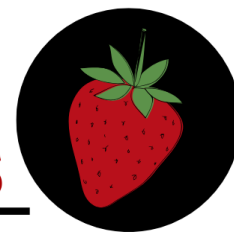


Disease Management in Home Strawberry Plantings



DEPARTMENT OF PLANT PATHOLOGY

Introduction

There is probably nothing more frustrating for a backyard gardener than to see the fruit of their labor lost to diseases and other pests. Diseases occur when environmental conditions are suitable for pathogens to attack the host plant. Some pathogens attack a wide variety of plants, whereas others attack only specific plants. Additionally, some pathogens can attack all plant parts, whereas others attack only selected tissues (i.e., flowers, fruit, roots, etc.).

Many types of microorganisms cause infectious diseases of plants, but the five major groups of plant pathogens are fungi, water molds, bacteria, viruses and nematodes. Adverse environmental conditions also can cause disease-like symptoms on plants; referred to as disorders. These include improper soil pH, nutrient deficiencies and toxicities, soil compaction, excess water, herbicide damage and more. Plants weakened by adverse environmental conditions may be further predisposed to attack by pathogens.

Successful disease management begins with accurate identification of the cause of the problem. Knowing the common diseases of individual crops aids greatly in disease identification and management. Many diseases are readily identified based on characteristic signs (observation of the pathogen) and symptoms (observation of damage to the plant) of disease. The identification of other diseases requires microscopic examination of diseased tissues or even more sophisticated laboratory techniques, both of which are available through the C. Wayne Ellett Plant & Pest Diagnostic Clinic, CFAES – Wooster, Wooster OH.

Disease Management

Prevention is the key to disease management in the backyard garden. There are several disease management options for the backyard strawberry grower that have minimal impact on the growing environment yet help to maintain a healthy crop. Creating an optimal growing environment for strawberries will minimize plant stress, which in turn will reduce plant disease susceptibility and ultimately improve crop yield and the aesthetics of the planting.

Several synthetic chemicals and natural products (also called biopesticides) are available to aid in the management of plant diseases, but they should always be used in conjunction with cultural practices intended to modify the environment to make it less conducive to disease development.

Site Selection and Preparation. Strawberries are prone to many root diseases making site selection a critical first step to ensuring a healthy and productive crop. Strawberries can grow in a wide range of soil types but grow best in sandy loam soil that is rich in organic matter (2 – 3%) and slightly acidic (pH of 5.8 – 6.5). Strawberries should be planted in areas that have good water drainage, on high ground to encourage good air circulation and reduce the risk of frost injury and receive 6 – 8 hours of direct sunlight. Grassy or weedy locations should be avoided, or the site should be treated with an herbicide or cultivated and left fallow for a season prior to planting. To avoid the build-up of root-rotting pathogens in the soil strawberries should be rotated to different areas of the garden every 2 – 3 years.



THE OHIO STATE UNIVERSITY
EXTENSION

CFAES provides research and related educational programs to clientele on a nondiscriminatory basis. For more information, visit cfaesdiversity.osu.edu. For an accessible format of this publication, visit cfaes.osu.edu/accessibility.

Variety Selection. In addition to flavor, bloom time, or cold hardiness, resistance to common diseases should be considered when selecting a variety for the backyard garden. A list of varieties recommended for Ohio and their susceptibility to diseases is provided in Table 1. Whether you prefer to start with bareroot plants or plugs, always inspect the plants for signs and symptoms of disease and insect pests. If plants show signs or symptoms of disease do not plant them. Planting disease resistant varieties can reduce the need for fungicide and bactericide applications.

Mulching. The application of mulch has many benefits including protecting the plants from cold injury, keeping plants cool during the summer, soil moisture conservation, and weed control. Organic (i.e., straw, hay, pine needles) mulch reduces winter injury and reduces fruit and flower diseases by acting as a barrier to spores that are present in the soil. In the spring, organic mulch should be removed and replaced with fresh mulch. Organic mulches can be contaminated with weed seed,

contain herbicide residue that can injure the plants, or harbor insect pest larvae, so it is important to check with the supplier to determine the source of the mulch and how it was prepared.

