

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 alfalfa, corn, dry beans, soybeans, small grains, and sugarbeets.

INTRODUCTION

Diseases are the most difficult plant injury to diagnose and manage. A plant **disease** is any condition that does not allow the plant to function normally. **Non-infectious plant diseases** are caused by non-living agents or cultural and environmental damage such as drought, soil compaction, hail, wind, toxic chemicals, nutrient deficiency, and temperature or moisture extremes. Non-infectious disease can not reproduce and spread from plant to plant.

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

An **infectious plant disease** is caused by a living organism that attacks and feeds on the host plant. The disease-causing organism is called a **pathogen**. In Michigan,

fungi, bacteria, and viruses are pathogens for field crops. Pathogens are spread from diseased plants to healthy plants by wind, rain, soil, people, machinery, and insects.

FUNGI

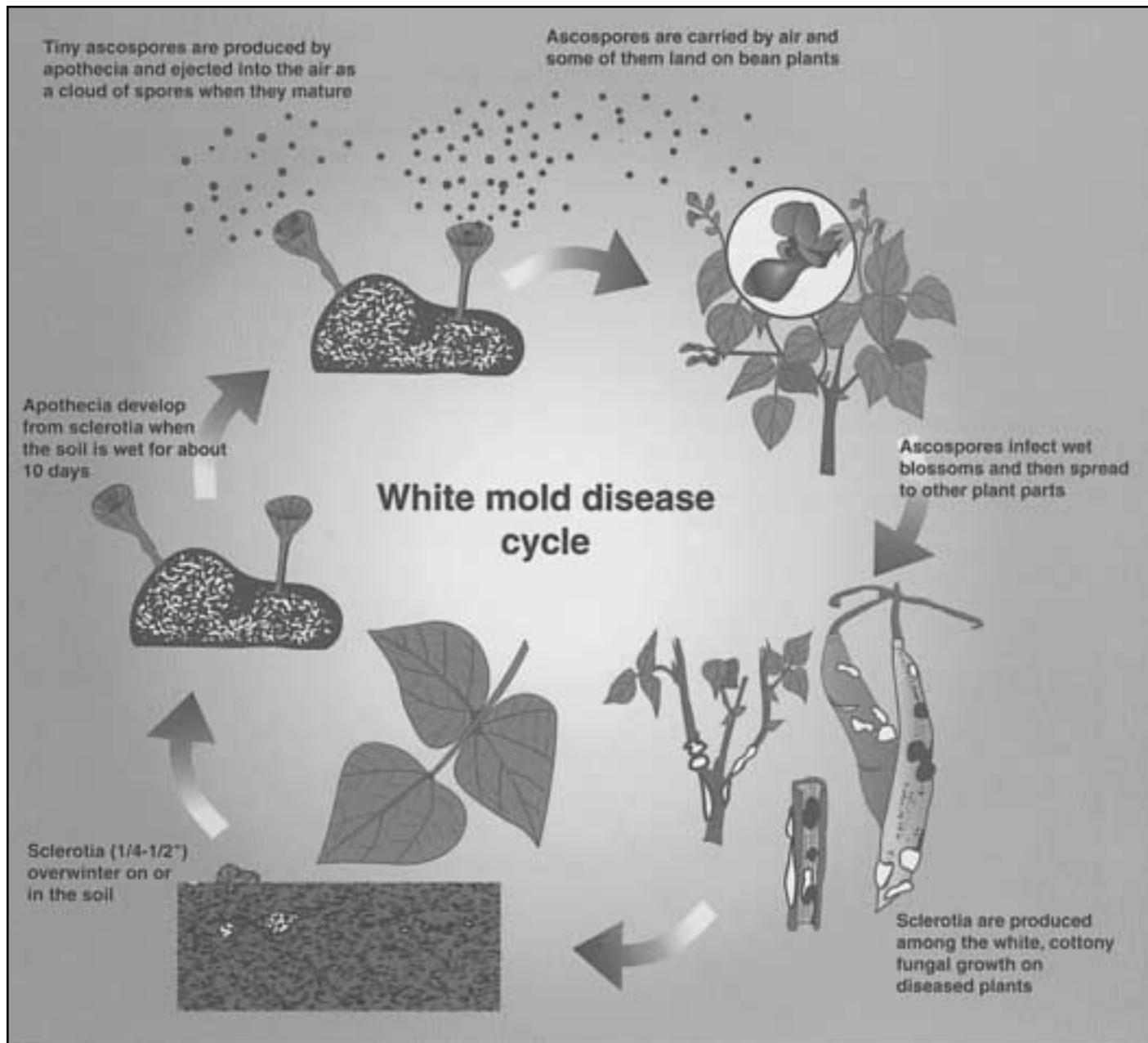
Fungi are the largest and most familiar group of plant pathogens. The best known fungi are mushrooms and yeast. Most fungi are extremely small and can not be seen without a microscope. Fungi can not convert sunlight into food and therefore feed on dead or decaying organic matter (for example, dead trees)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

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

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

Wind, splashing rain, insects, birds, workers' hands and clothing, and equipment easily transport spores from one location to another. Harsh environmental conditions will kill most spores; 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**. Sclerotia 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.



