Strawberry Diseases in Michigan
Michigan State University Extension Service
Sandra Perry and Donald Ramsdell, Department of Botany and Plant Pathology
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Sandra Perry and Donald Ramsdell, Department of Botany and Plant Pathology

Soil-Borne Root Diseases

Verticillium Wilt

The fungus *(Verticillium albo-atrum)* that causes Verticillium wilt can be very damaging to strawberry plantings. Several common garden crops (tomatoes, potatoes, peppers, eggplants) and some woody ornamentals are also susceptible to this disease. The fungus can survive in the soil for many years. Wounds are not necessary for infection — it occurs by direct penetration of roots in infested soil. In new strawberry plantings, disease symptoms appear about the time runner production begins (mid-July). In established plantings, the symptoms appear as the fruit begins to ripen.

Fig. 1. Verticillium wilt-diseased strawberry plant.

Symptoms:

1. Older outer leaves wilt, turn brown around the edge and between the veins (Fig. 1).
2. Leaf Petioles may turn red.
3. The crown and roots may show a brown discoloration indicating decay (Fig. 2).

Control: The fungus can be introduced into "clean" soil by infected planting stock or by using implements contaminated with Verticillium-infested soil.

The disease is most easily controlled by planting resistant varieties of strawberries (see Table 1 for a list of varieties and their disease resistance). To reduce the chances of Verticillium wilt, do not plant strawberries following tomatoes, potatoes, peppers, or eggplants.

Preplant soil fumigation should be done in the autumn prior to spring planting, to help control Verticillium wilt. Proper soil preparation for several months prior to fumigation is essential. Consult the MSU Fruit Pesticide Handbook (Extension Bulletin E-154) for soil fumigant recommendations.

Red Stele

Red stele root rot is caused by the fungus, *Phytophthora fragariae.* This pathogen survives overwinter in infected roots and can persist in the soil for many years. Red stele disease is worse in heavy soil or poorly drained planting sites. The fungus is most active in the spring and fall when soils are cold and wet.

Symptoms: Disease symptoms don't become evident until the bearing year (second season of growth). The fungus produces spores (zoospores) that are spread by water and mechanical means

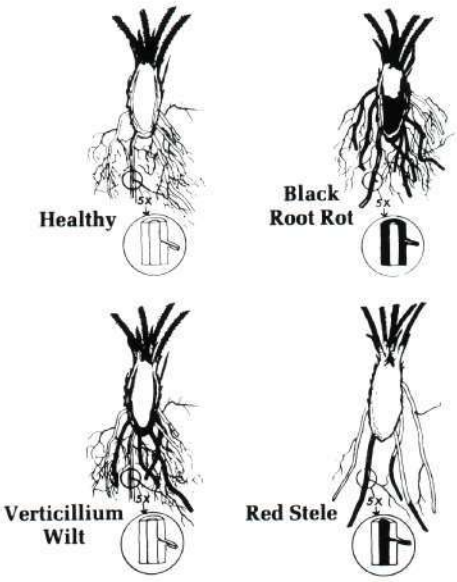

Fig. 2. Strawberry roots and crowns: healthy, black root rot, Verticillium wilt and red stele. (Diagram courtesy of Cornell University, Ithaca, New York)

Table 1. Disease Resistance in Strawberry Varieties.

Variety	*Time of Ripening (in June)*	*Red Stele*	*Verticillium*	*Leaf Spot*	*Leaf Scorch*	*Powdery Mildew*
Earliglow	Early	R	MR	MR	MR	MR
Darrow	Early	R	MR	MR	MR	MR
Midland	Early	S	S	R	R	S
Redglow	Early	MR	S	S	S	S
Sunrise	Early	MR	R	S	R	R
Fairfax	Early	S	?	R	R	MR
Robinson	Middle	S	R	SS	MS	S
Guardian	Middle	R	R	MS	R	R
Pocahontas	Middle	S	S	MS	MS	MS
Midway	Middle	MR	MR	MS	S	?
Sure Crop	Middle	MR	R	R	R	?
Catskill	Middle	S	R	SS	R	R
Redchief	Middle	R	MR	MS	R	R
Sparkle	Late	MR	S	S	MR	R
Marlate	Late	S	MR	R	MR	?
Fletcher	Late	S	R	R	R	R
Scott	Late	R	MR	?	R	R