Sanitation. Sanitation involves physically removing or destroying crop debris, diseased plant material, and weeds. Practicing sanitation throughout the season helps lower pathogen populations and limit the spread of disease. Effective weed control is crucial, as weeds attract insects, restrict airflow, and compete with strawberries for nutrients and water. Fruit should be harvested as soon as it ripens. Overripe or rotting fruit should be promptly removed and discarded. Do not leave fruit in the planting as several pathogens will overwinter on decaying plant material, including fruit. After harvest, the planting should be renovated by mowing the canopy and removing the clippings.

Synthetic Chemicals. There are several chemical control products available to the backyard gardener for controlling strawberry diseases caused by fungi.

Table 1. Strawberry Varieties for Backyard Plantings

This is a partial list of varieties suitable for Ohio growing conditions. A more comprehensive list is available in the Midwest Strawberry Production Guide (OSU Bulletin 926). R = resistant, MR = moderately resistant, S = susceptible, — = insufficient information

Variety	Leaf Spot	Leaf Scorch	Powdery Mildew	Verticillium Wilt	Phytophthora Crown Rot
Albion	S	S	S	R	R
Allstar	MR	MR	R	R	S
Cavendish	R	R	R	MR	S
Chandler	S	S	S	S	S
Delite	R	R	MR	R	S
Earliglow	R	R	S	MR	S
Guardian	S	R	S	MR	S
Honeoye	R	R	MR	S	S
Jewel	S	S	S	S	S
Lateglow	MR	MR	MR	R	S
Lester	R	R	R	R	S
Redchief	S	R	R	R	S
Scott	S	R	R	MR	S
Sparkle	S	S	S	S	S
Sunrise	S	R	R	R	S
Surecrop	MR	MR	-	R	S
Tribute	MR	MR	R	R	S
Tristar	MR	MR	R	R	S

Most of the available products work on contact and must be applied before the disease occurs or as soon as disease symptoms first appear. The most common fungicidal products for backyard garden use on strawberries contain sulfur, copper, or captan. Copper is the only chemical control product that is effective in reducing angular leaf spot disease, which is caused by a bacterial pathogen. A list of synthetic chemicals available for backyard use is provided in Table 2. When the risk of disease is low, the lower recommended rate can be used. Before applying a fungicide always read the product label carefully.

Biopesticides. Many growers choose biopesticides over traditional synthetic chemicals because they are organic and more environmentally friendly. Biopesticides are derived from materials found in nature such as plants, minerals, microorganisms (bacteria, fungi, viruses)

or secondary metabolites (i.e., antimicrobial compounds) from microorganisms. Biopesticides are often more sensitive to extreme temperature changes and should be handled and stored according to the recommendations on the product label. To ensure the most effective results, biopesticides should be used in combination with cultural practices such as mulching and sanitation. A list of biopesticides available for backyard use is provided in Table 3. Many of these products are also available as ready-to-use (RTU) formulations and can be directly sprayed on the plants without diluting. Before applying a biopesticide always read the product label carefully. Biopesticides that contain living organisms (i.e., *Bacillus*) may have a short shelf life. Always check the label to confirm that the product has not expired.

Table 2. Fungicides for Use in Backyard Strawberry Plantings

Other products not mentioned in the table may be available. Copper is a fungicide and bactericide.

Fungicide	Trade Names	Diseases Controlled	Recommended Rate (Per Gallon of Water)
captan	Hi-Yield Captan 50W Fungicide or Bonide Captan Fungicide 50 WP	Botrytis (gray mold), Leaf spot, Anthracnose fruit rot	4 to 8 tablespoons
copper	Liqui-Cop®	Leaf spot, Leaf scorch	3 to 4 teaspoons
	Liquid Copper 4E®	Angular leaf spot, Leaf scorch, spot, and blight, Powdery mildew	1 to 4 tablespoons
phosphorous acid salts	Monterey Garden Phos™	Leather rot, Red stele, Phytophthora crown and root rot	2 to 6 teaspoons
	Organocide Plant Doctor	Leather rot, Red stele, Phytophthora crown and root rot	2 to 6 teaspoons
sulfur	Safer® brand Garden Fungicide	Powdery mildew	8 tablespoons
	Bonide Sulfur Plant Fungicide	Powdery mildew	1 to 2 tablespoons
myclobutanil	Immunox Multi-purpose Fungicide	Leaf blight, Leaf spot, Powdery mildew	2.5 tablespoons

