Soybean Diseases

IOWA STATE UNIVERSITY
University Extension

CSI 0004 November 2010

For more information on scouting for corn and soybean pests, check out these ISU Field Guides produced by Iowa State University and the Iowa Soybean Association, available from the Extension Online Store (www.extension.iastate.edu/store or 515-294-5247).

This publication is a cooperative effort between the Iowa Soybean Association and the College of Agriculture and Life Sciences and Extension at Iowa State University.

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Funded in part by the soybean checkoff.

Contents

What is a plant disease?

A plant disease is any abnormal condition that alters the appearance or function of a plant. It is a physiological process that affects some or all plant functions and may reduce the quality and/or quantity of the harvested product.

Disease is a process or a change that occurs over time. It does not occur instantly like many noninfectious disorders (e.g., herbicide injury or lightning strike).

Visible effects of disease on plants are called symptoms. Any detectable change in color, shape and/or function of the plant in response to a pathogen or disease-causing agent is a symptom. Leaf spots or blights, discoloration of plant tissue, stunting and wilting are symptoms that may be evidence of disease.

Symptoms can occur throughout the plant or be confined to localized tissues. Although certain symptoms can be used to identify a particular disease, a number of pathogens may cause the same or similar symptoms. Furthermore, symptoms often change over time and are influenced by environmental conditions and can vary among soybean varieties.

Signs of plant disease are physical evidence of the pathogen, for example, fungal fruiting bodies, bacterial ooze or nematode females. Signs also can help with plant disease identification.

What causes plant disease?

Infectious plant diseases are caused by organisms that obtain their nutrition from the plants they infect. The parasitic organism that causes a disease is called a pathogen. Plants infected by a pathogen and serving as its food source are referred to as hosts – in this case the host is the soybean plant. Fungi, bacteria, viruses and nematodes are pathogens of soybeans in Iowa. Plants may be simultaneously infected by more than one pathogen.

A favorable environment is critically important for disease development. Even the most susceptible plants exposed to large amounts of a pathogen will not develop disease unless environmental conditions are favorable. Environmental conditions can affect disease development in two ways: directly affecting plant pathogens and/or causing soybeans to be more prone to attack by some pathogens. Temperature and moisture are the most important environmental factors; relative humidity, soil pH, soil texture, light and nutrient status also may affect disease development. Soil compaction, tillage practices, planting depth, seed bed preparation and residue management affect how soybean plants respond to particular environmental conditions.

Plant disease triangle

A susceptible host plant, a pathogen and a favorable environment are the three factors composing the plant disease triangle (Figure 1). All three factors are necessary for development of a plant disease; thus, disease can be affected by altering any of these three factors.

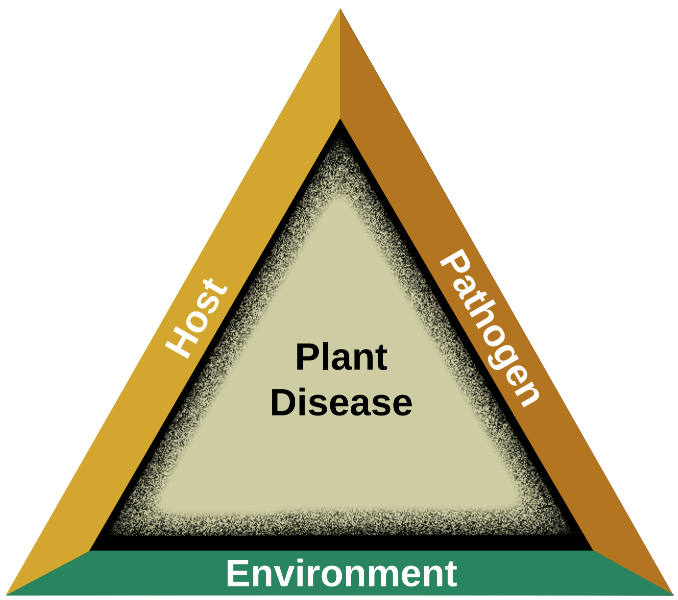


Figure 1. Plant disease triangle

Major groups of plant pathogens

Fungi

Fungi are the largest and perhaps most well-known group of plant pathogens. The vast majority of fungi, however, do not cause disease. Many help decompose organic matter, releasing nutrients for plants and other organisms to use. However, numerous fungi can cause plant disease, and a relatively small number of them cause disease in humans and livestock. Most plant pathogenic fungi are extremely small and, except for possible extensive growth on the surface of a plant, normally cannot be seen without a microscope.

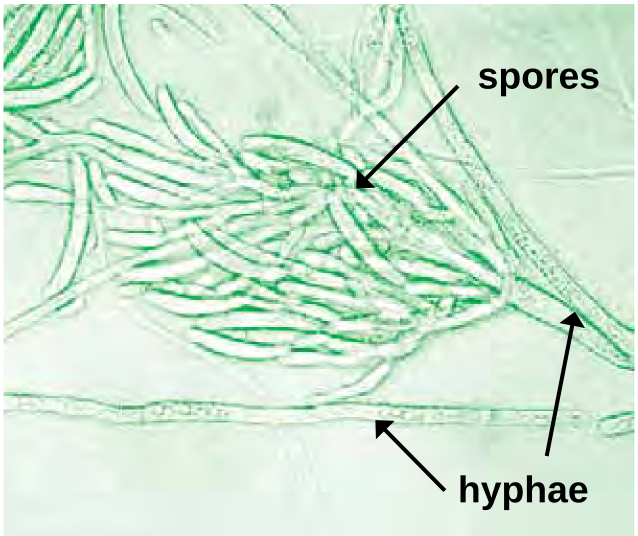


Figure 2. Hyphae and spores of the *Fusarium* fungus

Most fungi are composed of delicate, threadlike filaments called hyphae (Figure 2). Hyphae absorb water and nutrients needed for growth and reproduction of the fungi. Hyphae may also secrete enzymes, toxins and other chemical substances that may be important factors in disease development and symptom expression. A mass of hyphae is referred to as mycelium. The "fuzzy" fungal growth that is sometimes visible on plant surfaces is this mycelium (Figure 3). Oftentimes, however, mycelium develops completely or primarily inside the host and is not visible on the plant's surface.

Figure 3. Mycelium of the white mold fungus, *Sclerotinia sclerotiorum*

Most fungi reproduce by producing spores (Figure 2), which can be seen with a microscope. Spores are carried to plants primarily by wind and water. Some types of spores are produced inside structures called fruiting bodies, that may be seen on or in plant tissues. Spores and fruiting bodies are often used to identify a fungus. Some spores and fruiting bodies are resistant to adverse environmental conditions and can survive in soil or decaying plant material for a long time. Some fungi produce specialized resting structures known as sclerotia or microsclerotia. These structures are compacted masses of hyphae and stored foods that can endure long periods of unfavorable conditions.