White mold disease cycle.

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 disease in plants, but most bacteria are harmless or beneficial (for example, the nitrogen-fixing bacteria of legumes).

Bacteria enter plants through wounds or natural openings in the plant, usually in the leaf but sometimes roots and stems. Once inside the plant, bacteria begin to multiply rapidly. Bacteria 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 rapidly.

Bacteria do not produce spores or fruiting bodies—they reproduce by simple cell division. A cell splits into approximately two equal halves. 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 bacteria population may decline rapidly.

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



Stewart's wilt is caused by a bacteria that is transmitted by corn flea beetles.

VIRUSES

A **virus** is a very small non-living organism 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.

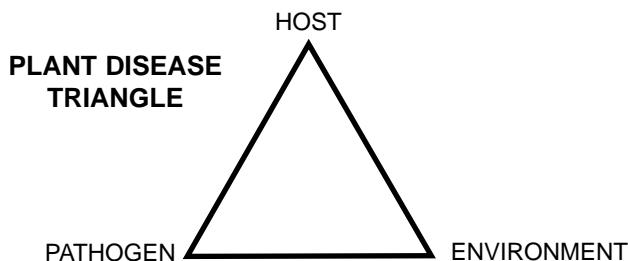
Plants infected with a virus can show any of the following symptoms: yellow to dark green mottling, stunting of the leaves, early leaf fall, loss of plant vigor, mosaic patterns on leaves, deformation of plant tissues, and reduced yield. Sometimes a virus disease is mistaken for nutrient deficiency, 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. Piercing-sucking insects, such as leafhoppers and aphids, are usually responsible for transmitting virus diseases. Pollen, soilborne fungi, or nematodes can transmit a few viruses. Viruses can also be transmitted by vegetative

means, such as tubers, bulbs, and root cuttings. Sometimes they are a serious problem for crops that are propagated from cuttings (for example, potatoes and mint).

DISEASE TRIANGLE

Plant diseases occur when a pathogen attacks a susceptible plant under environmental conditions that favor infection and growth of the pathogen. Plant diseases are the result of a complex interaction between the plant, the pathogen, and the environment. This interaction is often represented graphically 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 disease development.



The role of the environment in this interaction is important because pathogens need specific conditions to develop. If the environment is not suitable, a disease will not develop. Temperature and moisture are probably the two most important environmental conditions that influence plant diseases.

Air or soil temperature affects the growth of the host plant and/or the 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. 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 between 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, or destroying or removing infected plants disrupts the disease triangle.



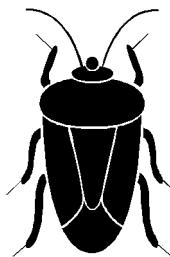
DISEASE CYCLE

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 plants 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, and/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 or animals). One example is the spread of barley yellow dwarf virus (BYDV) from plant to plant by aphids.



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 the appearance of the first symptoms is called the **incubation period**. An incubation period 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.

DISEASE MANAGEMENT

Options for disease management in Michigan field crops 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 field 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.

1. **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 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.

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



3. **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 soybeans and dry beans.

4. **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 different 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.

5. **SEED QUALITY.** Certified seed is high-quality seed that is selected from healthy, relatively disease-free plants. Certified seed is of known origin and genetic makeup and provides you with a genetically pure crop. 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

Controlling plant pathogens with other bacteria, fungi, or viruses is not very successful. Once disease has infected a field, there is little opportunity to use biological control. However, biological control can be successfully used on insect vectors and surrounding weeds that may serve as an inoculum for a pathogen. Rotation and tillage contribute to biological control by giving natural enemies time to reduce pathogen populations, even when the exact identity of the biological control agent is unknown.