Common Diseases of Backyard Strawberry Plantings in Ohio

Fruit Rots

Botrytis Grey Mold. The fungus that causes grey mold (*Botrytis cinerea*) can decimate a strawberry patch in a short period of time. The fungus causes flower blight, leaf blight and fruit rot. In patches that are not renovated annually the fungus can grow on the dead or dying plant tissue and cause a crown rot. Grey mold is most prevalent when there are extended periods of cool, wet weather during flowering. Diseased flowers turn brown and do not develop into fruit. Fruit rot is most common on ripe fruit but can also occur on immature fruit (white or green). Infections on the fruit appear as tan, soft, rotted areas. When it is rainy or humid the spots will become covered in grey spores. The spores can be blown by wind, splashed by rain or irrigation, or moved by insects (i.e., flies, bees) to new plants or fruit.

Sanitation practices are critical for grey mold management. Strawberry patches should be renovated immediately after harvest and the clippings should be raked and removed. Because the fungus can also grow on decaying straw or hay, all organic mulching should be removed, discarded and replaced with fresh mulch in the spring (once the threat of frost has passed). There are no varieties with resistance to *Botrytis*. When wet or humid weather persists during bloom, fungicides or biopesticides (Table 2 and 3) may be needed to prevent fruit rot.

Leather Rot. Leather rot occurs sporadically in Ohio and early fruit disease symptoms can easily be confused with grey mold. Strawberries with leather rot have an unpleasant odor and a bitter taste. The pathogen that causes leather rot (*Phytophthora cactorum*) is a water mold that thrives in wet soils. The pathogen infects flowers as well as green or red fruit. Infected green fruit turn brown and have a rough leathery appearance. Ripe fruit also have a leathery appearance but generally don't change color. Eventually infected fruit will shrivel and dry up becoming mummies.



Botrytis Grey Mold – Leaf Blight and Fruit Rot

Angela Madeiras, University of Massachusetts Amherst



Leather Rot

Steven Koike University of California Cooperative Extension and Melanie Lewis Ivey, the Ohio State University Extension



Anthracnose Fruit Rot

Melanie Lewis Ivey, The Ohio State University Extension

Spores in the soil or on mummies are splashed onto the flowers or fruit by irrigation water or rain. The pathogen also produces a spore that can swim to flowers or fruit that are resting on the soil.

Water management is key to preventing leather rot. Mulch will reduce the splashing of spores from the soil onto the flowers or fruit and will also act as a physical barrier between the soil and the fruit. Overhead irrigation is not recommended. Soaker hoses or drip irrigation will minimize the

Table 3. Fungicides for Use in Backyard Strawberry Plantings

Other products not mentioned in the table may be available.

Biopesticide	Trade Names	Diseases Controlled	Recommended Rate (Per Gallon of Water)
neem oil	Garden Safe Fungicide ₃ Concentrate	Powdery mildew	2 tablespoons
	Bonide Neem Oil	Powdery mildew	2 tablespoons
mineral oil	Bonide All Seasons Horticultural & Dormant Spray Oil®	Botrytis grey mold, Powdery mildew	2 tablespoons
bicarbonates	GreenCure®	Powdery mildew	1 to 2 tablespoons
	Bonide Remedy®	Botrytis grey mold, Powdery mildew	2 tablespoons
<i>Bacillus</i> spp.	Serenade Garden	Botrytis grey mold, Leaf spot, Leaf blight, Leaf scorch, Powdery mildew	4 to 8 tablespoons
	Garden Sentinel™ Biofungicide	Botrytis grey mold, Botrytis leaf blight, Powdery mildew	1 teaspoon
	Monterey Complete Disease Control	Botrytis grey mold, Angular leaf spot, Powdery mildew	1 teaspoon
	Bonide Revitalize Biofungicide	Botrytis grey mold, Powdery mildew, Leaf scorch, spot, and blight	1 teaspoon

spread of spores by splashing water. Diseased fruit and mummies should not be left in the patch as the pathogen overwinter in infected fruit. There are no varieties with leather rot resistance. Phosphorous acid salts are the only fungicides registered for backyard use against leather rot (Table 2).