Fungi can cause a variety of symptoms including leaf spots and blights, root rots, seedling blights, seed discoloration, wilts and stem rots.

Bacteria

Bacteria are perhaps more familiar to us as the cause of important human and animal diseases, such as tuberculosis and pneumonia. However, most bacteria are harmless and many are even beneficial, such as the nitrogen-fixing bacteria that form nodules on soybean roots. Nonetheless, some bacteria can also be destructive plant pathogens.

Bacteria are extremely small microorganisms, much smaller than fungal spores. They reproduce by individual cells splitting into nearly equal halves, each becoming a fully developed bacterium. A bacterial population may increase to very high numbers within a short period of time. For example, if a bacterium divided every 30 minutes, a single cell would produce more than 250 trillion descendants in 24 hours.

As bacteria divide, the cells tend to clump together in masses called colonies. Bacterial cells and colonies vary in size, shape, color and growth habit. These characteristics are used to identify specific bacteria.

Bacteria cannot make their own food; they must obtain it either from dead or decaying organic matter, or living tissue. Nearly all bacteria have the ability to grow and develop on dead tissue. Most plant pathogenic bacteria do not compete well with other organisms in the soil in the absence of their host plant, so their populations may decline rapidly when the host plant is not grown.

Bacteria are primarily spread from plant to plant by wind-driven rain and gain entrance into host tissues through natural plant openings. Wounds in plant tissues from insects, hail, wind or other causes also provide entry points for bacteria.

Typical symptoms of bacterial diseases include leaf spots, water soaking and soft rots of plant tissues.

Viruses

Like bacteria, viruses are probably most familiar to us as the cause of human and animal diseases, such as influenza, polio, rabies, smallpox and warts. Viruses, however, also cause several plant diseases.

Viruses are infectious, disease-producing particles that can only be seen with a very high magnification electron microscope. Virus particles are very small, measuring only about one-millionth of an inch. Viruses multiply by causing host cells to form more viruses instead of performing normal cell processes.

Almost all viruses can survive only in living cells. Therefore, their spread from diseased to healthy plants depends on some means of direct movement from host to host. Many viruses are transmitted by insects, called vectors, particularly aphids and leafhoppers (Figure 4). Some viruses are transmitted when equipment or people spread sap or juice from diseased plants to healthy plants. This type of mechanical transmission may happen by simple leaf contact between healthy and diseased plants.

Typical viral symptoms include mosaic patterns on leaves, deformation of plant tissues, stunting, seed discoloration and reduced yield.

Nematodes

Nematodes are microscopic, non-segmented, round, slender worms. Several thousand species of nematodes are found in soil, in fresh and salt water, in animals and within or on plants throughout the world. Nematodes are aerobic animals that require oxygen, which they absorb from water through their body wall. Most nematodes feed on dead or decaying organic material. Some are parasites on animals, plants, insects, fungi or other nematodes.

A single acre of cultivated soil may contain hundreds of millions of nematodes, but due to their small size, they are seldom, if ever, seen. Most adult parasitic nematodes of plants cannot be seen unless magnified. They rarely exceed ⅛ inch and may be smaller than 1⁄64 inch.

Plant-parasitic nematodes have a hollow, needle-like feeding structure called a stylet that is used to puncture plant cells (Figure 5). Nematodes inject substances into host plant cells through their stylets and then withdraw nutrition from the plant cells through their stylets.

The life cycle of a nematode includes an egg, four juvenile stages and an adult. Females lay eggs that hatch into juveniles. Juveniles molt between stages and become adults, and the egg-laying process is repeated. The life cycle of a plant-parasitic

Figure 4. Winged soybean aphid, one of several insects that can transmit viruses

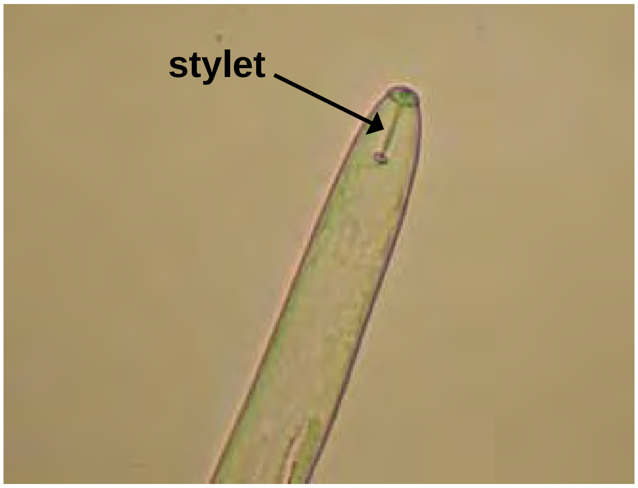


Figure 5. Plant parasitic nematode with a stylet

nematode can take 20 to 60 days to complete. Nematodes survive winters mainly in the egg stage.

Most plant-parasitic nematodes live in the soil and feed in or on plant roots. Some nematodes live part or all of their lives inside plant roots.

Most important, plant-parasitic nematodes feed on plant roots and directly interfere with water and nutrient uptake by the plant. Root injury from nematodes causes aboveground symptoms similar to those produced by other conditions that damage root systems. Plants frequently appear to be suffering from lack of moisture or nutrient deficiency, even when water and minerals are adequate. When nematodes occur in high population densities, stunting, yellowing, loss of vigor, general decline and eventual death of plants are typical aboveground symptoms.

Noninfectious disorders

Noninfectious disorders are caused by nonliving agents or factors. A noninfectious disorder can be caused by any physical or chemical component of the environment that is harmful to the plant's growth and development. Examples of noninfectious disorders are temperature and moisture extremes (Figure 6), hail (Figure 7), wind, lightning, unfavorable light, improper soil nutrient levels, toxic chemicals and mechanical damage.

Figure 6. Example of a noninfectious disorder – excessive moisture

Figure 7. Example of a noninfectious disorder – hail damage

Differences between noninfectious disorders and plant diseases

Noninfectious disorders cannot reproduce or spread from plant to plant. Symptoms of noninfectious disorders may appear suddenly and often occur in patterns across a field. Although symptoms on individual plants may change by becoming progressively better or worse, the area of a field that is affected will not increase over time. These points help differentiate noninfectious disorders from plant diseases.

A common example of a noninfectious disorder is herbicide injury. Herbicide injury can occur from drift onto soybeans from a neighboring field or if a sprayer used to treat the field was contaminated. If the symptoms appear in a drift pattern, then herbicide injury is a logical explanation.

