CHAPTER 7

DISEASE MANAGEMENT

LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Be able to define non-infectious and infectious disease.
- Understand how fungi, bacteria, and viruses produce disease.
- Understand the disease triangle and the disease cycle.
- Understand control methods specific to disease management.
- List the major diseases affecting asparagus, carrots, celery, cole crops, cucurbits, corn (sweet), onions, potatoes, tomatoes, and snap beans.

INTRODUCTION

Diseases are the most difficult type of plant injury to diagnose and manage. A plant **disease** is any condition that does not allow the plant to function normally. **Noninfectious plant diseases** are caused by nonliving agents or cultural and environmental factors such as drought, soil compaction, hail, wind, toxic chemicals, nutrient deficiency, and temperature or moisture extremes. Noninfectious disease cannot reproduce and spread from plant to plant.

Symptoms such as wilting, stunting, and yellowing of leaves may appear suddenly on a plant with a non-infectious disease. Few noninfectious diseases can be corrected or avoided, and often the symptoms resemble those of infectious diseases. For example, nutrient deficiency symptoms often resemble symptoms of root rot. The remainder of the manual focuses on infectious plant diseases and their management.

An **infectious plant disease** is caused by an agent that attacks and feeds on the host plant. The disease-causing agent is called a **pathogen**. In Michigan, fungi, bacteria, and viruses are pathogens for vegetable crops. Pathogens are spread from diseased plants to healthy plants by wind, rain, soil, people, machinery and insects.

FUNGI

Fungi are the largest and most familiar group of plant pathogens. The best known fungi are mushrooms and yeast. Most fungi are extremely small and cannot be seen without a microscope. Fungi cannot convert sunlight into food and therefore feed on dead or decaying organic matter (dead trees) or living matter (e.g., tomatoes, cole crops and corn plants).

Most fungi are made up of delicate, threadlike structures called **hyphae**. Hyphae grow and form masses called **mycelium**, which is the fuzzy growth that sometimes appears on the surface of the plant. Hyphae absorb nutrients and water needed for fungal growth and reproduction.

Most fungi reproduce by forming microscopic **spores** (sometimes called conidia). Spores come in many shapes and sizes. Some spores are produced on structures called **fruiting bodies**. Others appear on the plant surface as mold growth (powdery mildew and rust). Each fungus has a unique spore or fruiting body structure which is often used for identification.

Wind, splashing rain, insects, workers' hands, and clothing and equipment can easily transport spores from one location to another. Harsh environmental conditions will kill some spores, but other spores can be dormant for several months or years before germinating.

Some fungi survive harsh environmental conditions by producing specialized structures, such as **sclerotia**, which are masses of hyphae and food that can withstand long periods of extreme hot or cold temperatures and lack of water. When environmental conditions turn more favorable, the fungus again produces spores to infect hosts.

BACTERIA

Bacteria are very small, microscopic, one-celled organisms. Some bacteria are harmful to humans and animals because they cause diseases such as pneumonia, tuberculosis, typhoid fever, and anthrax. Bacteria also cause diseases in plants but most bacteria are harmless or beneficial (for example, the nitrogen-fixing bacteria of legumes). It is important to point out that the bacteria that are plant pathogens are **not** human pathogens.

Bacteria enter plants through wounds, natural openings in the plant, or direct penetration, usually in the leaf but sometimes roots and stems. Once inside the plant, bacteria begin to multiple rapidly and live in the spaces between plant cells. The life cycle of a bacterium may be only 20 minutes, so a population of bacteria may increase its numbers rapidly.

Bacteria do not produce spores or fruiting bodies; they reproduce by simple cell division. A cell splits into approximately two equal halves, and each half forms a new fully developed bacterium. Bacteria, like fungi, rely on their host plant for food. In the absence of a host plant, a bacterial population may decline rapidly.

Bacteria are spread primarily by wind-driven rain, but driving or walking through a field wet from dew will also spread bacteria. Insects spread some bacterial diseases, such as Stewart's wilt of corn. Typical symptoms of bacterial disease include leaf spots, soft rot of tissues, and water-soaking of tissue.

VIRUSES

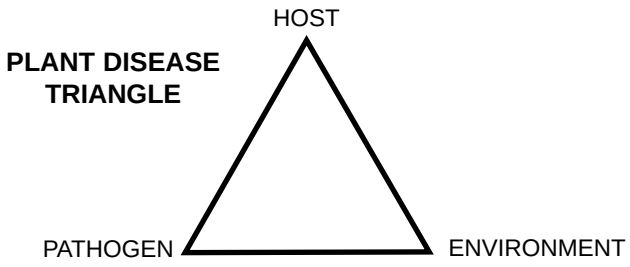
A **virus** is a very small non-living pathogen that cannot reproduce by itself. Viruses multiply by tricking the host cells into making more viruses. They are most familiar to us as the cause of human and animal diseases, such as polio, influenza, chickenpox, and warts. Viruses can also cause diseases in plants. Like bacteria, viruses infecting plants do **not** infect humans.

Plants infected with a virus can show any of the following symptoms: yellow to dark-green mottling, stunting of the leaves, early leaf fall, loss of plant vigor, mosaic patterns on leaves, deformation of plant tissues, and reduced yield. Sometimes a virus disease is mistaken for nutrient deficiency, pesticide or fertilizer injury, insect or mite activity, or other types of disease.

Because viruses can survive only in living cells, they need to enter a plant by means of a **vector**, usually an insect. Insect with piercing-sucking mouthparts, such as leafhoppers and aphids, are usually responsible for transmitting viruses. Pollen, soil-borne fungi, or nematodes can transmit a few viruses. Viruses can also be transmitted by vegetative means, such as tubers, bulbs, and root cuttings, and can be a serious problem for crops that are propagated from cuttings (for example, potatoes).

DISEASE TRIANGLE

Plant diseases occur when a pathogen attacks a susceptible plant (the host) under environmental conditions that favor infection and growth of the pathogen. Plant diseases are the result of a complex interaction between the host, the pathogen, and the environment. This interaction is often pictured as the disease triangle. By changing any side of the disease triangle, such as adding an unfavorable environment or using a disease-resistant variety, you can reduce the disease development.



The role of the environment in this interaction is important because diseases need specific conditions to develop. Temperature and moisture are two of the most important environmental conditions that influence plant diseases.

Air or soil temperature affects the growth of the host plant or pathogen. If the host plant is stressed or grows poorly, it may be more susceptible to disease. Temperature may also change the speed of growth of a pathogen.

Pathogens and host plants are also affected by moisture. Most fungal spores need moisture to germinate. A host plant experiencing moisture stress may be more susceptible to some pathogens. Also, many pathogens are spread by wind-blown rain or require moisture to infect the plant.

A successful disease management program takes into account the interactions of the environment, the disease, and the host plant. Disease management emphasizes reducing pathogen survival and limiting pathogen dispersal. For example, planting resistant varieties, improving soil drainage, and destroying or removing infected plants reduce the interaction between the three parts of the disease triangle.

DISEASE CYCLE

All plant pathogens have a basic chain of events involved in disease development called the **disease cycle**.

The basic steps are:

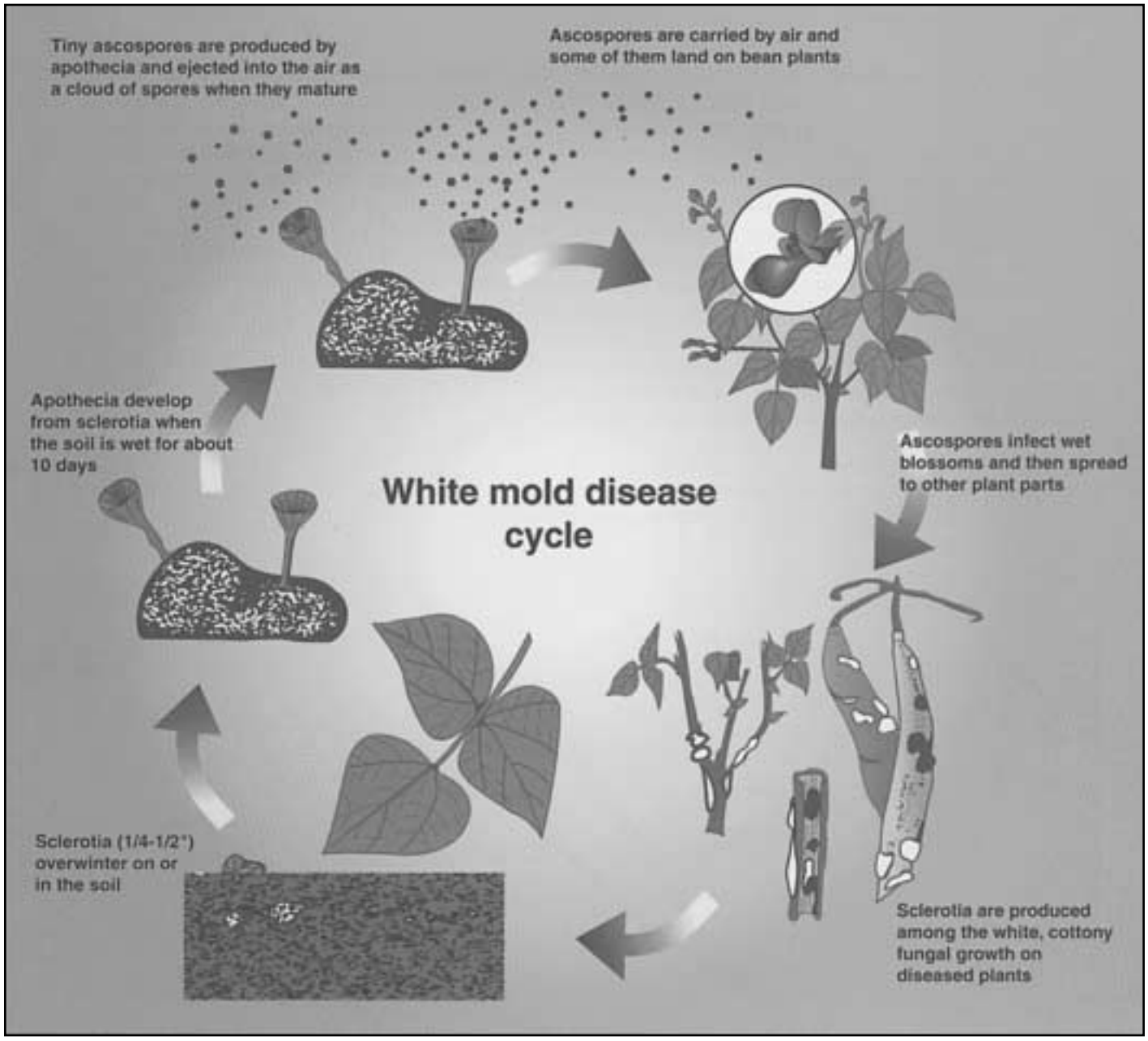
1. **Production of inoculum. Inoculum** is a source of a pathogen that infects and causes a disease (for example, fungal spores, bacterial cells, and virus particles). Inoculum can be present in soil, seed, weeds, crop residue, or other crops, or carried by the wind, rain, insects, animals, people, and machinery.
2. **Spread of inoculum.** The inoculum must disperse to the host plant. There are two types of spore movement:

active and passive. **Active movement** occurs when the inoculum is carried to a host by another organism (for example, insects, machinery or worker). One example is the spread of potato virus Y (PVY) by aphids from plant to plant. **Passive movement** is movement of the inoculum to a new host plant by wind or water. Most fungal and bacterial foliar pathogens disperse this way.