Anthracnose Fruit Rot. Anthracnose fruit rot is a fungal disease that occurs on flowers and fruit in warm and wet weather. Infected flowers may turn brown and die. On the fruit, brown, dry lesions develop that are slightly sunken. When it is warm and humid orange spore masses form over the lesions. The spores are spread by splashing water, rain driven wind and on equipment. Like leather rot, the fruit will shrivel and dry down into mummies. The fungus is introduced into the patch on infected

transplants and overwinters on plants, plant debris and mummified fruit. There are no winter hardy resistant varieties to anthracnose fruit rot. Disease-free transplants should be purchased from a reputable supplier to avoid introducing the fungus into the patch. Avoid overhead irrigation and maintain one to two inches of straw mulch between the rows to reduce splash dispersal of the spores. Fungicides with captan (Table 2) can be applied to reduce the number of new fruit infections but complete control should not be expected.

Leaf Diseases

Fungal leaf diseases can lead to severe defoliation and loss of plant vigor, particularly in highly susceptible strawberry varieties. The most common leaf diseases, leaf spot, leaf scorch, and leaf blight,

are widespread, while a newly emerging threat, *Neopestalotiopsis* disease, has also been identified in Ohio. Strawberry can also be affected by powdery mildew; however, many varieties are resistant to powdery mildew (Table 1) and thus this disease is not a major concern in backyard plantings.

Leaf spot, leaf scorch, and leaf blight overwinter in infected leaves and plant debris. As temperatures rise in the spring, these fungi produce spores that spread via water splash. *Neopestalotiopsis* disease, however, is primarily introduced through infected nursery stock, and its ability to survive Ohio winters is still uncertain. All four fungal pathogens can infect leaves, runners, petioles, and stems. *Neopestalotiopsis* can also be present on fruit, but it is rare to see fruit symptoms in Ohio. Symptoms of each disease are listed in Table 4.

Backyard gardeners are encouraged to plant resistant cultivars to help prevent leaf scorch, leaf spot, and powdery mildew. However, no cultivars are currently resistant to leaf blight or *Neopestalotiopsis* disease. To reduce the risk of infections, remove plant debris to lower the inoculum load in the garden. Thin plants to improve

air circulation and minimize shading, which can contribute to disease development. Sulfur and many biopesticides are effective in controlling powdery mildew if the leaves, including the underside of the leaves, are completely covered with the biopesticide. Captan, copper, and myclobutanil should be used to manage leaf spot, leaf scorch, and leaf blight. Captan is the best choice for management of *Neopestalotiopsis* disease, but results may be variable.

Angular leaf spot. Angular leaf spot (ALS) is the only bacterial disease affecting strawberries in Ohio. It is typically introduced into a planting through infected nursery stock. Warm days, cool nights and high humidity favor disease development. Symptoms and signs of ALS are described in Table 4. Like fungal leaf spot, scorch and blight, the pathogen overwinters in infected plant debris and spreads through rain or overhead irrigation. There are no varieties with reliable resistance to angular leaf spot. Copper fungicides may help slow disease development and spread, but their effectiveness varies. Treating the plants as soon as symptoms are observed will provide the best level of control.

Table 4. Symptoms of the major leaf diseases affecting strawberry in Ohio

Leaf Disease	Symptoms
Angular leaf spot	Small, angular water-soaked spots on the underside of the leaves; as the disease progresses the spots enlarge and are visible on the upper surface of the leaves; during high humidity, the spots may have a light-yellow ooze coming from them.
Leaf spot	Irregular shaped purple lesions or blotches on the upper side of leaves; center of the lesions turn grey or white colored as the disease progresses.
Leaf scorch	Irregular shaped purple spots on the upper leaf surface; enlarged spots have a black, tar-like appearance; leaves turn brown, dry up, and curl at the edges (scorch appearance).
Leaf blight	V-shaped lesions on the leaves that are initially a purplish-red color but turn brown as the disease progresses.
<i>Neopestalotiopsis</i> disease	Starts as small, dark brown spots that expand into large necrotic areas. Under humid conditions, black spore masses develop within the lesions.
Powdery mildew	White powdery fungal patches that first appear on the underside of the leaves. Infected leaves often curl upwards.