Chemical Control

Chemical seed or foliar treatments are often used to control pathogens. Seed treatments can be an effective control for pathogens that live on and/or disperse by seed. For example, treating wheat seed with a systemic fungicide prevents the survival and spread of wheat loose smut (*Ustilago tritici*), a fungal pathogen. Chemically treated seeds also protect against fungi living in the soil (for example, *Fusarium*, *Rhizoctonia*, *Pythium*). These fungi can cause seed and seedling death shortly after planting. Chemically treating dry bean, wheat, alfalfa, and corn seeds before planting helps prevent disease.

Though they're not economically feasible for many Michigan field crop situations, foliar pesticides can be used to control powdery mildew and rust on wheat, white mold in dry beans, *Cercospora* leaf spot in sugar beets, and a variety of diseases on seed corn. It is often much more difficult to control pathogens with pesticide applications than it is to control weeds or insects. The fact that pathogens live in close association with their host makes it difficult to kill the pathogen and not harm the host.



DISEASES OF ALFALFA

Phytophthora root rot



Phytophthora root rot in alfalfa.

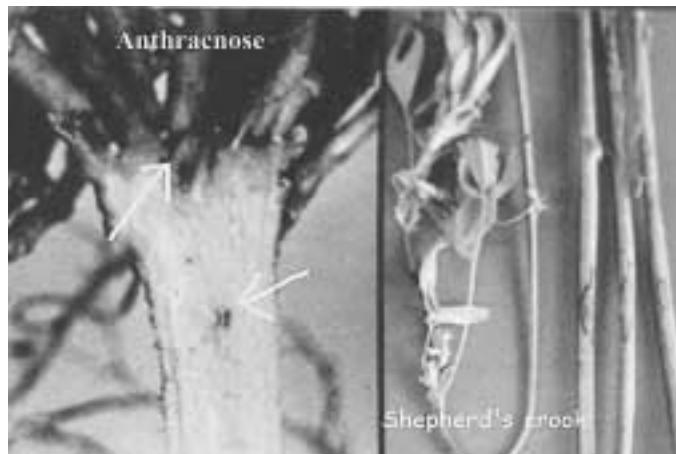
Pathogen type: fungus (*Phytophthora megasperma*)

Disease symptoms: The first signs of *Phytophthora* infections are dark brown lesions on the taproot. Infected plants will be stunted and yellow and may wilt and die. *Phytophthora* can also cause **damping-off**—when a seedling fails to emerge or collapses at the soil surface.

Environmental conditions favoring disease: *Phytophthora* is a soil fungus that becomes active after periods of excessive moisture. The pathogen grows best in poorly drained soils during periods of extensive rainfall, and young seedlings are the most susceptible.

Control: *Phytophthora* root rot yield losses can be minimized by improving soil drainage. Planting *Phytophthora* resistant varieties and treating seeds with fungicide can also help reduce the number of plants lost from damping-off.

Anthracnose



Alfalfa infected with anthracnose.

Pathogen type: fungus (*Collectotrichum trifolii*)

Disease symptoms: An alfalfa plant infected with the anthracnose fungus has diamond-shaped lesions near the base of the stem. The lesions are tan with dark brown borders and contain small, black fruiting bodies. Infected stems wilt, producing the characteristic "shepherd's crook" symptom. When alfalfa crowns are invaded, the inner tissues turn bluish black and the plant dies.

Environmental conditions favoring disease: Anthracnose is a warm, humid weather disease. The spores are spread by wind and splashing rain.

Control: The best control option for anthracnose is to plant resistant varieties. Foliar fungicides are not registered for alfalfa.

Crown Rot

Pathogen type: several species of fungus

Symptoms: The crown discolors, turning tan to black. Rotten tissue intersperses with healthy tissue. Slowly, the crown dies. Alfalfa stands gradually begin to thin.

Environmental conditions favoring disease: Fungal spores enter the alfalfa plant through wounds in the roots caused by environmental, mechanical, or insect damage. Therefore, this disease can occur under any environmental conditions that favor root damage.

Control: Minimizing traffic over the field reduces crown damage. Maintain plant vigor, monitor soil levels of potassium (K+), and practice a two-year crop rotation out of small grains.

DISEASES OF CORN

Corn Gray Leaf Spot

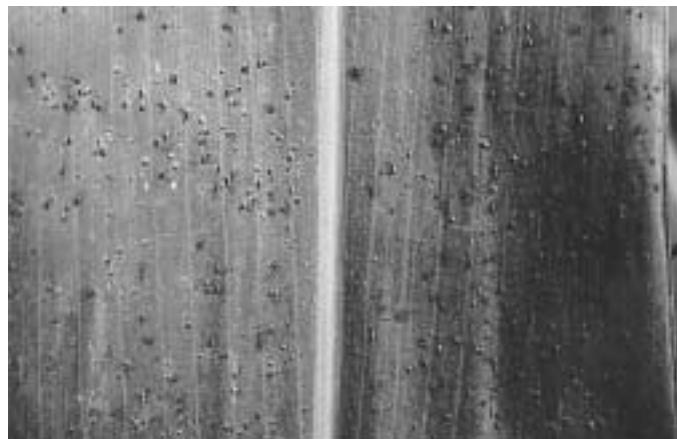
Pathogen type: fungus (*Cercospora zeae-maydis*)

Disease symptoms: Long, rectangular lesions appear on the leaf surface. Lesions are $\frac{1}{2}$ to 4 inches long and tan to gray.