MR = moderately resistant, R = resistant, SS = slightly susceptible, MS = moderately susceptible, S = susceptible, ? = unknown

(machinery, tools, shoes, etc.). These spores infect and destroy the small hair roots giving a "rat tail" appearance to the remaining root system. The normally cream colored core (stele) of the roots turns a rusty red to dark-brown (Figs. 2 & 3). The discoloration may include the entire stele or only the stele at the root tips. These symptoms are best seen in the spring by cutting a root lengthwise.

The fungus is restricted to the roots but any interference with root function is soon seen in leaf symptoms. New leaves are small and bluish green, while old leaves turn yellow or red. Plants are stunted, and little or no fruit is produced. Infected plants die out very quickly during dry weather.

Winter injury can also cause plants to appear stunted but there will be discoloration in the plant crown that is not present with red stele.

Control: Select a well drained planting site with loamy soil. Purchase resistant plants from reputable growers. Resistance to red stele disease is a relative term, however. There are at least five distinct biological races of the causal fungus and all varieties of strawberries are not resistant to all races of the fungus. Preplant soil fumigation is only a partially effective control practice for this disease. Resistant varieties are the best means of control. Inspect roots at planting time and discard any having a "rat tail" appearance.

Black Root Rot

The exact cause of this root rot is not known. Any condition that causes root injury or generally weakens plants will produce symptoms of black root rot. One or more of the following factors are associated with its appearance: soilborne fungi, nematodes, drought, winter injury, excessive fertilizer application, or excessive soil moisture. Plants may wilt, appear stunted, or die outright. The leaves may turn purplish with red petioles.

By the second growing season, the main, or perennial roots of a healthy strawberry plant become woody. They have a dark brown or black outer covering and the inside is usually lighter colored. There should be masses of fine white feeder roots branching from the main roots. A plant affected by black root rot will have brown or black (inactive) feeder roots or none at all. The outer root covering will die and pull off easily. The white core of the main roots may turn black in patches or along the entire length of the root (Figs. 2 & 4).

Control: If the disease is present in an established bed, abandon that bed and choose a new site. The alternative is to plow the plants under, work the soil for several months, fumigate the soil in the autumn, and plant healthy strawberry plants in the spring. Consult the MSU "Fruit Pesticide Handbook" (Extension Bulletin E-154) for fumigant recommendations. Proper cultural practices can help minimize the occurrence of black root rot. Plant certified disease-free stock into a fertile, well-drained sandy loam. Incorporation of organic matter at planting time stimulates beneficial biological activity in the soil. Adequate summer mulch prevents drought stress and a layer of mulch over the plants for winter prevents winter injury to the crown.