Noninfectious disorders may produce symptoms such as wilting, stunting, yellowing, deformation or death of plant tissues. Symptoms of some types of noninfectious disorders are similar to those of certain fungal and viral diseases (Figure 8). Plants stressed by noninfectious disorders may be more prone to attack by infectious diseases. For example, soybean plants stressed by herbicide injury may be more prone to root rot diseases. Problems on field crops frequently occur in combination, so when diagnosing a problem, all possible causes or combinations of causes must be carefully considered.

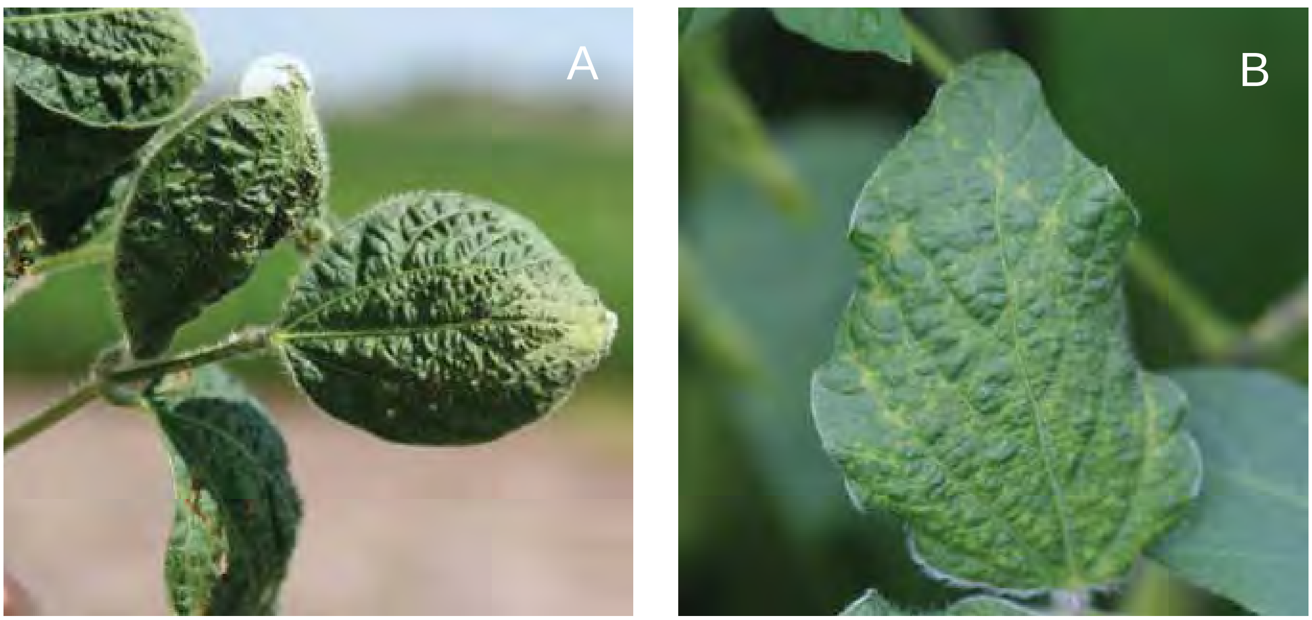


Figure 8. Herbicide injury (A) can appear similar to virus symptoms (B).

SEED transmitted *Some diseases may be transmitted in or on the seed. If this icon appears near the disease name, it indicates the pathogen can be seed transmitted.*

Alfalfa Mosaic
Alfalfa mosaic virus

SEED transmitted

Alfalfa mosaic, caused by *Alfalfa mosaic virus* (AMV), is a viral disease that is becoming increasingly common in soybeans. Alternate hosts of AMV include alfalfa, other legumes and solanaceous crops. AMV is transmitted by aphids.

Symptoms

Leaves have mottled patterns of bright yellow and dark green tissues. Newly emerged leaves may be smaller than usual with bright yellow spots and brown discoloration. Plants may be stunted. Plants infected by AMV do not produce seed with mottled seedcoats, unlike some other soybean viruses.

Disease Development

AMV is transmitted by more than 15 species of aphids, including the soybean aphid (*Aphis glycines*). Reports of alfalfa mosaic in soybeans have increased in recent years and are believed to be associated with outbreaks of soybean aphids. The disease may be more prevalent on edges of fields, especially in fields bordering alfalfa.

Management

Variety selection: Resistance to AMV has been identified in soybeans, but is not yet commercially available. However, current soybean varieties differ in tolerance to AMV, based on degree of symptom expression.

Foliar insecticides: These are not likely to be effective in reducing transmission of AMV by aphids.

Alfalfa mosaic foliar symptoms

Alfalfa mosaic foliar symptoms

Alfalfa mosaic foliar symptoms on seedlings

Bacterial Blight
Pseudomonas syringae

SEED transmitted

Bacterial blight is a very common foliar disease of soybean throughout the North Central region, but it seldom causes serious yield loss. Together with Septoria brown spot, it is usually the first foliar disease to occur on soybeans in most growing seasons. Diseased plants are usually widespread within a field.

Symptoms
Infection can first occur on cotyledons. As plants grow, young leaves are most susceptible. Lesions or dead spots are most obvious on leaves in the mid- to upper canopy but can also occur on stems, petioles and pods. Lesions are small, angular and reddish-brown with water-soaked margins surrounded by a yellow halo. As disease progresses, lesions often grow together to produce large, irregularly shaped dead areas. Centers of older lesions frequently fall out, causing leaves to appear tattered. On stems and petioles, lesions are large and black.

Disease Development
Bacteria survive winter in crop residue and seed and are spread by rain and wind. Bacteria can survive on leaf surfaces during the season and infect plants when conditions are suitable. Infection occurs through stomates and wounds caused by wind, hail, cultivation, etc. Thus, outbreaks are common after rainstorms with high winds. Cool, rainy weather favors disease development; high temperatures will slow or stop disease development.

Management
Variety selection: Use field-tolerant varieties. No resistance is commercially available, but field tolerance has been observed. Avoid planting extremely susceptible varieties where disease is a potential problem. Check with a seed dealer for varieties that have field tolerance.

Crop rotation and tillage: Rotation and tillage reduce survival of *Pseudomonas syringae*. Non-hosts include alfalfa, corn and small grains; other legume crops can be alternative hosts. If tillage is considered to decrease pathogen levels, be careful to minimize soil erosion and maintain soil quality.

Early symptoms of bacterial blight

Bacterial blight with leaf tattering

Bacterial Pustule

Xanthomonas axonopodis pv. *glycines*

SEED transmitted

Bacterial pustule occurs mid- to late season when temperatures are warmer and more favorable for disease development. Symptoms may be mistaken for bacterial blight, Septoria brown spot or soybean rust. Diseased plants are usually widespread within a field.