Environmental conditions favoring disease: The fungus causing corn gray leaf spot lives in crop residue left on the soil surface. The fungus grows best under high daytime temperatures (above 85 degrees F) and relative humidity (above 90 percent).

Control: Eliminating infected surface crop residue and rotating crops help control the fungus. Fungicides are used effectively in seed corn.

Common Rust



Close-up of leaf rust.

Pathogen type: fungus (*Puccinia sorghi*)

Disease symptoms: Oval or elongated brick-red blisters appear on the leaf surfaces. Rust can kill the leaves of young plants.

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

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

Gibberella Stalk and Ear Rot



Corn stalk of a *Gibberella* infected plant.

Pathogen type: fungus (*Gibberella* spp.)

Disease symptoms: *Gibberella* can cause both stalk and ear rot. When the fungus attacks the cornstalk, it often becomes soft and turns brown. The inside of the stalk shreds and turns pink to reddish. The interior of the stalk rots, and the stalk can be easily broken. The usual result is excessive plant lodging.

Gibberella ear rot is caused when the fungus enters the ear through the silk. As the fungus grows, it produces a white-pinkish mold on the ear tip. The fungus may not grow into large molds. *Gibberella* can produce a toxin, *vomitoxin*, that makes the grain unfit for feeding to livestock or humans.

Environmental conditions favoring disease: *Gibberella* stalk rot prefers dry conditions early in the season followed by warm, wet weather two to three weeks after silking. *Gibberella* ear rot develops best when the weather is cool and wet within three weeks of silking. The fungal spores overwinter in the soil and corn debris and are transported by the wind.

Control: Planting corn hybrids that have been selected for resistance to *Gibberella* is the most effective control method. Hybrids with tight husk coverage may have reduced rates of ear rot infection. Also, an early harvest and proper storage may reduce the possibility of ear rot infection. Healthy plants are less susceptible to stalk rot.

Corn Smut

Pathogen type: fungus (*Ustilago maydis*)

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 that turns silver-gray as they age. A mature gall is full of black, powdery fungal spores. The spores are dispersed into the air when the gall ruptures.

Environmental conditions favoring disease: Corn smut is most prevalent in warm and moderately dry areas. Galls are more likely to occur under dry conditions and temperatures of 78 to 94 degrees F. The smut fungus favors stressed plants. The fungal spores overwinter in the soil and prefer high levels of soil nitrogen.



Smut on ear.

Control: The best management strategy is to plant corn hybrids with some level of resistance. Rotating crops and burying crop residue also offer some control of the fungus.

DISEASES OF DRY BEANS

Dry Bean Halo Blight



Dry bean halo blight on leaves.

Pathogen type: bacterium (*Pseudomonas syringae*)

Disease symptoms: The leaves and/or pods have water-soaked marks. Surrounding each mark is a broad light green or yellow halo. The halo can be as big as a dime to the size of a quarter. Early pod infection causes the seeds to shrivel.

Environmental conditions favoring disease: The bacterium prefers cool weather. The pathogen is spread by splashing rain and workers and machinery moving in an infected field with wet plants. It survives on crop residue from season to season.

Control: Seed treatment controls surface contamination but not internal contamination. All seed should be blight tested at the Michigan Department of Agriculture lab. Any seed testing positive should not be used. The disease

usually stops developing under warm temperatures. Resistant varieties and seed treatments help reduce the possibility of infection. All navy bean varieties are resistant to halo blight. Yearly infections can be prevented by removing crop residue and by practicing a crop rotation of two or more years. The bacteria spread can also be reduced by minimizing work in fields when the plants are wet.

Common Blight



Common blight in dry beans.