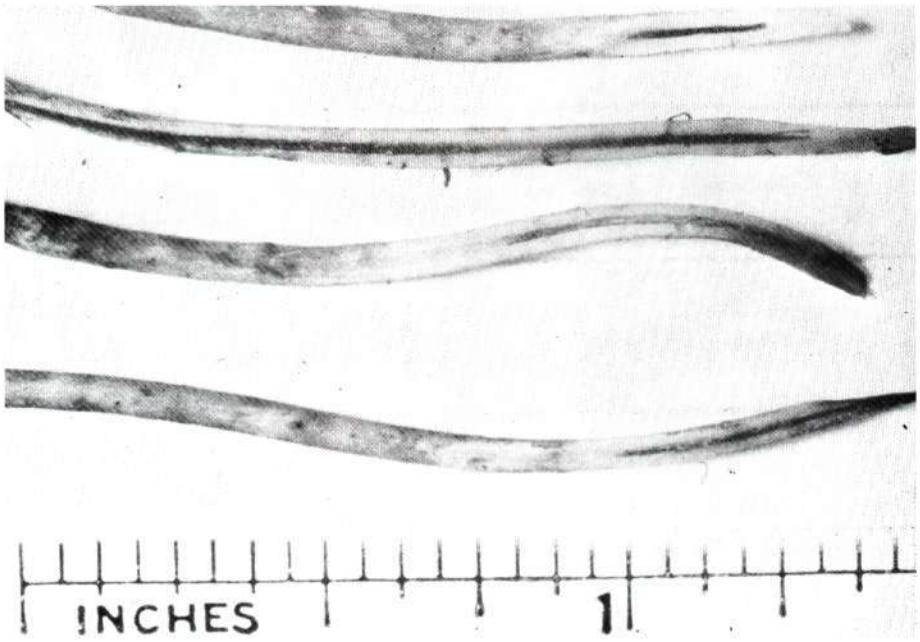

Fig. 3. Discolored root core (stele) resulting from red stele root rot.

Fig. 4. Darkened roots from black root rot. Note the white feeder roots at the crown of the plant.

Fruit Rot Diseases

Grey Mold

This disease is caused by the fungus, *Botrytis cinerea,* which overwinters on plant debris on the ground. Rainy or humid periods favor disease development. At the beginning of bloom, the fungus attacks the blossoms and causes a blossom blight leading to considerable crop loss. Fungus spores form on the blighted blossoms and infection spreads to both green developing fruit and ripening fruit. The disease first appears on fruit as small, water-soaked areas which are soon covered with grey, fuzzy-spore masses (Fig. 5).

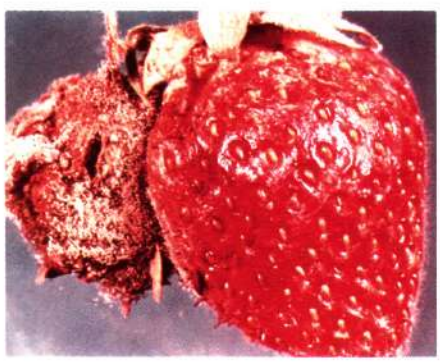

Fig. 5. Fuzzy spore masses on a Botrytis infected strawberry.

Control: Fungicide sprays beginning at first bloom and continuing at 7 to 10

day intervals through harvest are effective in controlling grey mold. See Extension Bulletin E-154 for fungicide recommendations.

Stem End Rot

This disease causes a rot at the stem end of the strawberry fruit. The disease is caused by the fungus *Dendrophoma obscurans* which overwinters in plant debris on the ground. In early-mid April, at about the time buds emerge from the crown, the fungus attacks the new leaves and causes the primary infection. Later, when fruit has formed, the calyx (fruit cap) becomes infected and instead of remaining green and healthy, turns brown. The fungus enters the fruit through the infected calyx, causing it to rot (Fig. 6). If uncontrolled, a considerable number of fruits may be rotted by harvest time. There is a leaf infection phase connected with stem end

Fig. 6. Diseased fruit cap and beginning of berry infection from stem end rot. Note healthy berry left center.

rot. It is called strawberry leaf blight — described under "leaf diseases" in this publication.

Control: Apply the first fungicide spray when leaves have expanded in the spring and flower buds are just emerging from the crown. Subsequent sprays aimed primarily at control of grey mold will control stem end rot for the duration of the season. Consult Extension Bulletin E-154 for fungicide recommendations.

Leather Rot

This disease is caused by the fungus *Phytophthora cactorum*. Ordinarily, leather rot is not very important, especially if Captan fungicide is an integral part of the spray program. This disease can become very important in some years, given favorable environmental conditions. Ripening fruit clusters that are touching the ground or standing in water after prolonged warm rains suddenly (in a day or two) turn grey-brown and become mushy. The fruit stems often become rotted. The disease progresses rapidly and a rotten smell pervades the field. After a few days, infected berries start to dry out and become leathery. If infected berries are cut longitudinally, the vascular system of the fruit is darkened and shows up as dark streaks radiating from the fruit core outward (Fig. 7).