3. **Infection.** Infection occurs when the plant pathogen becomes established in the host. A successful plant pathogen grows, spreads within the host plant and produces new inoculum. As the pathogen grows in the host plant, symptoms begin to appear. The time period between infection and appearance of the first symptoms is called the **incubation period**, which can be several days to months.

4. **Pathogen survival between susceptible crops.** In Michigan, pathogens need to survive the winter between growing seasons and periods when no host is present. Disease pathogens survive non-host periods by:

   - Surviving on crop residues left in the field.
   - Producing structures that resist microbial and environmental breakdown.
   - Infecting seeds.
   - Infecting alternate hosts. A pathogen with a large host range has an increased chance of survival. Some plant pathogens may survive in alternate hosts without causing disease.



A good example of the disease cycle can be seen by looking at the fungus that causes white mold.

DISEASE MANAGEMENT

Options for disease management are limited. The best available disease management strategies concentrate on preventing disease. Chapter 1 of this manual deals with general aspects of IPM; this section will address control options specific to diseases.

Cultural Control

Changing crop production practices can help reduce the incidence and impact of many vegetable crop diseases. Cultural practices can disrupt the disease cycle, create unfavorable environmental conditions for the pathogen, reduce the pathogen population in the field, and improve crop growth and vigor.

CROP ROTATION. Many plant pathogens survive from one growing season to the next in the soil or on crop residues. To reduce disease, avoid planting the same crop in a field year after year. Alternating to non-host crops provides time to reduce pathogen populations. Some pathogens have a wide host range and are not affected by the sequence of the crop rotation. The fungus, *Sclerotinia sclerotiorum*, responsible for white mold in soybeans, can also infect many other crops, including dry beans, potatoes, tomatoes, and canola. A rotation that includes two of these crops can increase the pathogen population faster than a rotation that includes only one host.

TILLAGE. Incorporating crop residue permits soil microorganisms to decompose the residue, prey directly on the pathogen, or outcompete the pathogen for resources, resulting in a decrease in the pathogen population. Corn residues left on the soil surface in combination with periods of high daytime temperatures and relative humidity are the favored growing conditions for the fungal pathogen *Cercospora zeae-maydis*, which causes corn gray leaf spot.

ROW SPACING. Soil moisture changes with row spacing. Wider row spacing allows the surface of the soil to dry out faster and increases the amount of time needed to create a closed row. For example, wider row spacing can reduce the incidence of white mold in snap beans.

VARIETY SELECTION. The use of resistant varieties or hybrids is the least expensive, easiest, and most effective way to control plant diseases. Plant varieties express varying degrees of resistance to many diseases. A resistant variety can act as a non-host crop for a specific pathogen. Partially resistant varieties may not prevent the spores of a pathogen from germinating and growing but may reduce the number of new spores produced. This helps keep the pathogen from reaching yield-reducing thresholds.

SEED QUALITY. Certified seed is high-quality seed selected from healthy, relatively disease-free plants of known origin and genetic makeup. Poor seed quality may be associated with fungal or bacterial pathogens that use seed for survival and dispersal. Plants infected with seed-transmitted pathogens should not be used for seed.

Biological Control

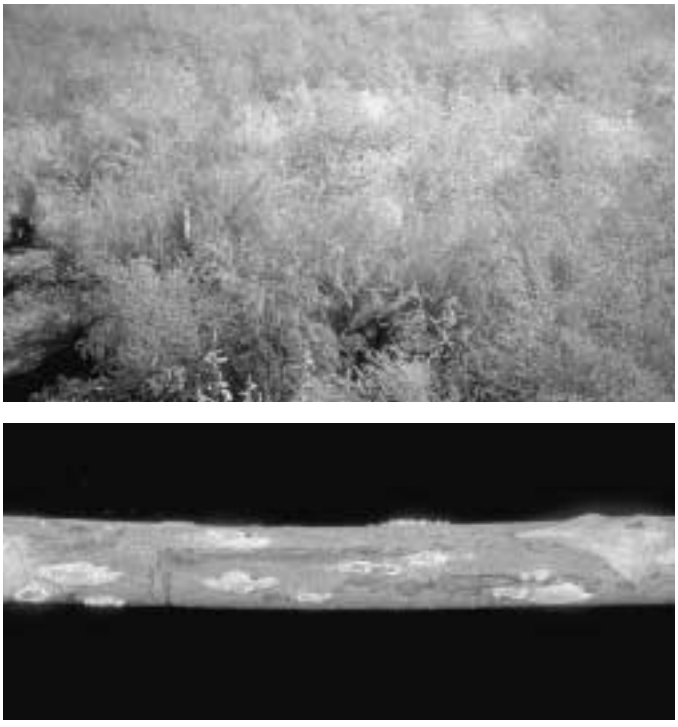
Biological control including bacteria or fungi have been developed primarily for soilborne pathogens. Once a pathogen has become established in a field, there is little opportunity to use biological control. Rotation and tillage contribute to biological control by giving natural enemies time to reduce pathogen populations.

Chemical Control

Chemical seed or foliar treatments are often used to control pathogens. Seed treatments can effectivly control pathogens that live or disperse by seed. For control of diseases of vegetable crops using pesticides, see Michigan State University Extension bulletin E-312, *Insect, Disease and Nematode Control for Commercial Vegetables*. Foliar fungicides are important in managing rust and purple spot on asparagus fern, Cercospora and Alternaria leaf blight on carrots, and early and late blight of celery.

DISEASES OF ASPARAGUS

RUST



Asparagus plants infected with rust appear yellow (top); rust on an asparagus stem (bottom).

Pathogen type: fungus (*Puccinia asparagi*)

Disease symptoms: This fungus attacks all aboveground plant parts. Plant symptoms include red or brown, elongated spots on spears, shoots, or needles; reduced plant vigor; increased water loss; and premature death. Severe rust infections can stunt or kill young shoots and defoliate plants; repeated defoliation leads to reduced yields.

Environmental conditions favoring disease: Spores remain in crop debris during the winter. In the spring, fungal spores are dispersed by wind and penetrate asparagus plant tissue. Disease development is more likely with heavy dews.

Control strategies:

- Plant moderately resistant asparagus varieties in well drained areas.
- Orientate rows with the prevailing wind to allow for free air movement. This keeps moisture levels low and helps prevent fungal spores from penetrating plant tissue.
- Apply fungicides when weather is favorable for disease development.

PURPLE SPOT

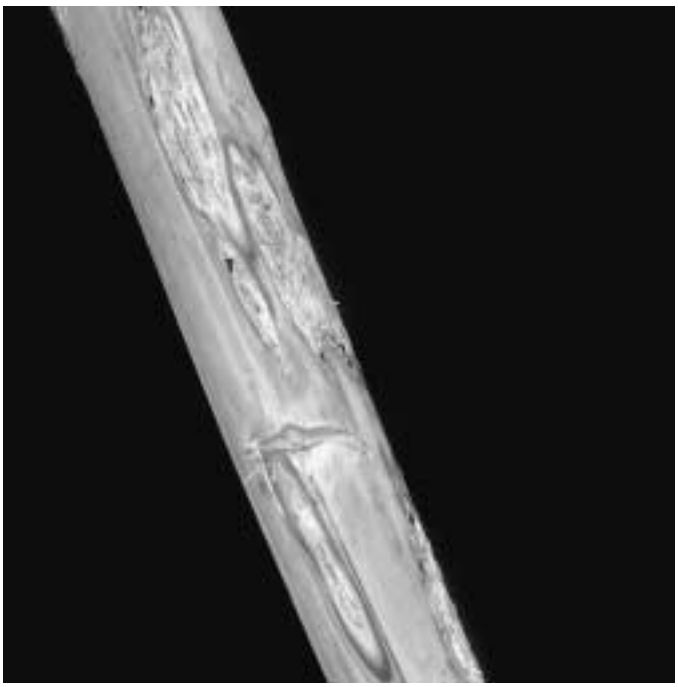
Pathogen type: fungus (*Stemphylium vesicarium*)

Disease symptoms: Small, elliptical, purple lesions with brown centers occur on all aboveground plant parts. Severe disease results in defoliation and dieback. Repeated defoliation can lead to reduced yields.

Environmental conditions favoring disease: The fungus enters the plant through wounds and stomata. It requires moisture from dew or rain to develop. Purple spot is worse when the weather is cool and wet during spear emergence.

Control strategies:

- Good field sanitation is important. Remove last season's fern growth, the primary inoculum source, before new spears emerge.
- Apply fungicides according to the TOM-CAST disease forecaster.



Lesions caused by purple spot on asparagus stem.