Foliar Diseases of Strawberry



Leaf Blight

Ontario Ministry of Farming, Agriculture and Agribusiness



Powdery Mildew

Ontario Ministry of Farming, Agriculture and Agribusiness



Leaf Scorch

Melanie Lewis Ivey, The Ohio State University Extension



Neopestalotiopsis Disease

William Kline, North Carolina State University Extension



Leaf Spot

Melanie Lewis Ivey, The Ohio State University Extension



Angular Leaf Spot

Mike Ellis, The Ohio State University

Crown and Root Diseases

Black Root Rot. Black root rot of strawberry is the most common root disease in Ohio, especially in older patches. The disease is caused by one or more fungal pathogens that are commonly found in the soil. Disease develops when plants are stressed by drought, water-logged soils, compacted

soils, winter or herbicide injury, or inadequate nutrition. Nematodes (microscopic worms in the soil) and insects feeding on the roots exacerbate the disease. Infected plants decline overtime and produce fewer and smaller berries compared to non-infected plants. As the plants continue to decline, they become stunted, and the edge of the leaves turn brown and wilt. The roots of infected plants are black, soft, and have a rat-tail appearance (the outer layer often sloughs off leaving only a thin strand of the root). Black root rot can be managed preventively by using production practices that promote healthy, vigorous growth and minimize plant stress. Avoid winter injury by planting winter hardy varieties in soils that are rich in organic matter and drain well. Control weeds in the patch as they will compete with the strawberry plants for nutrients and water. Renovate the patch yearly and use soil tests to guide fertilizer applications. There are no fungicides registered for use in backyard gardens that are effective in controlling black root rot. Diseased plants should be removed and destroyed.

Phytophthora Crown and Root Rot. Phytophthora crown and root rot is caused by the same water mold that causes leather rot. The first symptom of Phytophthora crown and root rot is stunting and wilting of young leaves. Leaves will eventually turn brown, and the plant will collapse. The roots will become black and when the crown of the plant is cut open it will have a dark red color. Most varieties grown in Ohio gardens are susceptible to Phytophthora crown and root rot.

Water management is the key to preventing and managing Phytophthora crown and root. Avoid planting in low lying areas or in soils that drain



Anthracnose Crown Rot

Top: Tim Elkner, Penn State Extension

Bottom: Melanie Lewis Ivey, The Ohio State University Extension



Black Root Rot

Alejandro Rojas, University of Arkansas



Phytophthora Crown and Root Rot

Left: Oregon State University
Below: Melanie Lewis Ivey, The Ohio State University Extension



Verticillium Wilt

Mike Ellis, The Ohio State University Extension

poorly. Use well or city water to irrigate. Pond water can contain *Phytophthora* spores and should be avoided. Avoid overwatering as spores can be spread in run-off.

Verticillium Wilt. Verticillium wilt is a fungal disease that has minimal impact in backyard strawberry plantings due to the availability of resistant varieties (Table 1). However, if resistant varieties are not planted and the fungus is in the soil, infected plants will rapidly die. *Verticillium* is often present in soils that previously had tomatoes, eggplants, or peppers. The disease is favored by cool, cloudy days intermixed with clear sky and warm weather. Symptoms include stunting, wilting, and leaf discoloration, and can be confused with other root diseases. However, the inner leaves of plants with Verticillium wilt tend to remain turgid and green but stunted until the plant dies. The disease can be managed primarily using resistant varieties, crop rotation (3 or more years), and avoiding sites that were previously planted with tomato, pepper, or eggplant. Weed removal is also important because many common garden weeds are hosts to the fungus. There are currently no fungicides registered for Verticillium wilt for the backyard garden.

Anthracnose Crown Rot. Anthracnose crown rot is caused by the same fungus (*Colletotrichum*) that causes anthracnose fruit rot. The disease is introduced into the planting via infected nursery stock, but symptoms often don't appear until the second year. Wilting and die back are the first symptoms of anthracnose crown rot. When the crown of a diseased plant is cut length wise it will have lesions that are reddish-brown in color (similar to Phytophthora crown and root rot). Mulching with straw is recommended to reduce water splash and disease spread. Infected plants should be removed and destroyed. Varieties vary in their susceptibility to anthracnose crown rot, but none are resistant. There are no fungicides specific to anthracnose crown rot.