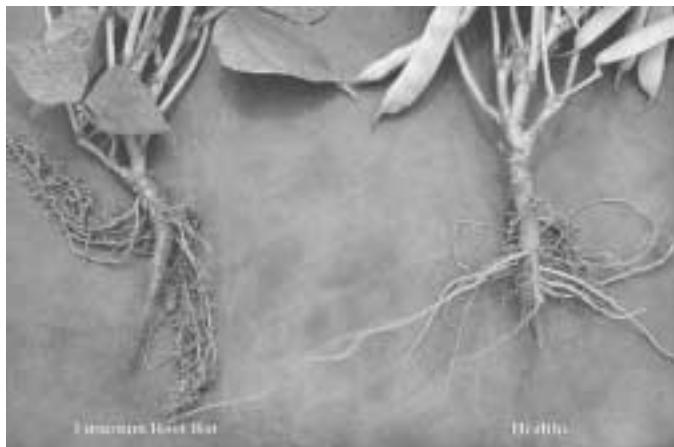
Pathogen type: bacterium (*Xanthomonas campestris*)

Disease symptoms: Leaves and pods have small, water-soaked spots that merge together and turn brown. Unlike halo blight, common blight has only a narrow, bright yellow margin around each spot. The water marks become dry, red-brown spots on infected pods.

Environmental conditions favoring disease: Common blight is more common in warm weather. The pathogen survives in infected seed and on crop residue. Bacteria are spread among plants and fields by splashing rain and people and machinery moving in the field when plants are wet.

Control: Seed treatment controls surface contamination but not internal contamination. All seed should be blight tested at the Michigan Department of Agriculture lab. Any seed testing positive should not be used. Yearly infections can be prevented by removing crop residue and by practicing a crop rotation of two or more years. To reduce the spread of bacteria, minimize work in fields when plants are wet. There are no varieties resistant to common blight.

Fusarium Root Rot



Fusarium root rot infected dry beans.

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

Disease symptoms: Two to three weeks after planting, reddish brown streaks appear on the seedling's stem. The lesions may extend upward to the soil surface and turn brown with age. Plants appear stunted with yellow leaves but seldom die.

Environmental conditions favoring disease: Early planting in cool, moist soil favors Fusarium root rot. Any condition that reduces root growth increases the likelihood of infection. The pathogen lives in the soil and can survive for years.

Control: The disease causes little damage to healthy plants. Therefore, the best control against Fusarium root rot is to maintain a healthy crop. Plant in late May or early June to avoid unfavorable soil conditions. A three-year crop rotation out of beans reduces the chances of infection. Varieties differ in resistance.

DISEASES OF SOYBEANS

Phytophthora Stem and Root Rot

Pathogen type: fungus (*Phytophthora sojae*)

Disease symptoms: The fungus can attack a plant at any growth stage, including seed. Infected seeds often die before they emerge. The fungus commonly destroys the plant at the soil level, causing the seedling or plant to fall over. This is called **damping-off**. If the plant is stressed, the disease can cause sudden wilting and drying of leaves. The roots and stems may also turn brown. Older infected plants were usually infected when they were seedlings. They may be stunted and eventually die.

Environmental conditions favoring disease: Periods of high soil moisture, rainfall, or standing water favor the development of the disease. The disease is found more frequently in heavy soils with poor drainage and areas with high rainfall. The fungus overwinters in the soil as spores. The spores are dispersed by the wind.



Phytophthora stem and root rot in soybeans.

Control: Use farming practices that reduce soil compaction, increase soil aeration, and improve soil structure. Avoid planting in poorly drained soils. Plant resistant hybrids. There is more than one race of *Phytophthora sojae*, and not every resistant hybrid is an effective control for every race of the pathogen. Check with your county Extension agent for information about resistant soybean varieties for your area.

White Mold

Pathogen type: fungus (*Sclerotinia sclerotiorum*)

Disease symptoms: Fungal spores enter the plant **only** through the flowers. A fluffy, white mold grows on nodes and stems. Leaves wilt and turn brown. This growth can girdle the stem, killing the plant. Dead plants stay erect. Hard, black fungal bodies (sclerotia) develop in and outside of the stems and pods. These fungal bodies can be harvested with the soybeans, returned to the soil, or moved around the field or from field to field to reinfect the following season.

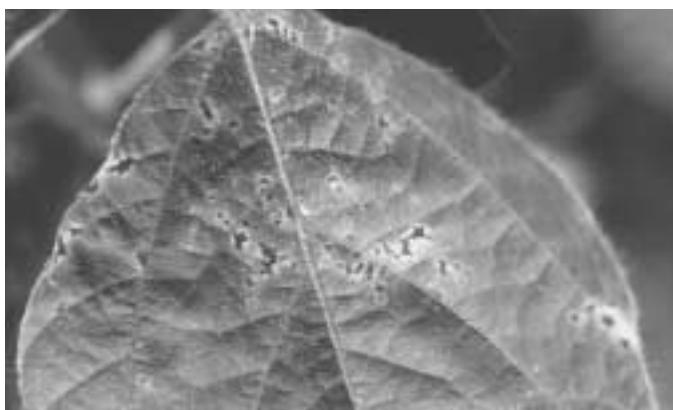
Environmental conditions favoring disease: Wet weather two weeks before and during flowering of the soybean plant is important for infection. The capacity of the soybean canopy to keep stems wet for extended periods of time contributes to disease severity.