FUSARIUM WILT AND CROWN ROT

Pathogen type: fungus (*Fusarium oxysporum* f. sp. *asparagi* and *F. proliferatum*)

Disease symptoms: Infected plants have weak, spindly spears in the spring followed later in the season by shoots with a brilliant yellow coloration and perhaps limited vascular discoloration. Feeder roots are frequently discolored and rotted. The discoloration may also extend into the storage roots, with pinpoint reddish lesions occurring where the fungus has entered the root. Crowns of infected plants may show internal discoloration extending from stems into the interior crown tissue. *Fusarium* fungi inhibit water uptake and food transportation within the plant. They may also cause damping-off of seedlings in crown nurseries, poor stand establishment in young asparagus fields, and a slow decline in productivity of mature fields.

Environmental conditions favoring disease: Fusarium proliferatum is spread from plant to plant via airborne spores that infect asparagus plants near the base of the stem. *Fusarium oxysporum* f. sp. *asparagi* is soilborne. The optimum temperature for the disease is between 75 and 86 degrees F. Excessive and insufficient levels of soil moisture increase the severity of decline. Attacks by the asparagus miner, rust, or purple spot weaken the plants and make them more susceptible to Fusarium infections. Plants stressed by adverse environmental factors, excessive cutting periods, or other organisms decline much sooner than non-stressed plants.

Control strategies: *Fusarium* is extremely persistent and difficult to control.

- Choose well-drained sites for asparagus fields.
- To minimize disease impact, minimize overcutting, drought, overwatering, insect injury, weeds and soil compaction.
- Destroy crop residue from the previous year in late fall or winter to reduce inoculum.
- Control rust, purple spot and insect pests.

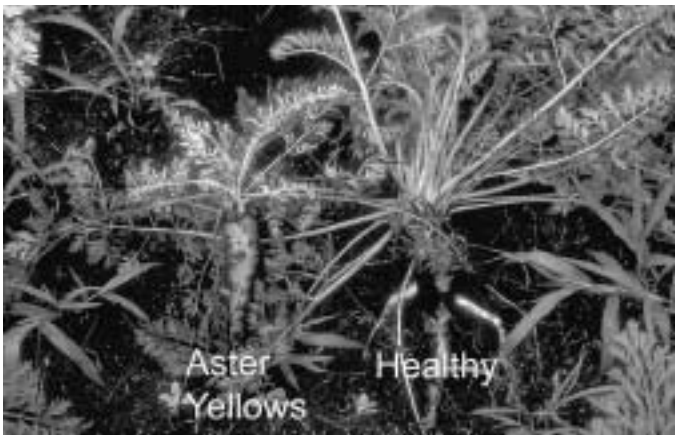
DISEASES OF CARROTS

ASTER YELLOWS

Pathogen type: phytoplasma—a very small organism intermediate in size between bacteria and viruses.

Disease symptoms: Infected plants are twisted, stunted, and yellow. Many more feeder roots and shoots than normal develop, and bronzing of foliage is common. Diseased carrots often have an unpleasant taste.

Environmental conditions favoring disease: The aster yellows organism is transmitted to healthy plants by infected leafhoppers, which infect the plant by penetrating the vascular tissue and injecting the mycoplasma through their saliva while feeding. It takes 11 days for healthy leafhopppers to acquire the ability to transmit the disease after they feed on infected plants. Only a small proportion of the leafhopper population will be infected —usually less than five percent—but a level of infection above one percent is considered a serious threat.



Aster yellows stunts and discolors foliage.

Control strategies:

- Control leafhopper populations to prevent disease transmission.
- Control weeds. Weed and grass hosts near the target crop can harbor aster yellows and leafhopper eggs.
- Plant tolerant/resistant carrot varieties.
- Plant early to establish the crop prior to possible infection.
- Remove infected plants, if feasible, to prevent the spread of an existing infection.

ALTERNARIA LEAF SPOT

Carrots infected with Alternaria.

Pathogen type: fungus (*Alternaria dauci*)

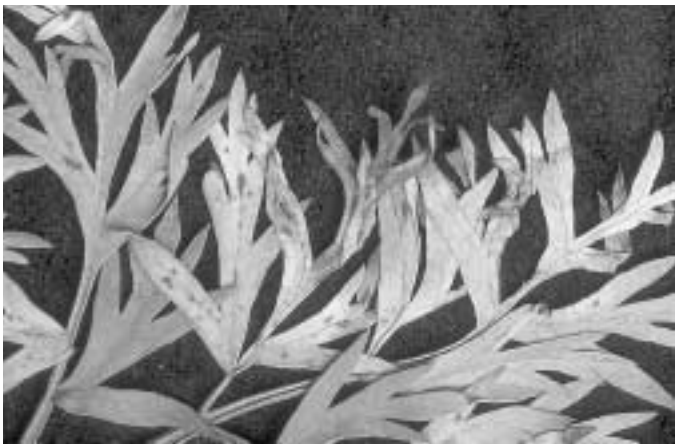
Disease symptoms: Dark brown/black spots with yellow margins appear on older leaves. The leaves may begin to curl at the edges as the plant matures. This can result in weak foliage or defoliation and make harvest impossible. The disease can also cause damping-off of seedlings and often occurs concurrent with Cercospora leaf spot.

Environmental conditions favoring disease: Alternaria fungus overwinters in soil and plant debris and in volunteer carrots. Pathogens are blown by the wind, carried by water or equipment, or introduced within the seed. Outbreaks occur first as isolated patches but quickly spread throughout the rest of the field. Favorable conditions such as overhead irrigation and rainy, windy weather increase the rate of spread of Alternaria.

Control strategies:

- Postharvest tilling helps reduce the overwintering inoculum. Turning under carrot residue will accelerate decomposition.
- Avoid continuous carrot cropping. Growers in Michigan frequently rotate a minimum of two years, but this does not seem to deter the disease.
- Do not plant new fields near infested fields.
- Use clean seed and resistant cultivars.
- Regular fungicide applications control Alternaria leaf spot.

CERCOSPORA LEAF SPOT



Leaves with lesions in a Cercospora infected carrot plant.

Pathogen type: fungus (*Cercospora carotae*)

Disease symptoms: The first symptoms are circular spots about 1/16 to 1/8 inch in diameter on both leaves and petioles. Spots resemble a target with a tan center, a dark brown ring, and an outer yellow ring, which will be inconspicuous on some plants. As the fungus grows, lesions encircle petioles, causing defoliation. Plants show symptoms as soon as three days after infection. Cercospora often occurs concurrent with Alternaria leaf spot.

Environmental conditions favoring disease: Cercospora produces spores during warm, humid weather. The spores are transported primarily by wind. Healthy carrot tissue can be infected when leaves remain wet for eight or more hours. The fungus can survive in seed, in carrot debris in soil, or in wild carrot.

Control strategies:

- Plant disease-free seed and disease-tolerant cultivars.
- Practice a two-year crop rotation and plow under carrot residue to decompose (the fungus dies after the debris decomposes).
- Chemical controls can be applied.

DAMPING OFF

Pathogen type: fungus (*Pythium* spp., *Phytophthora* spp.)

Disease symptoms: Damping off is a seedling disease that may be caused by several fungi, most commonly *Pythium*. Symptoms of damping off include wilting, browning and death. Seedlings are attacked at the ground level and develop water-soaked, discolored stems. Infected plants topple over and seldom recover. Yield loss due to Pythium damping off can be as severe as 100 percent.

Environmental conditions favoring disease: Infection rates can be high, particularly during periods of cool, wet weather. The fungus enters plant cells and consumes all cellular material, killing the cells and the plant. If the infection occurs in a mature plant, the host may be able to resist fungal growth but may exhibit stunting and a yield reduction.

Control strategies:

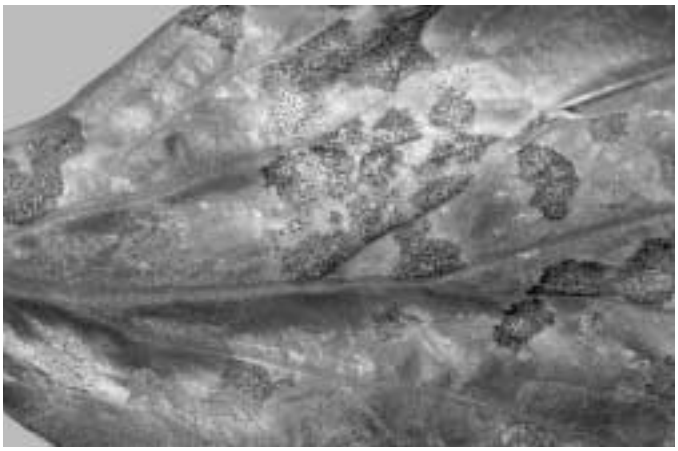
- Control soil moisture. Do not overwater seedlings (although this is not always in your control). Good drainage is important in limiting disease development. Compost and other soil amendments may help to improve drainage and air circulation and thereby decrease disease occurrence.
- Plant at times conducive to rapid plant growth to minimize the opportunity for infection.
- Crop rotation helps to decrease the incidence of damping off.
- Chemical controls are sometimes recommended for difficult cases, but they may not be cost effective.

DISEASES OF CELERY

ASTER YELLOWS

Aster yellows also infects celery. Please refer to the carrot disease section for information on aster yellows.

SEPTORIA LEAF BLIGHT (Late Blight)



Late blight in celery causes leaf spots that contain small, spore-filled black bodies.

Pathogen type: fungus (*Septoria apiicola*)

Disease symptoms: Somewhat circular spots on leaves and petioles can cause defoliation in severe cases. Lesions are tan to gray and contain small, black bodies resembling small grains of pepper to the unaided eye. These are actually black, flask-shaped structures that are embedded in diseased leaf tissue and contain the spores that spread the disease. Over time, leaf spots merge and kill the leaf.

Environmental conditions favoring disease: When the spore-filled structures become wet from rainfall or dew on leaves, spores are forcibly pushed onto the leaf surface. They are then spread by spattering raindrops or by clinging to machinery or skin or clothing of workers passing through the field. Spores within water droplets can be spread by strong winds during thunderstorms. It takes 12 days under normal conditions for symptoms to appear after an infection has occurred.