Common Injuries of Backyard Strawberry Plantings in Ohio

Tip Burn (Calcium Deficiency)

Calcium is an essential macronutrient for strawberries, playing a crucial role in the formation of new plant cells. A deficiency in calcium can lead to tip burn in rapidly growing new leaves. Symptoms first appear on the young leaves at the center of the plant and on the sepals. The leaf tips turn brown and brittle, and the affected leaves often become distorted, which can sometimes be mistaken for mite or thrips damage. In addition to leaf symptoms, calcium deficiency also affects young fruit, resulting in small, misshapen, and soft berries. Calcium deficiency is not always caused by a lack of calcium in the soil but rather by the plant's inability to transport calcium from the soil to its growing tips. This issue is more common in conditions that reduce transpiration, such as cool, humid weather or prolonged fog, which slow calcium movement within the plant. Other factors that can limit calcium uptake include low soil moisture, high temperatures, and acidic soil (pH below 5.8). Once calcium reaches the growing tips, it does not move to other plant tissues, making foliar and fruit applications the only effective way to increase calcium levels where needed. Calcium treatments are most beneficial when applied during peak fruiting periods or in cool, humid, and overcast conditions, when natural calcium movement within the plant is slow.



Tip burn on strawberry. University of California - ANR.

Cold Injury

Cold injury in strawberries occurs when plants are exposed to freezing temperatures without adequate protection, leading to damage in various plant parts and increasing their susceptibility to diseases. The severity of injury depends on factors such as temperature extremes, duration of exposure, plant growth stage, and the amount of snow cover. Winter injury to the crown can result in stunted growth and failure to produce new leaves or flowers in the spring. Injured crowns appear water-soaked, dark brown, or black, when cut open. Leaves affected by frost may appear wilted, dry, and brittle. Open strawberry flowers are particularly sensitive to frost and can be killed at temperatures below 28°F, with flowers developing blackened centers and failing to produce fruit. Fruit exposed to freezing temperatures may become misshapen, hard, and develop brown spots.

To protect strawberry plants from cold injury, several strategies can be used. Applying straw mulch in late fall insulates the crown and roots, providing essential winter protection. Fabric row covers or low tunnels can be used in the fall to shield plants from early frost and in the spring to protect young leaves and flowers. Overhead irrigation is another method that can protect plants from freezing by forming a protective ice layer over the plants.

Poor Pollination

Although strawberries self-pollinate, pollinators such as hover flies and bees will increase pollination. Cool, wet weather during the early bloom period can reduce self-pollination resulting in small, dimpled, uneven and seedy berries. If pollinators are not visiting the plants on warm and sunny days pollinator presence can be improved by avoiding the use of insecticides during bloom and planting pollinator friendly native plants that bloom around the same time as strawberries (e.g., red columbine, white wild indigo, white prairie clover) near the patch.



A. Frost injury on open strawberry flower. Ontario Ministry of Farming, Agriculture and Agribusiness. **B. Straw mulch** applied in the fall to protect plants from winter injury. Bruce Bordelon, Purdue University. **C. Low tunnels** can be used in the fall or spring to protect plant from winter injury. Dean Gunderson, Seed St. Louis.



Poor Pollination

Mark Longstroth, Michigan State University
Extension

Herbicide Injury

Herbicide injury in strawberries can occur due to direct application, drift, volatilization, contaminated soil, or residual herbicides from previous crops. The severity of damage depends on the type of herbicide, the rate of exposure, the plant's growth stage, and environmental conditions. Symptoms of herbicide injury vary depending on the specific herbicide involved. Glyphosate (i.e., Roundup), one of the most used herbicides for controlling garden and lawn weeds, can cause significant damage to strawberries if applied directly, through drift, or via soil residues. Symptoms of glyphosate injury include leaf yellowing, cupping, and curling. Runners and stems may become shortened, thickened, or fail to develop properly. Flowers may appear small, distorted, or fail to open, while fruit may be undersized, deformed, and ripen unevenly.

To prevent accidental exposure to glyphosate and other herbicides, avoid spraying on windy days to reduce the risk of drift, use shields when applying

herbicides near strawberry beds and dedicate a separate sprayer for herbicide use only. Additionally, when using straw mulch, it is important to ensure that it has not been exposed to herbicides, as residual chemicals can harm the plants.



Glyphosate Injury

Ontario Ministry of
Farming, Agriculture
and Agribusiness



Glyphosate Injury

Rocco Schiavone,
North Carolina State
University



THE OHIO STATE UNIVERSITY
EXTENSION

Melanie L. Lewis Ivey, Associate Professor
Department of Plant Pathology, Wooster, OH 44691

PP Series No. 154 03/25