Soybeans killed by white mold (X. B. Yang, Iowa State University).

Control: Planting wider rows allows the soil to dry out. This changes the environmental factors necessary for the pathogen to infect the soybean plant. Preventing the introduction of the pathogen by thoroughly cleaning equipment can minimize the spread of white mold between fields. The severity of white mold infections can be reduced by long crop rotations. However, the fungus attacks other field crops, including dry beans and vegetables such as tomatoes, potatoes, canola, and cucumbers. Therefore, alternate white mold-susceptible crops in rotations with corn or wheat to reduce fungal survival. Check with your county Extension agent for information on chemical control of white mold.

Septoria Brown Spot



Septoria brown spot infected soybeans.

Pathogen type: fungus (*Septoria* spp.)

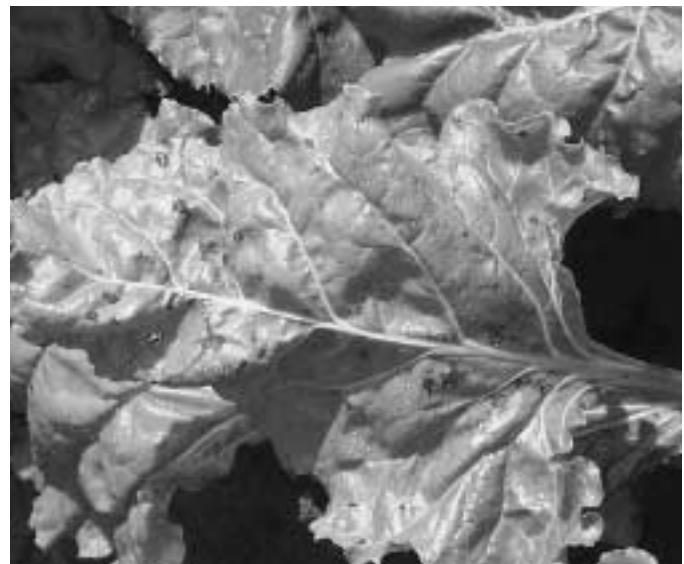
Disease symptoms: Irregular, dark brown spots that vary from minute flecks to lesions $\frac{3}{16}$ inch in diameter form on the leaves. The spots may have yellow borders. The symptoms usually appear on the lower leaves first. Eventually, the leaves drop off.

Environmental conditions favoring disease: Wet conditions with heavy rain spread the fungus upward in the plant canopy. The fungus attacks young seedlings early and late in the season. The spores overwinter in the soil and are dispersed by the wind.

Control: There is little to no economic loss from brown spot, so no control options are recommended. Continuous cropping of soybeans may increase the severity of the disease, however.

DISEASES OF SUGAR BEETS

Cercospora Leaf Spot



Cercospora leaf spot in sugar beets.

Pathogen type: fungus (*Cercospora beticola*)

Disease symptoms: Small, brown spots with purple borders appear on leaves and leaf stems. The spots merge, causing the leaves to turn yellow to brown. In high humidity and heavy dew, the spots look gray. Finally, the leaf collapses but remains attached.

Environmental conditions favoring disease: The fungus survives on crop residue and develops best in high temperatures and high humidity.

Control: Crop rotation and clean plowing to reduce crop residue diminish pathogen infection from year to year. Planting disease-tolerant varieties also reduces fungal infections. Foliar fungicides are effective and can be used even on disease-tolerant varieties.

Black Root

Pathogen type: Several fungi cause black root, but the most serious one is *Aphanomyces cochloides*.

Disease symptoms: The fungus infects the seedling roots. Brown, water-soaked regions appear on the stem and cotyledons. The infected root and stem turn black and become threadlike. Damping-off usually occurs.

Environmental conditions favoring disease: This soil-borne fungus prefers warm, wet soils.

Control: Seed treatments and tolerant varieties offer control. Also, planting on well drained soils will decrease the disease, which prefers wet areas of the field—for example, near drainage ditches and low spots. Crop rotation is also an effective control.