Control strategies:

- Plant disease-free seed and transplants.
- Plow under infected celery after harvest.
- Practice crop rotation with at least one year out of celery.
- Limit movement of machinery and workers in fields to reduce the spread of the disease.

BACTERIAL LEAF BLIGHT

Pathogen type: bacterium (*Pseudomonas apii*)

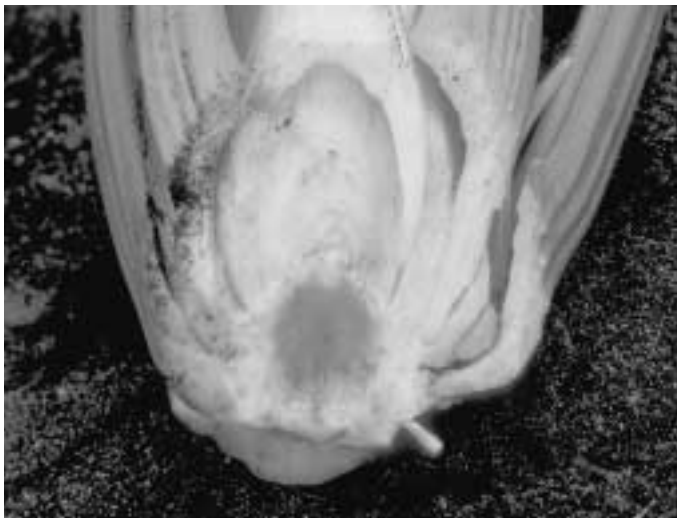
Disease symptoms: Irregular, circular, rusty-red spots up to five millimeters (0.20 inch) in diameter appear on the leaves.

Environmental conditions favoring disease: Disease development is favored by warm, moist conditions. The bacteria require ten hours of continuous leaf wetness and moderate temperatures to infect foliage. Bacterial leaf blight is a seedborne bacterium that spreads rapidly in a greenhouse because of the dense plant canopy and high humidity. In the field, bacterial spread is enhanced by overhead irrigation. The bacteria overwinter in undecomposed celery residue.

Control strategies:

- Hot water seed treatment will reduce seedborne inoculum but may also reduce seed germination.
- To minimize disease development and spread in greenhouses, space plants to allow adequate air movement, water early enough in the day to allow foliage to dry by evening, and utilize heating and venting to maintain the relative humidity below 85 percent.
- Do not plant diseased transplants.
- Avoid overhead irrigation to minimize the spread of the disease.
- Copper-based fungicides applied on a regular basis can limit disease spread.

FUSARIUM YELLOWS



Fusarium yellows causes the water-conducting tissue of a celery plant to turn brown.

Pathogen type: fungus (*Fusarium oxysporum* f. sp. *apii*)

Disease symptoms: Plants may become stunted and yellow and exhibit poor growth. The water-conducting tissues of the crown, petiole, and roots turn brown. Leaves become brittle and rough and curl upward.

Environmental conditions favoring disease: Symptoms are most severe when soil temperatures are warm. Fusarium yellows can be spread readily by movement of infested soil or transplants. The fungus infects common weeds such as lamb's quarters, smartweed, barnyard grass, and purslane, and can survive for long periods in soil as dormant spores. This allows the fungal population to grow in the absence of a celery crop.

Control strategies:

- Plant resistant or tolerant celery cultivars.
- Avoid planting celery into fields with known histories of Fusarium yellows.
- To avoid infestation of clean fields, keep equipment free of infested soil.
- Control weeds that serve as alternate hosts.

DISEASES OF COLE CROPS (cabbage, broccoli, cauliflower)

BLACK LEG

Pathogen type: fungus (*Phoma lingam*)

Disease symptoms: Dark, sunken cankers at the stem base or light brown, circular spots on the leaves are the early symptoms of black leg. Eventually, the cankers girdle the stem and move down to infect the roots. Small black specks—spores—can also be seen inside the cankers and spots.

Environmental conditions favoring disease: The fungus overwinters in crop debris and is easily spread. The fungus is most active in cool temperatures.

Black leg on cabbage.

BLACK ROT

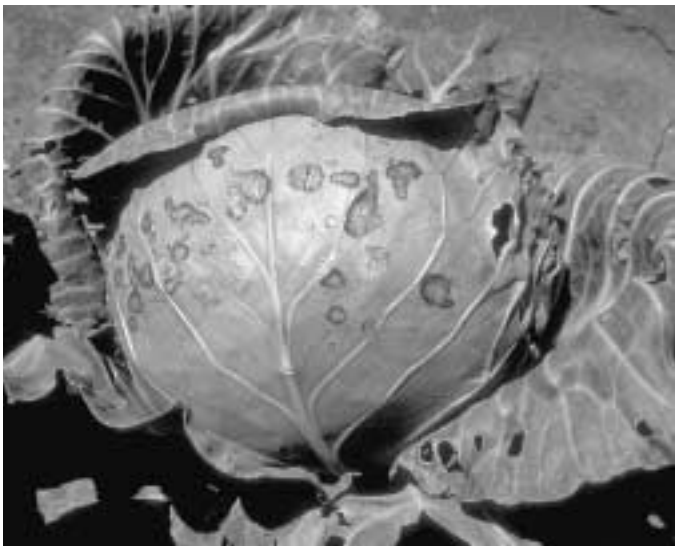
Cabbage infected with black rot (top); inside of a cauliflower stem infected with black rot (bottom).

Pathogen type: bacterium (*Xanthomonas campestris* pv. *campestris*)

Disease symptoms: Infected seedlings turn yellow and die. Symptoms on older plants include yellow, wedge-shaped areas at the leaf margins. The affected areas expand toward the center of the leaf, turn brown, and die. The veins become discolored at the leaf margins and the discoloration extends toward the base of the plant. The head is stunted, and symptoms are frequently more severe on one side of the head.

Environmental conditions favoring disease: The optimum temperature for disease development is 80 to 86 degrees F, and either rain or persistent dew is required. The bacteria overwinter on and in seed and debris from diseased plants left in the field. They spread by splashing water, on wind blown leaves, or by handling infected plants.

ALTERNARIA LEAF SPOT



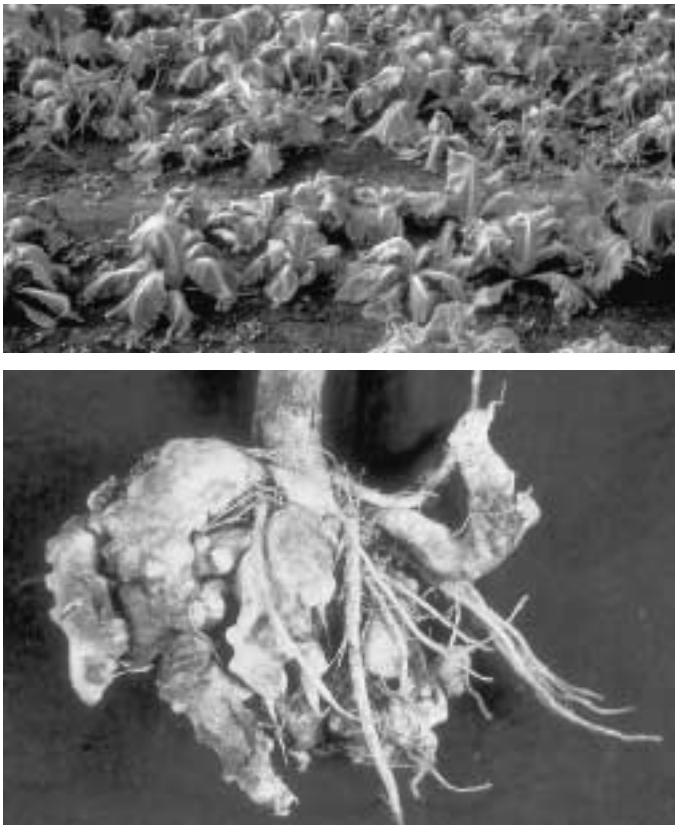
Alternaria can also cause head rot in cabbage.

Pathogen type: fungus (*Alternaria* spp.)

Disease symptoms: Spots with dark, concentric circles form on lower leaves. In moist weather, a dusty fungal growth occurs on the spots.

Environmental conditions favoring disease: Disease development is favored by cool, wet weather. The fungus overwinters in seed and diseased crop residues.

CLUBROOT



Clubroot causes wilting (top) and enlarged plant roots (bottom).

Pathogen type: fungus (*Plasmodiophora brassicae*)

Disease symptoms: Infected plants yellow and wilt. The roots are enlarged and "clubbed." Young plants can be killed; mature plants will not produce a marketable crop.

Environmental conditions favoring disease: Clubroot thrives in cool, wet soils. This soilborne fungus can remain viable indefinitely in the soil.

DOWNY MILDEW

Plants infected with downy mildew can have a white, fuzzy appearance.

Pathogen type: fungus (*Peronospora parasitica*)

Disease symptoms: Downy mildew begins as small, yellow spots on the leaves, which later turn brown. White fungal growth appears on the lower leaf surface during periods of moist weather.

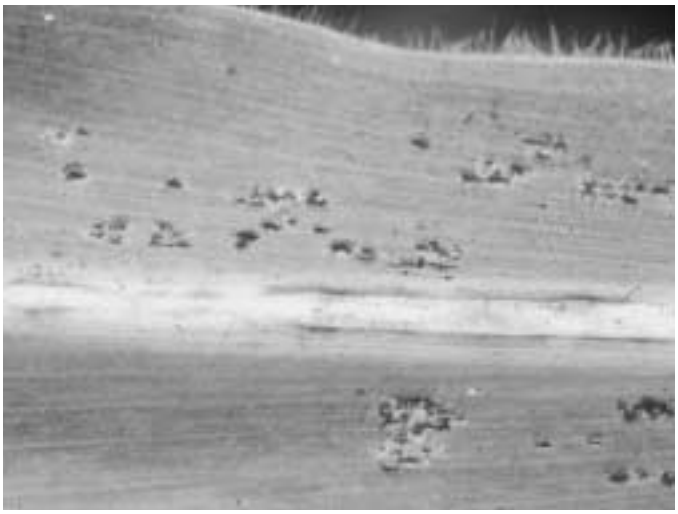
Environmental conditions favoring disease: Downy mildew is worse in cool, wet weather in spring and fall. Plants infected with downy mildew are often more susceptible to secondary pathogens, such as soft rot bacteria. The fungus overwinters on seed and in cruciferous weeds (for example, Shepherd's purse and mustard).