Symptoms

Lesions are found on outer leaves in the mid- to upper canopy. Lesions start as small, pale green specks with elevated centers and develop into large, irregularly shaped infected areas. Unlike bacterial blight, no water soaking is associated with lesions, but each lesion is surrounded by a greenish-yellow halo. A pustule may form in the center of some lesions, usually on the lower leaf surfaces. Pustules crack open and release bacteria. Bacterial pustule will not cause leaves to tatter like bacterial blight.

Disease Development

Bacteria survive winter in crop residue and seeds and are spread by rain and wind. Infection occurs through leaf stomates or wounds. Rainy weather favors disease development. Unlike bacterial blight, high temperatures do not slow disease development.

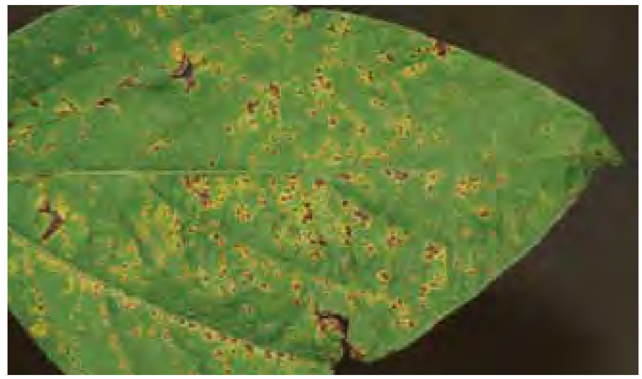
Management

Variety selection: Avoid planting extremely susceptible varieties. Some varieties are marketed as resistant to this disease.

Crop rotation and tillage: Rotation and tillage reduce survival of *Xanthomonas axonopodis* pv. *glycines.* Other legume crops may be hosts; non-hosts include alfalfa, corn and small grains. If tillage is considered, use proven conservation tillage practices to maintain soil quality.

Bacterial pustule early symptoms

Plant infected with bacterial pustule



Lesions surrounded by yellow halo

Lesions on bottom leaf surface

Close-up of pustule on bottom leaf surface

Bean Pod Mottle
Bean pod mottle virus

SEED transmitted

Bean pod mottle is a viral disease of soybean, snap bean and other legumes caused by *Bean pod mottle virus* (BPMV). Like many plant viruses, BPMV is spread by an insect. In the North Central region, the most important insect vector is the bean leaf beetle, *Cerotoma trifurcata*, which feeds on infected plants, then transmits the virus particles to the next plant on which it feeds.

Symptoms

Foliar symptoms include yellow and green mottled areas. Young leaves show symptoms more severely than older leaves, sometimes with a raised, blistered or distorted appearance. Symptoms can be transient and most obvious during periods of rapid plant growth and cool temperatures, but they may disappear during hot weather and during the reproductive stages of the crop. Symptoms may resemble injury from herbicide drift and are similar to those caused by other viruses. This makes it difficult to diagnose bean pod mottle and most other viral diseases based on symptoms alone. Laboratory tests can be done at diagnostic clinics to distinguish among suspected viruses.

BPMV is associated with green stem syndrome, a delayed maturity of the stems and petioles, which can make harvesting more difficult. Infection also decreases pod formation, reduces seed size, weight and number and may cause seed mottling.

BPMV-infected seed

BPMV foliar symptoms

Disease Development

There are three potential sources of BPMV: overwintered bean leaf beetles, perennial host species (e.g., *Desmodium* species) and infected seed (usually less than 0.1 percent). Although the level of virus transmission by overwintered beetles is low, beetles acquire BPMV from infected perennial host species and soybean seedlings infected via seed transmission.

The presence of bean leaf beetles is an indicator for increased risk of BPMV infection. The first-generation peak in beetle numbers occurs during late V or early R growth stages – around early July. The second-generation peak occurs during pod-fill stages (R3 through R6) in August.

Management

Variety selection: Although tolerance to BPMV infection has been identified in soybeans, commercial varieties are not clearly characterized for this trait. Currently, varieties differ in tolerance to BPMV, although the differences are not clearly studied.

Insecticide seed treatments: Consider planting treated seed if overwintering survival of bean leaf beetles is predicted. Also consider insecticide seed treatments if bean pod mottle has been confirmed in fields in previous years and bean leaf beetles have been present.

Foliar applied insecticides: Foliar applied insecticides can manage bean leaf beetle populations and may reduce incidence of bean pod mottle.

BPMV foliar symptoms

Bean leaf beetle

Bean leaf beetle feeding

Cercospora Leaf Blight & Purple Seed Stain

SEED transmitted

Cercospora kikuchii

Cercospora leaf blight has become more prevalent in Iowa. Yield losses due to this disease are common in the southern United States, but serious losses have not been reported despite widespread distribution of the disease in the North Central region. Diseased plants are usually widespread within a field.

Symptoms

Foliar symptoms usually are seen at the beginning of seed set and occur in the uppermost canopy on leaves exposed to the sun. Affected leaves are discolored, with symptoms ranging from light purple, pinpoint spots to larger, irregularly shaped patches typically only on the upper leaf surface. As disease develops, affected leaves may become leathery and dark purple with bronze highlights. Symptoms may be confused with sunburn. Discoloration may extend to the upper stems, petioles and pods. Infection of petioles and severe symptoms may lead to defoliation of the uppermost leaves and give the appearance of a maturing crop. However, petioles of fallen leaves remain attached to the stem, and lower leaves of the plant remain green.

Symptoms of purple seed stain are distinct pink to dark purple discolorations of seed. Discolored areas vary in size from small spots to the entire surface of the seed coat; however, infected seeds may not show symptoms.

Disease Development

The fungus survives winter in infested crop residue and infected seed. Most early season infections do not cause symptoms but contribute to infection of foliage and pods later in the season. Warm and wet weather is favorable for infection. Foliar symptoms are the result of an interaction between a toxin produced by the fungus and sunlight. Weather conditions during flowering and plant maturity will affect the incidence of purple seed stain. Despite being caused by the same organism, there is no consistent relationship between the occurrence of Cercospora leaf blight and purple seed stain.

Management

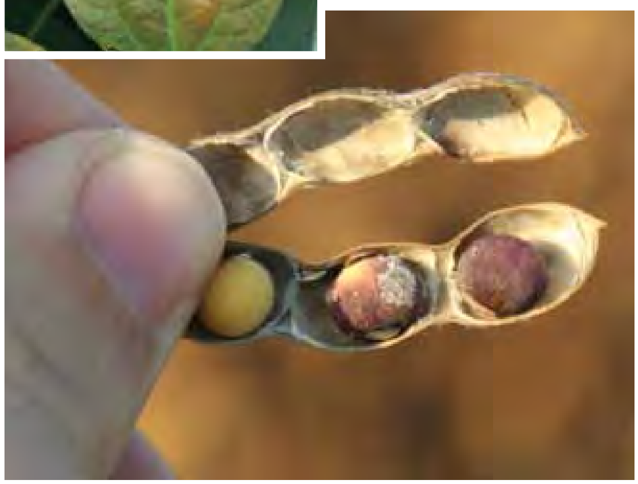
Variety selection: There are commercially available varieties resistant to Cercospora leaf blight. However, there are no known sources of resistance for purple seed stain.

