through winter dormancy.

Structural roots are produced from the crown during the current year. Transient feeder roots consisting of primary tissues are produced from both structural and perennial roots. They may only live a few weeks and are replaced during the growing season; they are constantly dying back and being replaced. The transient roots function to absorb water and nutrients; the perennial roots cannot. Thus, all types of roots are important in maintaining healthy plants and good yields. Death to transient rootlets by pathogens or unfavorable soil conditions is not as damaging to plant vigor if the plant is able to replace them. However, often the structural and perennial roots also become infected. When this happens, the plant is greatly weakened, producing little or no fruit. Plants may suddenly wilt, or plants

which were healthy the previous season may develop slowly in the spring. Proper diagnosis of soilborne problems requires careful examination of the roots and crown.

Red Stele (*Phytophthora fragaria*): Symptoms of red stele infection are numerous: wilting; young leaves with a bluish-green tint; and older red, orange or yellow leaves. Severely diseased plants may die or remain stunted, producing few runners and small berries. When roots are cut open lengthwise, the core will show a reddish-brown discoloration; however, a reddish core does not guarantee that red stele is present. Plants showing symptoms usually occur in patches where the soil is wettest.

This fungus causes a root rot and wilt, and is a major disease of strawberries where cool, wet soil conditions occur. The fungal spores actually swim and need water in the soil in order to find and infect roots. The fungus enters the main perennial roots and grows along the stele, the plant's food and water transport system. Roots begin to rot from the tip within a few days after infection. Depending on the extent of the infection and the plant's resistance, stunting or wilting and collapse of the plant will result.

Management: Good soil drainage, texture, and planting in raised beds in wet areas will discourage growth of the fungus. Purchase planting stock only from nurseries that have been inspected and certified disease-free. Disease resistant varieties are available. Consult your nursery supplier for more information. Pre-plant soil fumigation may reduce *P. fragaria* infestation in soil but avoiding wet sites is more reliable. Post-plant treatment with a systemic fungicide is also an option. See pest management schedule for materials and timing.

Verticillium Wilt (*Verticillium albo-atrum*): Symptoms of Verticillium wilt are marginal and interveinal browning and eventually collapse of outer leaves; inner leaves are stunted and may wilt but tend to remain green until the plant dies.

This fungus has a wide host range among annual and perennial crops and weeds. *Verticillium* is spread from field to field by water, wind or on infected planting stock, and crop and weed debris. Plants that are fruiting are affected more severely, and the first symptoms are noticeable as temperatures increase in late spring.

Management: Do not use solanaceous crops (such as tomato or potato), or squash or raspberries for rotation crops. In addition, control pigweed and lamb's-quarters which are also hosts for Verticillium. Preplant soil fumigation may help in managing this disease. See disease resistant variety chart for selection of resistant varieties.

Black Root Rot: Above-ground symptoms of this disease are similar in appearance to red stele. That is, a general lack of vigor and eventual collapse of plants especially during dry weather. Underground symptoms consist of blackened feeder roots and, eventually, structural and perennial roots. Structural roots will rot from the outside to the center, leaving the core white for a period of time, unlike red stele where the core is usually red.

Black root rot has no simple causes or remedies. It is a disease complex, involving several pathogens combined with plant stress. The key pathogens include *Rhizoctonia, Pythium,* and lesion nematode. The pathogens involved in this disease are commonly found in soils but usually don't cause disease symptoms on healthy plants. Stressed plants are a different story. Strawberry plants may be stressed in a number of ways, such as drought, winter injury, root feeding insects or nematodes, poor nutrition, soil compaction, or improper herbicide use. Stresses reduce the plant's resistance to disease. Long after the initial stress, root rotting pathogens may infect and continue to damage the plant's roots and crown.