Control strategies for diseases of cole crops:

- Plant disease-free or certified seed and transplants.
- Avoid dipping transplants in water before planting to reduce the spread of disease.
- Practice at least a three-year crop rotation out of cole crops for most diseases.
- Plant disease-resistant cultivars.
- Maintain good weed control.

DISEASES OF CORN

COMMON RUST



Blisters on corn leaf infected with common rust.

Pathogen type: fungus (*Puccinia sorghi*)

Disease symptoms: Oval or elongated, brick-red blisters appear on the leaf surfaces, husks, leaf sheaths, and stalks. Severe infections result in leaf death. Killing the leaves of young plants reduces plant vigor and yield.

Environmental conditions favoring disease: The fungal spores are wind dispersed every year, usually late in the season. Rust develops under cool temperatures (60 to 73 degrees F) and high humidity and bright days.

Control strategies: Planting resistant hybrids is the best way to control rust. Fungicides are used, especially in seed corn.

CORN SMUT

Ear of corn infected with corn smut.

Pathogen type: fungus (*Ustilago zeae*)

Disease symptoms: Galls are formed on aboveground young growing parts of the plant, typically the ear, tassel, leaves, and stalk. The young galls have a greenish white covering, which turns silver-gray with age. Mature galls are full of black, powdery fungal spores that disperse into the air when the gall ruptures.

Environmental conditions favoring disease: Corn smut is most prevalent under dry conditions and temperatures of 78 to 94 degrees F and on stressed plants. Fungal spores overwinter in the soil and prefer high levels of soil nitrogen.

Control strategies:

- The best management strategy is to plant corn hybrids that have some level of resistance.
- Rotating crops and burying crop residue may be helpful.

STEWART'S WILT

Corn leaf showing symptoms of Stewart's wilt.

Pathogen type: bacterium (*Erwinia stewartii*)

Disease symptoms: Symptoms appear first on leaves and are more severe on young plants than on older plants. Pale green to yellow streaks with irregular margins extend the length of the leaf and turn brown. Infected young plants may show brown discoloration; cavities may form in the center of the stem near the soil line. If plants are infected after tasseling, leaf lesions develop. Light green to yellow, water-soaked streaks with wavy, irregular margins are formed parallel to leaf veins. The streaks turn tan, enlarge and coalesce (merge) with age, resulting in blighting. When these leaves are held up to the light, insect feeding scars can be observed in these lesions. The bacteria spread through the host via the vascular system and may enter the kernels. When infected stalks or leaves are cut open, droplets of yellow bacterial ooze may extrude from the vascular tissue.

Environmental conditions favoring disease: The bacterium overwinters in corn flea beetles and is spread to corn when corn flea beetles feed on corn plants. (Corn flea beetles carrying the bacterium can be expected if the sum of the average monthly temperatures [in degrees F] for December, January and February exceeds 90 degrees.) Stewart's wilt is most severe when temperatures are high (88 to 98 degrees F).

Control strategies:

- Plant resistant hybrids.
- Control the pathogen vector, corn flea beetles.

DISEASES OF CUCURBITS (cucumbers, melons, pumpkins, squash)

ALTERNARIA LEAF SPOT

Alternaria causes leaf spot.

Pathogen type: fungus (*Alternaria cucumerina*)

Disease symptoms: Small, circular, tan spots with a concentric ring pattern form on the leaves. Spots coalesce, causing defoliation.

Environmental conditions favoring disease: The disease develops best under bright sunshine, frequent dews or showers, and temperatures between 60 and 90 degrees F. Fungus spores are spread by rain, wind, and splashing water. The fungus overwinters on and in seed, as well as in residue from diseased plants.

Control strategies:

- Destroy volunteer cucurbit crops and weeds that may harbor fungal spores.
- Practice crop rotation out of cucurbits to reduce the risk of Alternaria leaf spot and other diseases.
- Apply fungicides as needed.

MOSAIC VIRUSES

Cucumber field damaged by virus (top); zucchini fruit damage by virus (bottom).

Pathogen type: virus

Disease symptoms: Mosaic viruses cause plant leaves to be mottled dark and light green and crinkled. The disease is more noticeable on young leaves. Older leaves have V-shaped dead areas extending from the leaf margins to the middle vein. The fruits of diseased plants are mottled, warty and misshapen.

Environmental conditions favoring disease: Many weeds act as hosts. The virus is spread primarily by aphids.

Control strategies:

- Plant disease-resistant varieties.

POWDERY MILDEW

Powdery mildew on cucumber.

Pathogen type: fungus (*Erysiphe cichoracearum, Sphaerotheca fuliginea*)

Disease symptoms: Powdery mildew causes a white, powdery growth on leaves and stems. The white, powdery areas may expand and merge. The crown leaves are the first to become infected and may die. Yield is reduced in infected plants, and fruit quality is poor. Powdery mildew infection renders the plant and fruit more susceptible to other diseases.

Environmental conditions favoring disease: Leaves are most susceptible 16 to 23 days after unfolding. The fungus reproduces under dry conditions and will not grow when the leaf surface is wet. The optimum temperature is about 81 degrees F. Powdery mildew is spread by spores generally carried by wind.

Control strategies:

- Plant disease-resistant varieties.
- Scout for the first sign of disease and then apply a fungicide.

PHYTOPHTHORA ROOT, CROWN, AND FRUIT ROT

Phytophthora fruit rot on pickles and watermelon.

Pathogen type: fungus (*Phytophthora capsici*)

Disease symptoms: Phytophthora attacks fruits lying on the soil. The fungus causes partial or complete rotting of the fruit. Infected roots and stems are soft, water-soaked and brown.

Environmental conditions favoring disease: The fungus prefers moist, humid, warm conditions and is favored by saturated soil conditions. The soilborne fungus is spread readily by splashing water.

Control strategies:

- Crop rotation.
- Water management.
- Good drainage and eliminate excess moisture.

DISEASES OF ONIONS

PURPLE BLOTCH

Purple blotch on onion leaf.

Pathogen type: fungus (*Alternaria porri*)

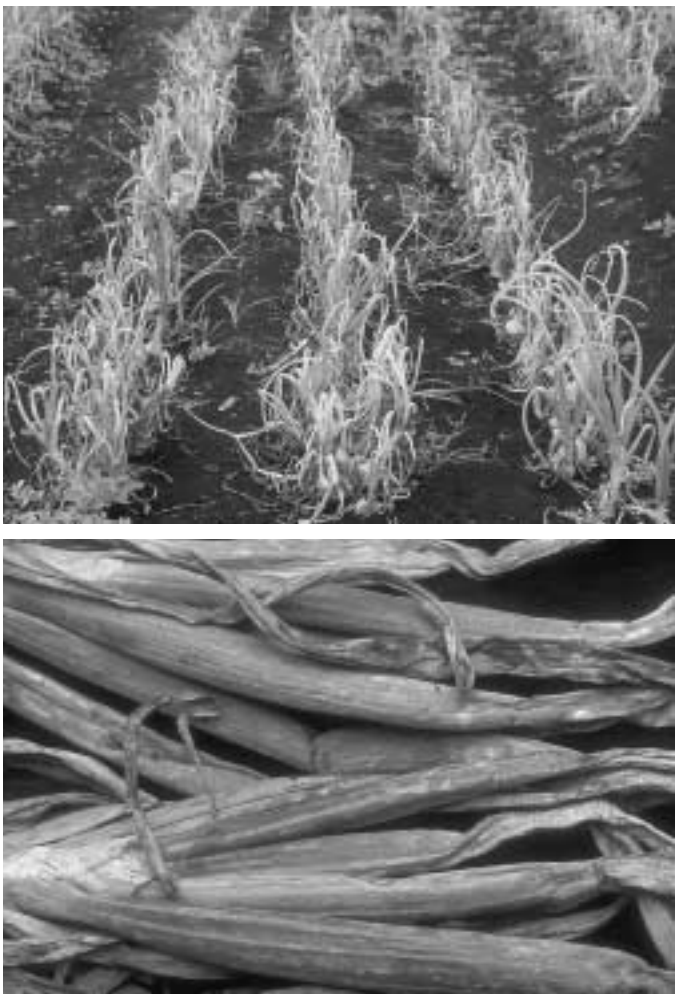
Disease symptoms: Small, white, sunken lesions with purple centers appear on leaves. These spots enlarge to encircle the leaf, resulting in premature senescence. Darkened zones with the characteristic purple color appear on leaf surfaces as the plant matures.

Environmental conditions favoring disease: Fungal spores develop in high humidity, rain, or persistent dew with an optimum temperature range of 77 to 85 degrees F. Purple blotch infections are more severe following injury caused by thrips, hail, or wind-blown soil.

Control strategies:

- Plant top-quality seed and disease-free transplants.
- Dispose of onion culls by incorporating them into the soil immediately after harvest.
- Practice a three- to four-year crop rotation.
- Apply fungicides when weather conditions favor disease development.

DOWNY MILDEW



Severe downy mildew infections result in stand decline (top); downy mildew on onion leaves (bottom).

Pathogen type: fungus (*Peronospora destructor*)

Disease symptoms: Disease symptoms appear on older leaves as elongated spots. Under humid conditions, the fungus produces purplish spores on the leading edge of the lesion. Eventually, affected leaves turn yellow and collapse.

Environmental conditions favoring disease: Fungal spores develop under high humidity, either from rain or persistent dew, at an optimum temperature range of 77 to 85 degrees F.

Control strategies:

- Plant high-quality seed and disease-free transplants.
- Dispose of onion culls by incorporating them into the soil immediately after harvest.
- Practice a three- to four-year crop rotation.
- Apply fungicides when weather conditions favor disease development.

SMUT

Onion smut.