Fungicides: Foliar fungicides are registered for Cercospora leaf blight. Applications made during pod-filling stages can reduce the incidence of purple seed stain, but may not affect soybean yield.

Crop rotation and tillage: Rotation to non-host crops such as alfalfa, corn and small grains and tillage to bury infested crop residue will reduce pathogen levels. If considering tillage, use proven conservation practices to maintain soil quality.

Foliar symptoms include yellow-gold to purple patches (above and left).

Purple seed stain (below)



Downy Mildew
Peronospora manshurica

SEED transmitted

Downy mildew is a very common foliar disease of soybeans, but it seldom causes serious yield loss. The pathogen may also infect seed and reduce seed quality. Diseased plants are usually widespread within a field.

Symptoms and Signs

Seedlings that are infected from oospores on the seed can develop large chlorotic areas on the first and second pairs of true leaves. The disease is more common in late vegetative and reproductive growth stages. Lesions occur on upper surfaces of leaves as irregularly shaped, pale green to light yellow spots that enlarge into pale to bright yellow spots. Older lesions turn brown with yellow-green margins. Young leaves are more susceptible than older leaves, so disease is often found in the upper canopy. Lesion size varies with the age of the leaf affected.

On the underside of the leaf, fuzzy, gray tufts may be seen growing from each lesion, particularly when humidity is high or leaves are wet, for example, early in the morning.

Infected pods show no external symptoms, but the inside of the pod and seed may be covered with a dried, whitish fungal mass that appears crusty and contains spores. Infected seed can be smaller, appear dull white and have cracks in the seed coat.

Disease Development

Peronospora manshurica survives in leaves and on the surface of seed. Extended periods of leaf wetness are favorable for movement of the pathogen. High humidity and moderate temperatures favor infection. The increased resistance of older leaves and higher temperatures midseason usually stop disease development before extensive damage occurs.

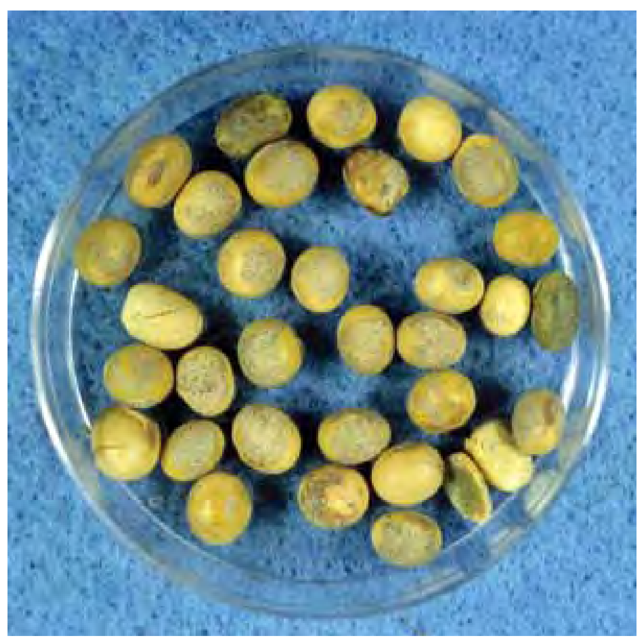
Management

Variety selection: Many sources of resistance are available. However, many races of the pathogen have been identified, and varieties that are resistant to all known races have not yet been developed.

Crop rotation and tillage: Crop rotation and burial of infested crop residue using conservation tillage practices can reduce pathogen levels.

Downy mildew symptoms on upper leaf surface

Fuzzy, gray tufts on underside of leaf



Downy mildew-infected seeds

Frogeye Leaf Spot
Cercospora sojina

Frogeye leaf spot has become more prevalent in Iowa. It is especially problematic in continuous soybean fields. Diseased plants are usually widespread within a field.

Symptoms

Early season infections from infected seed result in stunted seedlings. On leaves, lesions are small, irregular to circular and gray with reddish-brown borders that most commonly occur on the upper leaf surface. Lesions start as dark, water-soaked spots that vary in size, and as lesions age, the central area becomes gray to light brown with dark, red-brown margins. In severe cases, disease can cause premature leaf drop and will spread to stems and pods.

Symptoms on stems are not as common or distinctive as foliar symptoms and appear as narrow, red-brown lesions that turn light gray with dark margins as they mature.

Lesions on pods are circular or oval shaped and are initially red-brown and turn to light gray with a dark brown margin. Seed close to lesions on pods can be infected. Infected seeds have light to dark gray discolored blotches that vary in size and cover the entire seed in severe cases. The seed coat often cracks.

Disease Development

The fungus survives in infested crop residue and infected seed. Early season infections contribute to infection of foliage and pods later in the season. Warm, humid weather promotes spore production, infection and disease development. Young leaves are more susceptible to infection than older leaves, but visible lesions are not seen on young, expanding leaves because the lesions take two weeks to develop after infection. It is common for disease to be layered within the canopy. This is a result of little to no infection during dry periods and higher levels of infection during wet or humid weather.

Management

Variety selection: Resistant varieties are available and should be used where disease is a potential problem. Several races of the pathogen have been identified, and varieties with resistance to all known races are available.

Crop rotation and tillage: Rotation and tillage will reduce survival of *Cercospora sojina*. Crops not susceptible to this pathogen are alfalfa, corn and small grains. If tillage is considered to promote decay of crop residue, great care should be taken to minimize soil erosion and maintain soil quality.

Fungicides: Foliar fungicides applied during late flowering and early pod set to pod-filling stages can reduce the incidence of frogeye leaf spot and improve seed quality and yield.

Frogeye leaf spot foliar symptoms (right)

Close-up of frogeye leaf spot (above)

Phyllosticta Leaf Spot

Phyllosticta sojicola

Phyllosticta leaf spot is an occasional, minor disease of soybeans. It rarely affects yield.