Fig. 7. Discolored vascular system with radiating brown streaks in a Phytophthora (leather rot) infected berry.

Control: Apply Captan 50W fungicide at the rate of 5 lb/acre as soon as symptoms are seen. Thorough spray coverage is essential! Follow-up sprays at 2 to 3 day intervals are necessary if rainy weather continues. Withhold sprinkler irrigation until the field surface dries out.

Leaf Diseases

Leaf Scorch

The fungus *(Diplocarpon earliana)* causing leaf scorch can live through the winter in old, infected strawberry leaves. Spores are easily spread by splashing rain or by mechanical means, such as by machinery or people passing through an infected planting. The first symptoms are irregular purple spots 1/4" in diameter scattered profusely over the upper leaf surface (Fig. 8). Spots may appear at any time during the growing season. As the spots age, black pimple-like fruiting bodies of the fungus are produced in the center of each spot. Spots may rapidly become so numerous that the entire leaf dries up and looks

Fig. 8. Purple spotted leaves typical of leaf scorch disease.

"scorched" as though by fire. Spots may also occur on petioles, stolons and fruit stalks.

Control: Plant resistant varieties. Remove and destroy leaves after fruit bearing. The grey mold/stem end rot fungicide program will usually control scorch. Consult Extension Bulletin E-154 for appropriate fungicides.

Leaf Blight

Leaf blight is caused by *Dendrophoma obscurans,* the fungus which also causes stem end rot. The leaf blight symptoms first consist of roughly circular, purplish spots, 1/8 to 1/4 inch in diameter. Later, these lesions coalesce to form large V-shaped dead areas in the leaves following the major leaf veins (Fig. 9).

Control: See control for stem end rot.

Fig. 9. Leaf spots and larger lesions along veins caused by leaf blight disease.

Leaf Spot

This disease is caused by the fungus *Mycosphaerella fragariae*. The fungus overwinters on old, infected, strawberry leaves. In the spring, the pathogen attacks young leaves, leaf stalks, calyces (caps) and stolons. Infection is favored by cool, wet weather. Leaf spots are circular and 1/8 to 1/4 inch in diameter (Fig. 10). The center of the lesion or spot is tan and has a purple border. This

Fig. 10. Purple bordered tan spots found on leaves with leaf spot disease.

same fungus can also cause a fruit disorder called "black seed," but it is not usually important in Michigan.

Control: Certain varieties are more resistant than others. The normal fungicide sprays applied to control fruit rots will usually control leaf spot. However, leaf spot disease can build up during the first year after planting when growers do not apply many fungicide sprays to non-bearing plants. Consult Extension Bulletin E-154 for fungicide recommendations.

Powdery Mildew

Powdery mildew is not a serious disease of strawberries in Michigan. The fungus *(Sphaerotheca macularis,* appears as a greyish-white coating on the undersides of leaves late in the growing season. Diseased leaves curl upward and turn red or purple in color. Leaf function is impaired but symptoms develop so late in the season that plant vigor is seldom affected.

Control: Use resistant varieties.

Virus Diseases

There are several virus diseases that can infect strawberries. Visible symptoms may not be evident in the plants, however, plant vigor is generally affected — causing the plants to die when weather conditions become unfavorable. Visible symptoms can include leaf crinkling, variegation, cupping, and stunting. Plants showing these symptoms should be removed and destroyed. The predominant virus disease of strawberries in Michigan is "June Yellows" (Fig. 11). The main

Fig. 11. Stunted and discolored leaves resulting from "June Yellows" virus infection.

symptoms are stunting and yellowing of leaf margins.

Control: Purchase only certified virus-free strawberry plants. Many strawberry viruses are transmitted by aphids. The only way to assure that the plants remain reasonably virus-free is to carry on an aphid spray control program throughout the growing season. However, if the strawberry bed is renewed every 2 to 3 years, virus build-up should not become a problem and no control measures are necessary.

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