Pathogen type: fungus (*Urocystis magica*)

Disease symptoms: Gray streaks appear on leaves, leaf sheaths and bulbs. These streaks are filled with a dark brown, powdery mass of spores. Affected leaves become twisted and deformed and eventually may die.

Environmental conditions favoring disease: Cool weather delays plant growth, thereby extending the period an onion is susceptible to onion smut. This soilborne fungus can serve as an infection source for 15 years. Spores are spread whenever soil, water, and plant parts are moved from one place to another.

Control strategies:

- Plant disease-free seed and transplants.
- Use treated seed.
- Use an in-furrow fungicide treatment for problem fields.

BOTRYTIS LEAF BLIGHT

Botrytis leaf blight on leaves (top) and the onion fruit (bottom).

Pathogen type: fungus (*Botrytis squamosa*)

Disease symptoms: The first symptoms are numerous white specks on the leaves. The spots expand, causing the leaves to die, starting at the leaf tip.

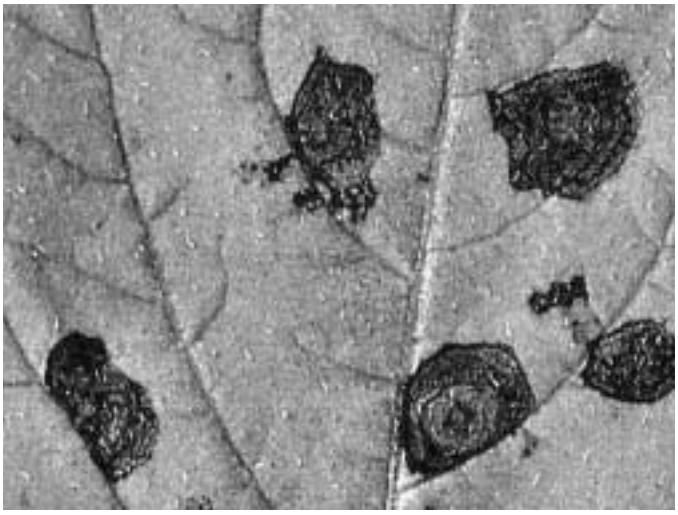
Environmental conditions favoring disease: Plants may become infected where leaf tissue has been injured by thrips, blowing sand, or other agents. Fungal spores are spread by wind and develop best under warm, wet weather conditions.

Control strategies:

- Plant high-quality seed and transplants free of disease.
- Dispose of onion culls by incorporating them into the soil immediately after harvest.
- Practice a three- to four-year crop rotation to reduce the incidence of infestation.
- Apply fungicide when weather conditions favor disease development.

DISEASES OF POTATOES

EARLY BLIGHT



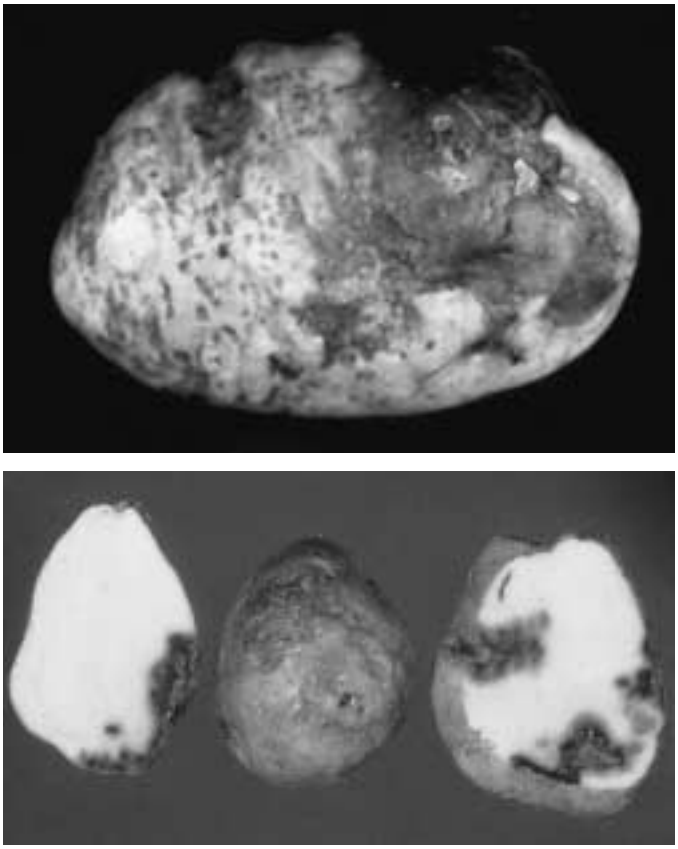
Early blight symptoms on potato foliage.

Pathogen type: fungus (*Alternaria solani*)

Disease symptoms: Small, angular, brown spots with concentric rings that create a target pattern occur on lower leaves. Several spots may run together and kill the leaf. In severe infections, upper leaves and stems may have brown lesions.

Environmental conditions favoring disease: Spores are spread by the wind and favored by warm weather (68 to 86 degrees F), heavy dews or rain, and high relative

humidity. The disease is more likely to develop on older or stressed foliage and on plants with poor mineral nutrition. The fungus survives the winter on tubers and crop residue and in the soil.



Early blight also infects tubers on the surface (top) and the interior (lbottom).

Control strategies:

- Crop rotation helps reduce overwintering fungus.
- Begin fungicide applications when the first lesions are visible on the lower leaves. Fungicide applications will not kill the existing infection but should stop the fungus from spreading.

LATE BLIGHT

Late blight symptoms on potato foliage.

Late blight symptoms on potato foliage (close-up).

Pathogen type: fungus (*Phytophthora infestans*)

Disease symptoms: Leaf lesions consist of large (1/2 to 1 inch in diameter), black, water-soaked areas. Leaves quickly dry and leaf and stem tissues die. A white mycelial growth on the leaves and stems is characteristic of this disease. Tubers exhibit a reddish brown dry rot.

Environmental conditions favoring disease: Late blight can develop from seed tubers, volunteers in the field or cull piles, and infected tubers sprouting in the spring. The fungal spores are carried by wind to healthy potatoes. The pathogen will continue to reproduce and spread on potatoes during favorable conditions (cool to warm, humid, rainy weather).

Potato tuber infected with late blight.

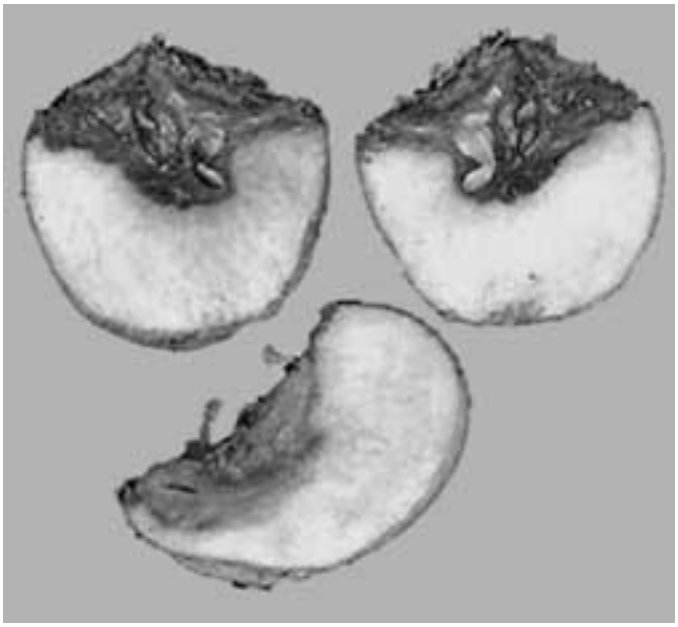
Control strategies:

Below are a few general tactics used to control late blight. For more specific control information, contact the potato disease lab at Michigan State University or refer to MSU Extension bulletins.

- Plant resistant varieties and carefully inspect all seed before planting.
- Remove cull piles.

- Practice crop rotation to reduce the potential for carryover of the late blight fungus.
- Scout fields regularly for late blight, and as soon as plants show symptoms of infection, begin applications of labeled fungicides according to MSU Extension recommendations.

FUSARIUM DRY ROT



Potato tuber infected with dry rot.

Pathogen type: fungus (*Fusarium sambucinum*)

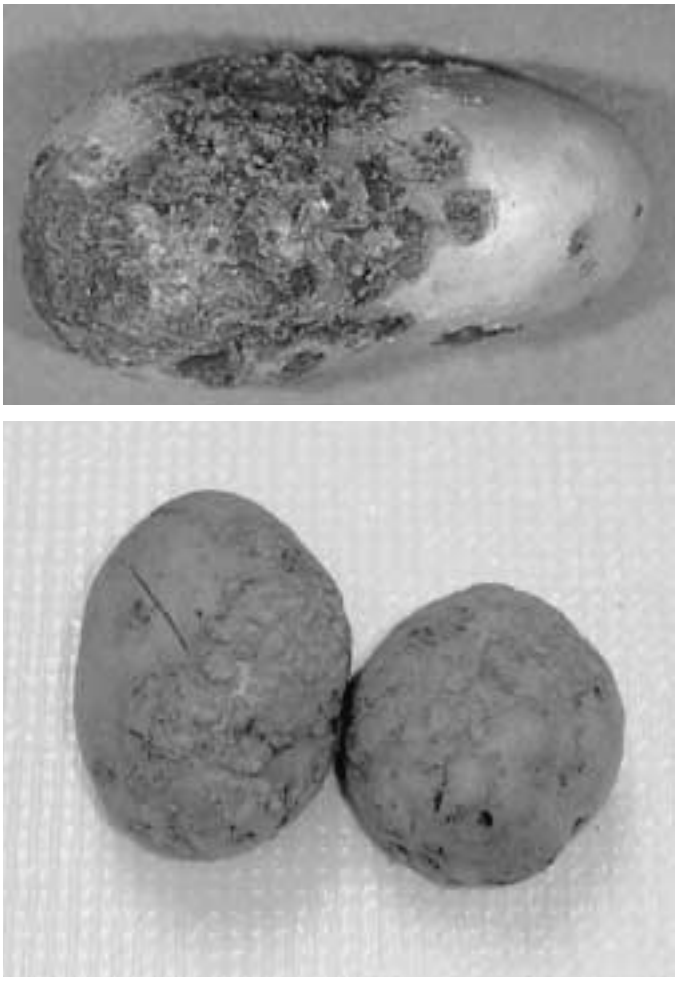
Disease symptoms: Fusarium dry rot affects potato tubers. Tubers become infected when wounds occur in the skin during harvest and handling. Infected tubers may appear wrinkled or have sunken areas. The internal tissue of the tuber has sharply defined brown, rotten areas. Potatoes that appear normal at harvest can develop disease symptoms after a few weeks.