Rhizoctonia Root Rot

Pathogen type: fungus (*Rhizoctonia solani*)

Disease symptoms: Sudden wilting, leaf stems turning black, and outer leaves yellowing are the first symptoms. The wilted leaves collapse and die. The roots may partially or completely rot. Infected areas on the root surface are dark brown to black.

Environmental conditions favoring disease: This is a common soil fungus that attacks a wide host range. Rhizoctonia root rot prefers high temperatures and is more severe in heavy, poorly drained soils.

Control: Rhizoctonia root rot is difficult to control. Tillage, fertilizing, promoting healthy plants and good soil drainage, practicing crop rotation, and controlling weeds all help reduce the occurrence of this disease.

Pathogen type: fungus (*Fusarium graminearum*)

Disease symptoms: Infection occurs at flowering, and infected spikelets will have a bleached appearance. Orange or pink spore masses can be found at the bases of the spikelets. The fungus enters the kernels, turning them light brown to pink when infections occur early in the season. Infected kernels may be shrunken, wrinkled, and lightweight, though many infected kernels show no symptoms. The fungus produces vomitoxin, a toxin that can cause vomiting, nausea, dizziness, and diarrhea in non-ruminant animals such as humans and hogs. The chance of vomitoxin getting into human food is slim because grain is tested. However, problems may develop from feeding livestock uncleaned, scabby wheat, oats, or barley. Hogs fed 10 percent or more scabby grain may vomit and refuse to eat the grain mixture. Vomitoxin does not break down easily and can remain in stored grain for a long time.

Environmental conditions favoring disease: The fungus develops in cool to moderate, wet weather during flowering and grain ripening. Periods of rain immediately before flowering and lasting for three or more days after flowering begins are highly favorable for scab development. The wind disperses spores that overwinter in infected grain and corn residue.

Control: Scab-infected seeds should not be used. Seed treatment will reduce seedling diseases but does not affect infection at flowering. The same fungus that causes wheat scab also causes stalk rot in corn. Therefore, plant away from old cornfields and avoid rotating wheat, corn, barley, oats, or rye into corn. Plant two or more varieties that flower three to seven days apart to reduce the risk of scab.

DISEASES OF WHEAT AND SMALL GRAINS

Wheat Scab



Scab causes premature ripening of wheat (G. Munkvold, Iowa State University).

Wheat Yellow Mosaic Virus

Pathogen type: virus

Disease symptoms: Young leaves have light green or yellow streaks and dashes. Older leaves may be bright yellow-green. The leaf markings are parallel with leaf veins and taper at both ends to form spindles. Wheat yellow mosaic virus-infected plants tend to be uniformly distributed throughout the field. Infected plants produce fewer tillers, smaller heads and less seed per head than healthy plants. Plants may be mildly stunted, but this is not often evident.

Environmental conditions favoring disease: Cold air temperatures (40 to 50 degrees F) favor infection by this virus. Generally, as temperatures warm, the plant appears to have outgrown the virus. In years with prolonged cool temperatures, susceptible varieties can display symptoms through early June.

Method of transmission: The virus survives in the soil and is transmitted to plants by a soilborne fungus, *Polymyxa graminis*. Cultivating equipment, wind, water, and other factors that disperse infested soil spreads wheat yellow mosaic virus. Soils may remain infected for years.

Control: Resistant varieties and long crop rotations with legumes reduce the potential for wheat yellow mosaic virus infections.

Barley Yellow Dwarf Virus



Barley yellow dwarf virus in wheat, with healthy plants on the left (G. Munkvold, Iowa State University).

Pathogen type: virus

Disease symptoms: Starting at the leaf tip, leaves turn yellow or bright red. Infection in young plants may cause stunting. Plants can be attacked in both the fall and spring. Plants infected in fall may be unable to survive the winter. Spring infections may result in discoloration of only the top leaf (flag leaf). Distribution of the virus in the field depends on the aphid population.

Environmental conditions favoring disease: Moderate temperatures favor foliar symptoms. Barley yellow dwarf virus epidemics occur when the weather conditions favor the aphid vectors. Cool (50 to 65 degrees F), moist weather is most favorable. Aphid movement can be local, from one field to another, or aphids can be carried hundreds of miles by the wind. Generally, aphids migrate from the southern states to the northern states in spring and from north to south in fall.

Method of transmission: More than 20 species of aphids are known to transmit the virus, which exists as several strains. Several aphids transmit some strains of the virus

equally well, whereas other strains can be transmitted by only one or two aphid species. All cereals and wild grasses are hosts.