Symptoms and Signs

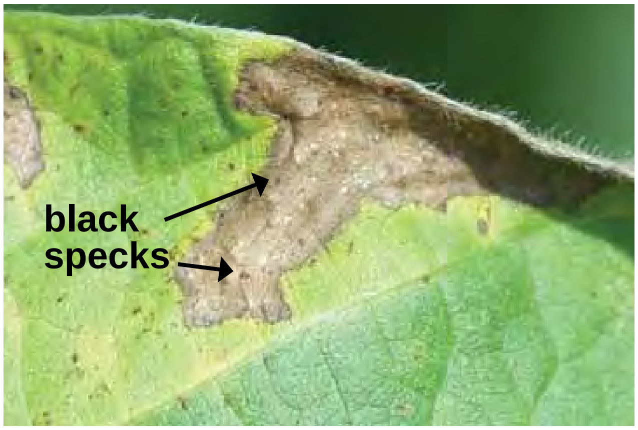
Plants are susceptible to infection at all stages. Lesions most often occur on leaves and are circular, oval and irregular or V-shaped. Lesions appear gray or tan and have a narrow, dark margin. In older lesions, numerous small, black specks may be visible. These are pycnidia, the fruiting structures of the fungus. Disease also may progress to the petioles, stems and pods.

Disease Development

The fungus likely survives in infested crop residue. Cool, moist conditions favor disease development.

Management

Management is usually not needed. Crop rotation and tillage will reduce survival of *Phyllosticta sojicola*.



Phyllosticta leaf spot foliar symptoms and signs

Powdery Mildew
Microsphaera diffusa

Powdery mildew is more prevalent in cooler than normal seasons. While this disease is uncommon, when it does show up in fields, there can be noticeable yield loss.

Symptoms and Signs

The most common and characteristic sign of powdery mildew is white, powdery fungal growth that can cover all aboveground plant parts, particularly the upper surface of leaves. Powdery mildew usually does not appear until mid- to late reproductive stages. Initially, small fungal colonies form and grow together as they enlarge. Eventually, entire surfaces of infected plant parts are covered with white fungal growth. Advanced symptoms include yellowing of plant tissues and premature defoliation.

Disease Development

The fungus survives in infested crop residue. Favorable conditions include cool, cloudy weather and low humidity. Powdery mildew is frequently more severe in late-planted soybeans.

Management

Variety selection: Most commercial varieties are resistant.

Fungicides: Fungicides effectively manage powdery mildew; however, there are limited situations where fungicide use will be profitable.

Signs of powdery mildew

Septoria Brown Spot
Septoria glycines

Brown spot is the most common foliar disease of soybean. Disease develops soon after planting and is usually present throughout the growing season. Yield losses depend on how far up the canopy the disease progresses during grain fill. Diseased plants are usually widespread within a field.

Symptoms

Symptoms are typically mild during vegetative growth stages of the crop and progress upward from lower leaves during grain fill. Infected young plants have purple lesions on the unifoliate leaves. Lesions on later leaves are small, irregularly shaped and dark brown, and are found on both leaf surfaces. Adjacent lesions can grow together and form larger, irregularly shaped blotches. Infected leaves quickly turn yellow and drop. Disease starts in the lower canopy and, if favorable conditions continue, will progress to the upper canopy. Lesions on stems, petioles and pods are not as common, but appear as brown, irregularly shaped spots ranging from small specks to 1/2 inch in diameter.

Disease Development

The fungus survives on infected leaf and stem residue. Warm, wet weather favors disease development. Disease usually stops developing during hot, dry weather, but may become active again near maturity or when conditions are more favorable.

Management

Variety selection: There are no known sources of resistance, but differences in susceptibility occur among soybean varieties.

Crop rotation and tillage: The host range of *Septoria glycines* includes other legume species and common weeds such as velvetleaf. Rotation to non-host crops such as alfalfa, corn and small grains and incorporation of infested crop residue into the soil will reduce the survival of *Septoria glycines*. If tillage is an option, use conservation tillage practices to maintain soil quality.

Fungicides: Foliar fungicides labeled for brown spot control are available. Applications made during R3 through R5 soybean growth stages may slow the rate of disease development into the middle and upper canopy and protect yield.

Smaller brown spot lesions

Larger, irregularly shaped brown spot lesions

Brown spot infection in the lower canopy

Soybean Mosaic

Soybean mosaic virus

SEED transmitted

Soybean mosaic is a viral disease of soybean and other legumes caused by *Soybean mosaic virus* (SMV). SMV is moved from plant to plant or vectored by aphids. Soybean mosaic does not generally affect yield; although infected plants may produce fewer and smaller seeds, the major concern with SMV is reduced seed quality due to mottled soybeans. There may be clusters of symptomatic plants or just single plants with symptoms in a field.

Symptoms

Foliar symptoms include a mosaic of light and dark green areas, chlorosis and puckered or curled leaves. The youngest and most rapidly growing leaves show the most symptoms. Symptoms are most obvious at cooler temperatures and often disappear when it is hot. Symptoms can resemble injury from herbicide drift and are similar to those caused by other viruses. This makes it difficult to diagnose SMV, like most other viruses, based on symptoms alone. Laboratory tests can be done at diagnostic clinics to distinguish among soybean viruses.

Infected plants can be stunted with shortened petioles and internodes. They also can have reduced pod numbers, and infected pods are smaller, flatter, more curved and with less hair than non-infected pods. Seed mottling may occur (see page 10) and seed germination may be reduced.

Disease Development

Infected seed is the most important way SMV is introduced into a soybean field. Seed transmission depends on the variety planted and ranges from 0 to 75 percent. In most modern soybean varieties, rates of seed transmission are usually between 0 to 5 percent. Once the virus is in the field, aphids can spread it from plant to plant as they feed. More than 30 species of aphids transmit SMV worldwide, including the soybean aphid (*Aphis glycines*).

Symptoms of virus infection are frequently associated with specific fields, especially those with moderate to high insect activity. Infection with more than one virus is common, and the risk of yield loss or reduced seed quality is much greater with dual or multiple infections than with only one virus.

Management

Variety selection: Although most commercial soybean varieties are susceptible to SMV, resistance has been identified in soybean genotypes and varieties.

SMV foliar symptoms

Planting date: Later planted soybeans may have a higher risk of SMV infection and spread by insect vectors.

Foliar insecticides: These are not effective in reducing transmission of SMV by aphids. While aphid populations may be reduced, SMV infection is unaffected.

Soybean Rust
Phakopsora pachyrhizi

Soybean rust is an aggressive disease capable of causing defoliation and significant yield loss. Soybean rust is not endemic to Iowa but is found in most soybean growing areas of the world.

Symptoms and Signs

Soybean plants are susceptible at any stage of development, but symptoms are most common after flowering. Early symptoms of rust infection begin on lower leaves. Lesions begin to form on lower leaf surfaces, starting as small, gray spots and changing to tan or reddish-brown. Lesions are scattered within yellow areas that appear translucent if the affected leaves are held up to the sun. Mature lesions contain one to many small pustules that usually occur on lower leaf surfaces. These pustules produce spores, and spore production may continue for weeks. Severe rust infections result in premature defoliation and early maturity.