Environmental conditions favoring disease: *Fusarium fungi* are common soil fungi. Fusarium dry rot does not usually spread from tuber to tuber in storage, but under high humidity, secondary infections of bacterial soft rot may develop.

Control strategies:

- Clean and disinfect all harvest and storage equipment before the beginning of the harvest season.
- Handle tubers carefully to minimize bruising when harvesting.
- Do not wash tubers before placing them in storage—this can increase infections and rot.

COMMON SCAB



Potato tubers infected with common scab.

Pathogen type: bacteria-like organism (*Streptomyces scabies*)

Disease symptoms: Common scab affects potato tubers. Tiny, dark spots develop on the tuber and rapidly expand, producing brown areas with a cork-like texture—scabs. The scabs may be raised, pitted, or shallow, depending on environmental conditions, the strain of bacterium, and the potato variety.

Environmental conditions favoring disease: Scab development is favored by dry soil conditions and alkaline soils. The disease organism enters the plant through wounds or natural openings such as stomata or lenticels. It is spread by infected seed potatoes, wind and soil.

Control strategies:

- Use scab-free certified seed.
- Maintain a low soil pH and healthy soil.
- Maintain adequate soil moisture during tuber initiation to minimize scab development.

BLACK SCURF/STEM CANKER

***Rhizoctonia solani* causes tuber and stem damage in potatoes.**

Pathogen type: fungus (*Rhizoctonia solani*)

Disease symptoms: This pathogen is both seed- and soil-borne. On tubers, irregularly shaped, black, canker-like masses appear—black scurf. The pathogen causes brown to black lesions on belowground stems of immature plants. Eventually, these lesions sink into the stem surface, causing cankers that can girdle and kill stolons or stems. This results in pruning and loss of tuber development sites.

Environmental conditions favoring disease: Disease development is enhanced during cool, wet weather and in cold, wet soil.

Control strategies:

- Practice crop rotation with non-host crops.
- Encourage rapid plant development of sprouts to reduce the disease severity.
- Remove plant residue to allow soil to dry out and warm up in the early spring.
- Plant disease-free seed. Seed treatment effectively controls the seed-borne pathogen.

DISEASES OF SNAP BEANS

FUSARIUM ROOT ROT

Fusarium root rot in snap beans.

Pathogen type: fungus (*Fusarium solani* f. sp. *phaseoli*)

Disease symptoms: Two to three weeks after planting, reddish brown streaks appear on the stem just below the soil surface. The lesions may extend upward to the soil surface and become brown with age. Severely infected roots die. Plants appear stunted with yellow leaves, but the fungal infection seldom kills the entire plant.

Environmental conditions favoring disease: Early planting in cool, moist soil favors the disease. Any conditions reducing root growth increase the likelihood of infection with Fusarium root rot. The pathogen can survive for years in the soil in the absence of beans.

Control strategies:

- Avoid plant stress. The disease causes little damage to healthy plants. A three-year crop rotation out of beans reduces the chance of a Fusarium infection.

WHITE MOLD

White mold kills branches and stems, giving them a white appearance.

Pathogen type: fungus (*Sclerotinia sclerotiorum*)

Disease symptoms: Leaves may become slightly chlorotic but typically wilt and take on a gray-green cast, although the veins remain green. Eventually, leaves become tan, curl, and die but remain attached to the stems. The fungus often girdles the main stem or its branches, usually 6 to 12 inches from the soil line. Branches and stems killed by the fungus generally have a white, bleached appearance. Infected pods are soft and mushy but later become dry, light-colored and shriveled. White, fluffy mold covers the diseased plant tissue during periods of high relative humidity.

Environmental conditions favoring disease: Small, hard bodies called sclerotia survive in soil or inside debris from diseased plants. Sclerotia germinate best when soil temperatures are 55 to 65 degrees F and soils are moist for seven to 10 days. Light stimulates the germinated sclerotia to form mushroom-like structures. Spores released from the mushroom-like structures may land on dead flower petals sticking to recently formed pods, where they may germinate and penetrate host tissues if free water from dew or rain is present.

Control strategies:

- Plant wider rows to allow the soil to dry out. This changes the environmental factors necessary for the pathogen to infect the plant.
- Prevent the introduction of the pathogen by thoroughly cleaning equipment to minimize the spread between fields.
- Practice crop rotation. The severity of white mold infections can be reduced by long crop rotations. Be aware that the fungus attacks other vegetables such as tomatoes, potatoes, and cucumbers, and field crops including dry beans and canola.

HALO BLIGHT

Pathogen type: bacterium (*Pseudomonas syringae* pv. *phaseolicola*)

Disease symptoms: Numerous small, dead leaf spots with yellow haloes appear. Cool, wet weather favors this disease and results in relatively large haloes (up to 1/2 inch in diameter). During periods of high relative humidity, a cream-colored ooze is produced in pod spots. When temperatures are high, the bacteria move systemically in the plant, resulting in the absence of halos and death of the entire leaf.

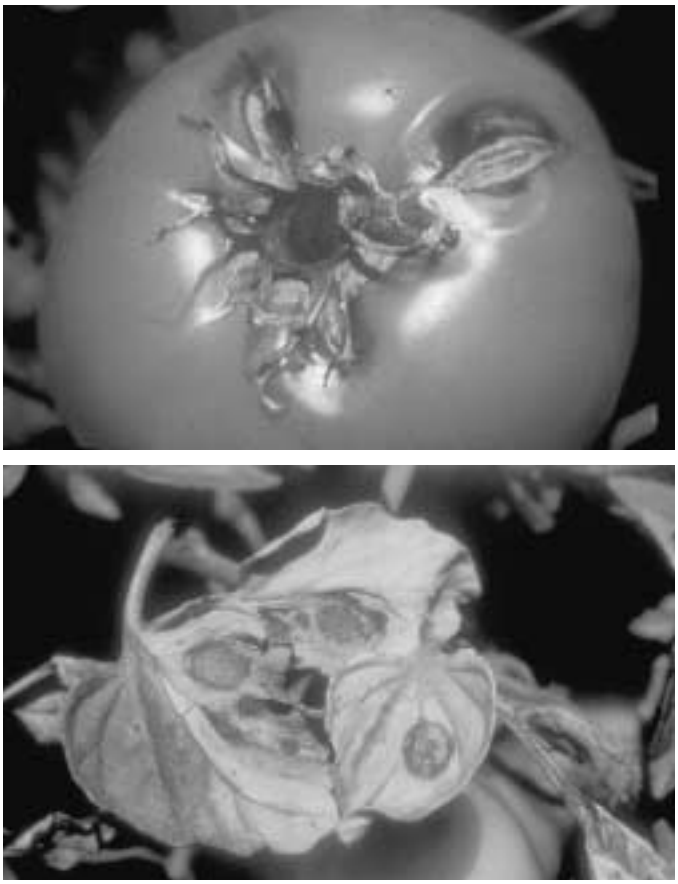
Environmental conditions favoring disease: Water from rain or irrigation, dust, machinery, and humans can all contribute to disease spread. Disease development is most rapid in wet weather.

Control strategies:

- Use disease-free seed.
- Practice crop rotation.
- Promptly incorporate old plant debris.
- Keep equipment out of field when plants are wet.

DISEASES OF TOMATOES

EARLY BLIGHT OF TOMATO



Early blight on tomato fruit (top) and leaves (bottom).

Pathogen type: fungus (*Alternaria solani*)

Disease symptoms: On established plants, symptoms include dark brown spots up to 1/2 inch in diameter with dark, concentric rings that develop first on oldest leaves and progress upward on the plant. Affected leaves may die prematurely, resulting in substantial early defoliation, fruit sunscald, and poor fruit color. Typically, fruit spots occur at the stem end as a rot that radiates out from the area of attachment between the calyx and the fruit. The spot is usually brown to black, up to 1 inch in diameter, firm, and depressed, with distinct concentric rings.

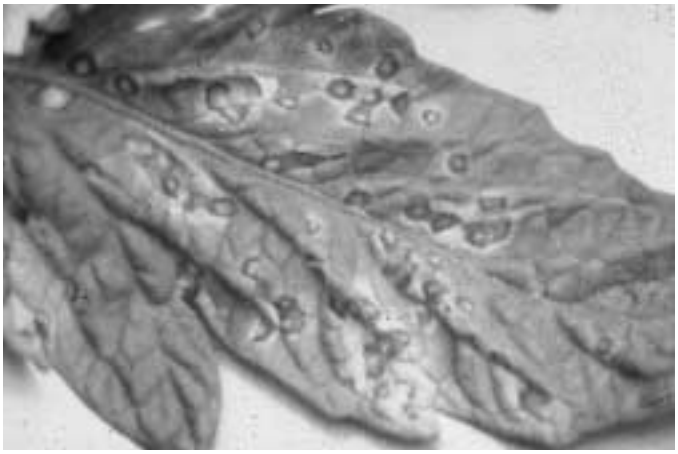
Environmental conditions favoring disease: The fungus overwinters in soil or in plant debris, where it can persist for a year or more. The fungus may also be introduced into a field on seed and transplants. Spores are disseminated by wind and running water. During periods of free moisture on the leaves, the fungus penetrates the plant. The disease occurs under a wide range of weather conditions and is favored by heavy dew and rainfall and is especially severe on plants with poor vigor.

Control strategies:

- Plant disease-free transplants.
- Practice crop rotation with crops other than potato, eggplant, and pepper.