Management: Control of black root rot in an existing field is difficult since there is no systemic material that can be applied for control. Stress management is the key to black root rot management. Therefore, replacing winter mulch that has blown off, irrigating during dry weather and after renovation, maintaining good nutritional status in the plants, and not allowing the soil to be compacted are important practices to reduce plant stress and thereby reduce possibility of black root rot developing in the field.

The long-term strategy for managing black root rot relies on site selection and crop rotation. Choose a site which has well drained soil with good soil organic matter content and has not grown strawberries recently. Where black root rot has been a problem, a rotation with a 3-6 year period without strawberries is recommended. This long rotation is needed because causal organisms can persist in the soil for a long time. Using a variety of crops and cover-crops in this period is recommended to help break up the disease cycle and avoid alternate hosts of this disease.

Soil fumigation for controlling black root rot can work well, but can also fail under certain conditions. Fumigation sterilizes the soil of pathogens and beneficial organisms. Organisms reintroduced in this "clean" soil grow rapidly in the absence of competition or predators. Pathogens, even in very small quantities, in soil from non-fumigated areas carried into fumigated areas on shoes, equipment or roots of strawberry transplants, may allow pathogens to build up to high levels. Thus, soil fumigation runs the risk

Table 14. Strawberry cultivar descriptions.

		— DISEASE RESISTANCE[a] —				
CULTIVAR	SEASON	VERTICILLIUM WILT	RED STELE	LEAF DISEASES[b]	POWDERY MILDEW	COMMENTS
Earliglow	Early	R	R	R	PR	Standard for early varieties; small berry size; excellent flavor, moderate production.
Veestar	Early	R	S	S	S	Early, good flavor and appearance, berry size medium to small, productive.
Sable	Early	U	R	U	U	Early, good flavor, productive. Berry size medium.
Annapolis	Early	R	R	S	S	Large fruit, good flavor but soft, moderate yields.
Mohawk	Early	R	R	R	R	Fruit size may be small, and yields low in far northern areas.
Northeaster	Early	R	R	R	S	Large fruit, strong flavor. Moderate plant vigor.
Honeoye	Early-mid	S	S	PR	S	Large fruit, productive; has performed well in New England, but lack of red stele resistance a concern. Tends to become soft in hot weather; flavor distinctive.
Guardian	Mid	R	R	R	S	Very productive, firm large fruit, sometimes rough (uneven) looking. Botrytis is generally more prevalent. Tends to get a "long neck" which breaks down and is an easy entry for slugs and sap beetles.
Redchief	Mid	PR	R	R	R	Productive, with good color and size. Flavor average. Excellent disease resistance.
Lester	Mid	S	R	R	R	Productive good berry size though size tends to "run down" quickly. Flavor is good. Lacks adequate winter hardiness for northern New England.
Cavendish	Mid	R	R	R	U	Mid-season, productive. Disease resistant, uneven ripening habit.
Kent	Mid	S	S	PR	S	Extremely productive berry with large firm fruit. Tends to yield fruit in middle of rows, resulting in high rot, so keep rows narrow. Flavor average.
Jewel	Mid	S	S	R	PR	Large soft fruit, can be very dark. Tends to soften in hot weather.
Mira	Mid	S	R	R	R	Large fruit, good quality.
Allstar	Mid-late	R-T	R	T	T	Productive, elongated flavorful berries. Has a lighter color than most berries. Good fruit size.
Seneca	Mid-late	S	S	U	U	Fruit large, irregular and firm; plants moderately vigorous.
Mesabi	Mid-late	R	R	PR	U	Productive with good berry size, scarlet color, good flavor. Plants compact, resistant to 5 races of red stele.
Winona	Mid-late	S	R	R	R	Large fruit, vigorous plant.
Lateglow	Late	R	R	PR	S	Productive, good berry size and flavor. First berries extremely large. Low yields in northern New England.
Tribute	Day Neutral	PR	R	T	R	Slightly later than 'Tristar,' with larger fruit. Flavor not as strong, and plants are more vigorous.
Tristar	Day Neutral	R	R	T	R	Bears an early crop, smaller than 'Tribute,' flavor is excellent. Flesh and skin firm. Moderate vigor. Size reduced when weather is too hot.