Disease Development

The rust pathogen can only survive on green tissue; thus, the pathogen is unable to survive in areas where killing frosts eliminate susceptible hosts. For the most part, rust survives on kudzu, a viney legume growing in the southern parts of Texas, Louisiana, Mississippi, Alabama and Georgia, as well as Florida and Mexico. The movement of rust from the southern United States northward depends on rust spores increasing at sites where the pathogen has survived the winter, dispersal of the spores to new areas and establishment of the disease in those areas. These steps need to be repeated several times within a growing season in order for rust to cause an epidemic in Iowa.

When spores land in new areas, infection takes place only when prolonged periods of leaf wetness (6 to 12 hours) and moderate temperatures occur in those areas. Cool, wet weather or high humidity favor soybean rust epidemics. Dense canopies also can provide ideal conditions that encourage disease development. Infection can spread rapidly to middle and upper leaves once the canopy closes.

Management

Variety selection: A limited number of resistant breeding lines have been identified; however, there are currently no commercially available soybean rust resistant varieties in North America. Resistant varieties have been released in other countries, but none are resistant to all known races of the pathogen.

Soybean rust in the field

Soybean rust foliar symptoms

Soybean rust in the lower canopy

Fungicides: Currently, foliar fungicides are the only viable option for managing soybean rust. To manage the disease effectively and profitably, fungicides need to be sprayed prior to infection or, at the latest, very soon after initial infection. National and local spread of soybean rust can be tracked to help gauge if/when to start scouting or initiate fungicide applications (http://sbr.ipmpipe.org).

Anthracnose Stem Blight

SEED transmitted

Colletotrichum truncatum and several related species

Anthracnose is generally a late season disease that is prevalent on maturing soybean stems throughout Iowa. Soybean, however, is susceptible to infection throughout the growing season. Diseased plants are usually widespread within a field.

Shepherd's crook caused by petiole infection

Symptoms and Signs

Infected seed may or may not show symptoms. When seed symptoms do occur, they appear as brown discoloration or small gray areas with black specks. Damping off may occur if infected seed is planted.

Leaves, pods and stems may also be infected without showing symptoms. Foliar symptoms include reddish veins, leaf rolling and premature defoliation. On stems and petioles, symptoms typically appear as irregularly shaped red to dark brown blotches during early reproductive stages. Petiole infection may result in a shepherd's crook. Early infection of leaf petioles may cause premature defoliation and yield loss. Infection of young pods results in seedless pods at maturity while pods infected later contain seeds that are infected. Near maturity, black fungal bodies that produce small, black spines and spores are evident on infected stems, petioles and pods.

Anthracnose on stems, early symptoms (left); later symptoms (right)

Disease Development

The fungus survives winter as mycelium in crop residue or infected seed. Although plant stand may be affected by early season infection, most infection occurs during the reproductive stage of the crop. Spores produced by the fungus are sensitive to drying; thus, free moisture for 12 hours or longer is necessary for successful infection. Warm, wet weather favors infection and disease development.

Management

Variety selection: There are no known sources of resistance to anthracnose, but soybean varieties differ in susceptibility.

Crop rotation and tillage: Crop rotation and tillage will reduce survival of *Colletotrichum* species. Non-legume crops such as corn are not susceptible to this pathogen. If tillage is considered, great care should be taken to minimize soil erosion and maintain soil quality.

Fungicides: Foliar fungicides labeled for anthracnose are available. Applications should be made during the early to midreproductive growth stages of the crop, although there are limited situations where fungicide use will be profitable.

Brown Stem Rot
Phialophora (Cadophora) gregata

Brown stem rot (BSR) is an economically important disease of soybean in Iowa and throughout the North Central soybean growing region of the United States.

Symptoms
Leaf symptoms on infected plants vary and depend on the soybean variety, strain of the fungus and environmental conditions. In some instances, no foliar symptoms occur. Characteristic foliar symptoms include interveinal chlorosis and necrosis, followed by leaf curling and leaf death. Foliar symptoms can be similar to those of sudden death syndrome and stem canker and appear after early pod set. Stem symptoms usually occur prior to leaf symptoms. Externally, infected plant stems look healthy. However, when stems are split longitudinally, internal browning of vascular tissue and pith is evident, especially at nodes and in lower parts of the stem.

Disease Development
The fungus does not produce long-term survival structures but can reproduce on soybean residue throughout the winter. Severity of BSR and yield reduction is related to soybean variety, fungal population levels in soil and plant residue and environmental conditions. BSR is more severe when temperatures are cool and adequate soil moisture is present. Foliar symptoms are particularly sensitive to environmental conditions during reproductive growth stages of the crop and are suppressed when temperatures are high or soil is dry during these stages.

Management
Variety selection: The most efficient way to manage BSR is with the use of resistant varieties. Many sources of resistance are available. It is also known that soybean cyst nematode (SCN) breaks resistance to BSR in most BSR-resistant varieties. However, many soybean varieties with PI 88788-derived SCN resistance also have BSR resistance. Therefore, planting soybean with PI 88788-derived SCN resistance can reduce the adverse effect of SCN on BSR resistance. Varieties with Peking- or Hartwig-derived SCN resistance, however, may be susceptible to BSR.

Crop rotation and tillage: *Phialophora gregata* survives on crop residue. It has a limited host range,

Foliar symptoms appear after early pod set.

Characteristic foliar symptoms include interveinal chlorosis and necrosis.

Internal browning of vascular tissue and pith

so crop rotation to a non-host crop (corn, small grains and forage legumes) will reduce pathogen levels. In fields where disease is severe, rotation to a non-host crop for three or more years is recommended. If tillage is being considered to decrease pathogen levels, great care should be taken to minimize soil erosion and maintain soil quality.

Charcoal Rot
Macrophomina phaseolina

SEED transmitted

Charcoal rot can be an important disease and is most yield-limiting when weather conditions are hot and dry.

Symptoms and Signs

Symptoms of charcoal rot usually appear after flowering. Initial symptoms are patches of stunted or wilted plants. Leaves remain attached after plant death. The lower stem and taproots of these plants are discolored light gray or silver. When stems are split, black streaks are evident in the woody portion of the stem. In addition, the fungus produces numerous tiny, black fungal structures called microsclerotia that are scattered throughout the pith and on the surface of taproots and lower stems. These microsclerotia give the tissue a charcoal-like appearance.

Infected seed either show no symptoms or have microsclerotia embedded in seed coat cracks or on the seed surface. Infected seed have lower germination, and if seed does germinate, the seedlings usually die within a few days.