- Remove or destroy crop residue immediately after harvest.
- Maintain fertility and moisture levels, but do not overfertilize with nitrogen.
- Avoid planting near windbreaks and in shady areas.
- Fungicides are essential to tomato production in Michigan and are applied on a calendar schedule or according to a disease forecaster.

SEPTORIA LEAF SPOT



Septoria leaf spot on tomato.

Pathogen type: fungus (*Septoria lycopersici*)

Disease symptoms: Small, circular, gray spots with dark borders form on the leaves. Black specks (reproductive structures of the fungus) can be seen within the spots.

Environmental conditions favoring disease: The disease develops and spreads most rapidly in wet weather—spores are dispersed by splashing water. The fungus survives in crop residue and on/in seed.

Control strategies:

- Avoid planting near windbreaks and in shady areas.
- Remove or destroy crop residue immediately after harvest.
- Practice a two- to three-year crop rotation to reduce potential outbreaks.
- Apply fungicides when needed.

ANTHRACNOSE

Lesions caused by anthracnose on tomato.

Pathogen type: fungus (*Colletotrichum coccodes*)

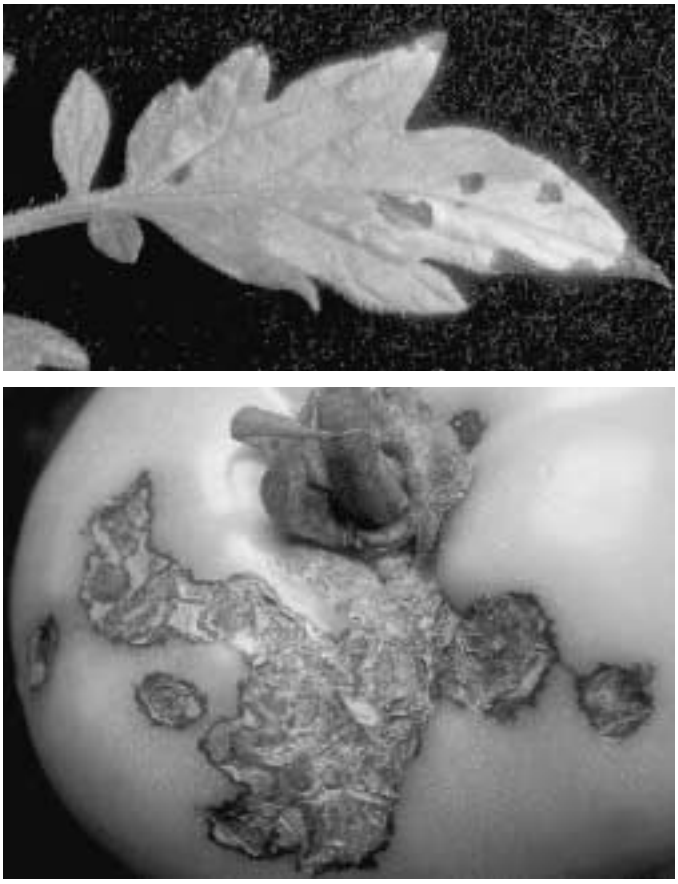
Disease symptoms: Symptoms on ripening fruit are small, slightly depressed, water-soaked, circular spots that increase in size (up to 1/2 inch in diameter), become more sunken, and typically develop concentric rings. Lesions may merge, resulting in large rotted areas on the fruit. The lesions may darken and small, black fruiting structures appear in the center. These fruiting bodies exude masses of slimy, tan or salmon-colored spores during warm, humid weather.

Environmental conditions favoring disease: The fungus overwinters in soil and infected plant debris. Splashing water spreads spores. The fungus can penetrate the outer layer of the fruit directly and may also enter through wound sites. On ripe fruit, a lesion can develop within five to six days following spore contact. The fungus can cause infection when temperatures range from 55 to 95 degrees F, though lesions develop most rapidly at 80 degrees F. Wet, rainy weather increases disease development.

Control strategies:

- Practice a two- to three-year crop rotation.
- Remove or destroy crop residue immediately after harvest.
- Fungicides are essential to tomato production in Michigan and are applied on a calendar schedule or according to a disease forecaster.

BACTERIAL SPOT



Bacterial spot can affect the leaf (top) and the fruit (bottom).

Pathogen type: bacterium (*Xanthomonas axonopodis* pv. *vesicatoria*)

Disease symptoms: Small, dark, greasy-looking spots develop on leaves and stems. On green fruit, small, dark, raised spots occur and may be surrounded by water-soaked margins. Spots enlarge up to 1/4 inch in diameter and are brown and scabby.

Environmental conditions favoring disease: Abundant rainfall and high humidity are requirements for spread and infection. Maximum growth of the bacteria is associated with temperatures between 75 and 86 degrees F. The bacteria can be carried on the surface of the seed and may overwinter in the soil in association with roots of non-hosts. Penetration of plant tissue occurs through wounds caused by broken plant hairs, insects, and windblown sand and soil.

Control strategies:

- Plant disease-free seed and transplants or chemically treated seed.
- Practice a three-year crop rotation with nonsusceptible hosts.
- Control solanaceous weeds, such as black nightshade.
- Apply copper-based fungicide.

CHAPTER 7

Review Questions

Chapter 7: Disease Management

Write the answers to the following questions and then check your answers with those in the back of the manual.

1. Which of the following can cause a non-infectious disease?
   A. Drought
   B. Insects
   C. Viruses
   D. Bacteria

2. An organism that causes disease is a:
   A. Parasitoid.
   B. Predator.
   C. Pathogen.
   D. Parasite.

3. Infectious plant diseases can be spread from diseased plants to healthy plants.
   A. True
   B. False

4. Which of the following is a living microscopic one-celled organism?
   A. Virus
   B. Fungus
   C. Bacterium
   D. Fruiting body

5. Which of the following uses spores to reproduce?
   A. Virus
   B. Bacterium
   C. Fungus
   D. Nematode

6. Draw a picture of the disease triangle and label its three parts.

7. By changing an environmental factor such as soil moisture, you can influence plant diseases.
   A. True
   B. False

8. List the four basic steps of the disease cycle.

9. A plant pathogen that is dispersed by wind to unaffected plants is said to move by:
   A. Active movement.
   B. Passive movement.

10. The source of a plant pathogen that causes a disease is called a(n):
    A. Infection.
    B. Parasite.
    C. Inoculum.
    D. Host.

11. The time period between infection and appearance of the first plant symptoms is the:

    A. Preharvest interval.
    B. Restricted entry interval.
    C. Incubation period.
    D. Disease period.

12. Cultural control methods can disrupt the disease cycle by:

    A. Creating unfavorable conditions.
    B. Improving crop growth.
    C. Reducing the plant pathogen population in a field.
    D. All of the above.

13. Which of the following is **not** a cultural control?

    A. Planting high-quality seed.
    B. Treating seeds with a fungicide.
    C. Increasing the row spacing.
    D. Practicing crop rotation.

14. Which of the following diseases of asparagus is more likely to develop if the weather is cool and wet during spear emergence?

    A. Crown rot.
    B. Fusarium wilt.
    C. Purple spot.
    D. Rust.

15. An asparagus plant infected with purple spot or rust is more susceptible to Fusarium infections.

    A. True.
    B. False.

16. Which of the following diseases of carrots and celery is transmitted by leafhoppers?

    A. Aster yellows.
    B. Damping off.
    C. Leaf blight.
    D. Leaf spot.

17. Which of the following is **not** a symptom of a carrot plant infected with damping off?

    A. Wilting.
    B. Browning of foliage.
    C. Purple spots on foliage.
    D. Death of plant.

18-21. Match the following celery diseases with the characteristic disease symptoms.

    A. Aster yellows
    B. Bacterial leaf blight
    C. Septoria leaf blight (late blight)
    D. Fusarium yellows

    18. ___ Plants are stunted and yellow, and the water-conducting tissue of the crown and roots turns brown.
    19 ___ Leaf spots contain small, black bodies that contain spores.
    20. ___ Plants are stunted and wilted.
    21. ___ Rusty-red spots up to 5 mm in diameter appear on leaves.

22. Which of the following diseases of cole crops results in enlarged roots?

    A. Damping off.
    B. Downy mildew.
    C. Black Leg.
    D. Clubroot.

23. Yellow, wedge-shaped areas starting at leaf margins are a characteristic of which cole crop disease?

    A. Alternaria leaf spot.
    B. Black leg.
    C. Black rot.
    D. Downy mildew.

24. Which of the following diseases of corn results in parts of the plant being covered with spore-filled galls?

    A. Ear rot.
    B. Rust.
    C. Smut.
    D. Stewart's wilt.

25. Stewart's wilt is spread from corn plant to corn plant by:

    A. Insect.
    B. Rain.
    C. Soil.
    D. Wind.

26-29. Match the following cucurbit diseases with the characteristic disease symptoms.

A. Alternaria leaf spot
B. Mosaic viruses
C. Powdery mildew
D. Phytophthora fruit rot

26. ___ Leaves and stems have a white, snow-like growth.
27. ___ Attacks fruit lying on the soil surface.
28. ___ Fruits are mottled, warty and misshapen.
29. ___ Concentric ring pattern develops on leaves.

30. Which of the following is **not** a disease of onions?

A. Botrytis leaf blight.
B. Downy mildew.
C. Purple blotch.
D. Stewart's wilt

31. A potato tuber that has odd-shaped cankers on the outer surface is infected with:

A. Black scurf.
B. Early blight.
C. Fusarium dry rot.
D. Late blight.

32. Which of the following potato diseases does **not** affect the foliage?

A. Early blight.
B. Common scab.
C. Late blight.
D. Mosaic virus.

33. The snap bean disease halo blight is caused by a bacterium.

A. True.
B. False.

34-37. Match the following tomato diseases with the characteristic disease symptoms.

A. Bacterial spot
B. Anthracnose
C. Septoria leaf spot
D. Early blight

34. ___ Leaves have small, gray spots with dark borders.
35. ___ Small water-soaked sunken spots appear on the fruit.
36. ___ Spots appear on the fruit at the stem end as the rot moves from foliage to fruit.
37. ___ Small, greasy spots develop on leaves; green fruits have small, dark, raised spots that enlarge and become brown and scabby.