[a] I=intermediate, PR= partially resistant, R= resistant, S= susceptible, T= tolerant, U= unknown. [b]Includes leafscorch and leafspot.
Adapted from Pennsylvania State University, Small Fruit Production and Pest Management Guide. Used by permission.

Table 15. Efficacy of fungicides for strawberry disease management.

Fungicide[a]	Gray mold	Leather rot	Leaf spot	Powdery mildew	Anthracnose	Red Stele
Alone						
Aliette[b]	-	+++	-	-	-	++
Cabrio	++	?	+++	+++	++++	?
Captan	+++	+	+++	-	+++	-
Elevate[c]	++++	-	-	-	-	-
Quadris[d]	+	+	+++	+++	++++	-
Ridomil Gold	-	+++	-	-	-	++++
Sulfur	-	-	-	+++	-	-
Switch[e]	++++	-	-	-	++	-
Thiram	+++	+	++	-	+++	-
Topsin-M[c]	+++	-	+++	++	+	-
In Combination						
Topsin-M plus captan	+++	+	+++	+++	+++	-
Topsin- M plus thiram	+++	+	+++	+++	++	-
Elevate plus captan	+++	+	++	-	++	-
Elevate plus thiram	+++	+	++	-	+	-

Efficacy rating system: ++++= excellent; +++=good; ++=moderate; +=poor; - =not effective or not labeled for this use; ?+ unknown.

[a] *This is not a complete listing of the fungicides used for strawberry disease management.*

[b] *Limited efficacy data available for Aliette.*

[c] *___Fungicide that is prone to develop resistant strains of fungi For resistance management, Topsin-M, and Elevate are recommended only in combination with an unrelated fungicide such as; captan or thiram.*

[d] *This material is extremely phytotoxic to McIntosh and some other apple varieties and should not be used near apples or in a sprayer also used on apples.*

[e] *Note restrictive plant back regulations ont his product.*

of favoring Black Root Rot rather than controlling it. Moving to a planting site which has not grown strawberries recently, and is well-drained is the best method of managing this disease.

Virus Diseases

Viruses are disease-causing organisms so small they cannot be seen with an ordinary microscope. Several viruses infect strawberries in the Northeast, and it is not uncommon for two or more viruses to be found within the same plant. Viruses in a plant may not show obvious symptoms. However, their presence does weaken the plant.

Loss of vigor and yield caused by viruses are more likely to show up when growing conditions are unfavorable and plants are stressed. Virus symptoms on strawberries, include chlorotic (yellow) spots or irregular patches on leaves. Leaves may crinkle, or otherwise be malformed. Herbicide injury and virus symptoms may be similar.

Management: Once strawberry plants are infected with a virus, they cannot be cured. The infection is passed on to all daughter plants via runners. Most viruses are spread from plant to plant via aphids. Chemical insecticides will not kill aphids before they are able to transmit viruses and may even stimulate aphids to feed. Planting virus-free material will decrease overall damage from virus diseases.

Insects

Fruit Damaging Insects

Tarnished Plant Bug (*Lygus lineolaris*): The tarnished plant bug (TPB) is a small (1/4") bronze-colored insect with a triangular marking on its back. The immature stage, or nymph, is smaller and bright green, resembling an aphid, but much more active. Both adults and nymphs feed on the developing flowers and fruit, sucking out plant juices with straw-like mouth-parts. This results in deformed fruit: typically “cat-faced” berries, also called nubbins or button berries. Such fruit are generally unmarketable.

Management: Controlling weeds in and around the planting may reduce populations of this insect, but insecticide sprays may be necessary. If mowing around fields, do so after insecticides have been applied (to control migrating insects). Avoid planting strawberries near alfalfa which attracts high populations of TPB. White sticky traps are available for