Control: Resistant oat varieties are available. Barley and wheat varieties show differences in barley yellow dwarf virus infections, but they are not resistant. Plant winter wheat five to 10 days after the Hessian fly-free date and barley as late as practical to avoid early fall infections. Plant spring oats as early as possible. Vigorously growing plants are more tolerant of barley yellow dwarf virus. Control volunteer wheat, barley and oats—they can serve as reservoirs of the virus. Chemical control of the aphid vectors is not effective or economical.

Leaf Rust



Leaf rust pustules on wheat (G. Munkvold, Iowa State University).

Pathogen type: fungus (*Puccinia recondita*)

Disease symptoms: Small, round or oval, raised, orange-red blisters or pustules appear on leaf surfaces. They can be either scattered or clumped on the leaf surface. Each pustule contains thousands of spores. Rubbing the pustules and releasing the spores confirms the identification of rust.

Environmental conditions favoring disease: Cool nights and warm, bright days. The stems and leaves need to be moisture free for six to eight hours.

Method of transmission: Fungal spores are windblown. New infections can occur every 10 to 12 days.

Control: Plant resistant varieties. Fungicides can be effective for early-season infections.

General Control Practices for All Wheat and Small Grain Diseases

1. Select varieties that are high yielding and resistant to the major diseases.
2. Plant more than one variety. Planting varieties that flower at different times helps to reduce the incidence of scab.

3. Treat all seeds before planting. This is a must for any wheat grown in Michigan. Seed treatments reduce infections by seedborne pathogens such as wheat scab and are critical to control loose smut and common (stinky) smut.
4. Scout fields beginning in mid-May to identify fields that are potential problems. Remember to scout the entire field to locate pockets of infection.
5. Protect the flag leaf. Eighty percent of the yield comes from the flag leaf. Chemical treatments should not be applied until the flag leaf has emerged and only in conjunction with scouting. Fungicides are not labeled for application after flowering.



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:

- Active movement.
- Passive movement.

10. The source of a plant pathogen that causes a disease is called a(n):

- Infection.
- Parasite.
- Inoculum.
- Host.

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

- Preharvest interval.
- Restricted entry interval.
- Incubation period.
- Disease period.

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

- Creating unfavorable conditions.
- Improving crop growth.
- Reducing the plant pathogen population in a field.
- All of the above.

13. Which of the following is NOT a cultural control?

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

14. Biological control is the most effective tactic to use to control plant pathogens.

- True.
- False.

15. Which of the following alfalfa diseases causes the stems to take on a “shepherd’s crook” shape?

- Phytophthora root rot.
- Crown rot.
- Anthracnose
- Verticillium wilt.

16-19. Match the following corn disease with the characteristic disease symptoms.

- Gibberella stalk and ear rot
- Corn smut
- Common rust
- Corn gray leaf spot

- Forms galls that usually appear on the ear.
- Produces a pinkish mold.
- Leaves have dark red blisters.
- Fungus produces long, gray lesions on leaf surfaces.

20. Which of the following plant diseases is transmitted by aphids from an infected plant to a non-infected plant?

- White mold.
- Common rust.
- Corn smut.
- Barley yellow dwarf virus.

21-26. Match the following diseases with the type of plant pathogen that causes them.

- Bacterium
- Fungus
- Virus

- Septoria brown spot
- Common blight
- Fusarium root rot
- Wheat yellow mosaic
- Dry bean halo blight
- Anthracnose

27. The plant pathogen that causes white mold in soybeans enters the plant through the soybean _____.

- Stem.
- Root.
- Flower.
- Leaf.

28. Damping-off in soybeans can be caused by which plant disease?

- Septoria brown spot
- Fusarium root rot
- Phytophthora stem and root rot
- Common blight

29. More than one type of fungus can cause black root disease in sugar beets.

- A. True.
- B. False.

30. Wheat kernels that produce vomitoxin have been infected with:

- A. Wheat scab.
- B. Leaf rust.
- C. Wheat yellow mosaic virus.
- D. Barley yellow dwarf virus.

31. Vomitoxin is poisonous to humans.

- A. True.
- B. False.

32. Wheat yellow mosaic virus is transmitted to plants by:

- A. Insects.
- B. Fungi.
- C. Wind.
- D. None of the above.

33. Your barley plants have small, orange-red, round blisters or pustules on the leaves. When you rub the sores, lots of little specks or spores are released. Your barley plants are infected with which disease?

- A. Barley yellow dwarf virus
- B. Leaf rust
- C. Wheat yellow mosaic virus
- D. Wheat scab

34. List three common practices used to control small grain diseases.