Disease Development

The fungus survives in soil or soybean residue as microsclerotia. Microsclerotia infect roots of soybean plants, sometimes very early in the season. Many environmental factors affect microsclerotia survival, root infection and disease development. Charcoal rot is most prevalent during hot, dry weather, especially when it occurs during the R1-R7 soybean growth stages. The fungus is more abundant in soil when pH is very acidic or alkaline.

Management

Variety selection: Resistant varieties are not available; however, soybean varieties vary in susceptibility.

Crop rotation: Growing small grains, such as wheat or barley, can reduce microsclerotia numbers. Corn is also a host of *Macrophomina phaseolina* so it will not reduce levels of the fungus when planted in rotation with soybeans. The fungus is less damaging to corn than to soybeans.

Tillage: Fields with minimal or no tillage may have fewer symptoms because of lower soil temperatures and greater water-holding capacity.

Charcoal rot in the field

Black streaks in woody portion of the stem

Microsclerotia in the stem

Seeding rates: Avoid excessive seeding rates so that plants do not compete for moisture, which increases disease risk during a dry season.

Fusarium Wilt and Root Rot
Fusarium species

Fusarium is a very common soil fungus, and more than 10 different species are known to infect soybean roots and cause root rot. The species *Fusarium oxysporum* is responsible for causing Fusarium wilt. Although Fusarium root rot is a widespread disease in the United States, the economic impact on yield is not well documented.

Plants wilting from root rot

Symptoms

Symptoms of Fusarium wilt are more noticeable under reduced moisture and hot conditions and are often misdiagnosed as those of Phytophthora root rot. Infected plants have brown vascular tissue in the roots and stems and show wilting of the stem tips. However, external decay or stem lesions are not seen above the soil line. Foliar symptoms include scorching of the upper leaves, while middle and lower canopy leaves can turn chlorotic and later wither and drop from the plant.

Young plants are at the greatest risk to root rots caused by *Fusarium* species. Infected plants may exhibit poor or slow emergence, and seedlings are often stunted and weak. Seedlings with root rot have reddish-brown to dark brown discolored roots. Infected plants may have poor root systems and poor nodulation, which may cause the plants to wilt and die.

Sliced stem revealing brown vascular tissue

Disease Development

The fungus survives in the soil either as spores or as mycelium in plant residue. Certain weeds may serve as hosts to some pathogenic *Fusarium* species. The fungi can infect plants at any stage of soybean development but infection is particularly favored when plants are weakened. Stresses such as herbicide injury, high soil pH, iron chlorosis, nematode feeding and nutritional disorders can all predispose plants to infection. After infection, damage to plants can be worsened if soil moisture is limited because of the compromised root systems.

Management

Variety selection: Varieties have varying levels of susceptibility, but no resistant varieties have been described.

Stress factors: Reducing or eliminating stress factors, such as use of herbicides that cause injury to soybeans, wet soils and soybean cyst nematode, can help reduce root rot problems. Growing varieties tolerant to iron deficiency chlorosis should be considered if the root rot seems associated with iron deficiency chlorosis.

Seed treatments: If *Fusarium* is a problem in a field, fungicide seed treatments may protect seedlings in subsequent years.

Planting date: Plant soybeans in problematic fields when soils are warmer.

Phytophthora Root and Stem Rot
Phytophthora sojae

Phytophthora root and stem rot is an economically important disease of soybeans that is most severe in poorly drained soils. Diseased plants often occur singly or in patches in low-lying areas of the field that are prone to flooding.

Symptoms

Phytophthora sojae can infect soybeans at any growth stage from seed to maturity. Early season symptoms include seed rot and pre- and post-emergence damping off. Stems of infected seedlings appear water-soaked, while leaves may become chlorotic and plants may wilt and die. On older plants, symptoms vary depending on the variety. For susceptible plants, leaves become chlorotic between the veins and plants wilt and die, with the withered leaves remaining attached. Varieties that are not fully susceptible may appear stunted, but plants are typically not killed.

The most characteristic symptom of Phytophthora root rot, however, is a dark brown lesion on the lower stem that extends up from the taproot of the plant. The lesion often reaches as high as several nodes and will girdle the stem and stunt or kill the plant.

Plants wilting from *Phytophthora sojae* infection

Dark brown lesion on the lower stem that extends up the taproot, girdling the stem

Disease Development

Phytophthora sojae survives on crop residue or in the soil as oospores. When soil temperatures reach 60ºF, oospores germinate to produce structures that release swimming spores, called zoospores, under saturated soil conditions. The zoospores are attracted to soybean roots. Infection occurs via the roots, and from there the pathogen colonizes the roots and stems. Disease is most common in poorly drained soils, but may occur in other soils as well.

Management

Variety selection: Phytophthora root rot is best managed by planting resistant varieties. Many race-specific resistance genes (called *Rps* genes) to *Phytophthora sojae* have been identified in soybean breeding lines. Some of these genes have been incorporated in commercial soybean varieties; thus, there are soybean varieties available that have complete resistance to a specific race of *Phytophthora sojae*. There are numerous races (now called pathotypes) of *Phytophthora sojae*, and many pathotypes can exist in a single field. Furthermore, new pathotypes can develop that can infect varieties with specific *Rps* genes.

Partial resistance is available to *Phytophthora sojae*. Partial resistance is effective against all races of *Phytophthora sojae*; however, it is only expressed after the first true leaves emerge, not in very young seedlings.

Crop rotation and tillage: Continuous soybean production may increase disease severity. But rotation to non-hosts may not reduce disease severity because oospores can survive in soil for long periods of time. Disease is more severe in no-till fields because these fields can be wetter. If tillage is considered to improve drainage, use proven conservation tillage practices to maintain soil quality.

Seed treatments: Where *Phytophthora sojae* is a problem, seed treatments with mefenoxam or metalaxyl as an active ingredient can provide some protection. Seed treatments are especially helpful with poor quality seed and in fields with a history of this problem.

Dark brown lesions on lower stems

Phytophthora root rot in the field

Pod and Stem Blight & Phomopsis Seed Decay

Diaporthe phaseolorum var. *sojae* and *Phomopsis longicolla*

Pod and stem blight is one of three diseases that make up the *Diaporthe-Phomopsis* complex. Other diseases in this complex include seed decay and stem canker (see page 31). Stems, petioles, pods and seeds are all susceptible to infection.

Symptoms and Signs

The most characteristic sign of pod and stem blight is linear rows of black specks on mature stems of soybeans. The specks, which are flask-shaped fruiting structures of the fungus known as pycnidia, can be seen during the season on prematurely killed petioles or stems.

Poor seed quality may result from infection. Seed infection occurs only if pods become infected. Pod infection can occur from flowering onwards, but extensive seed infection does not occur until plants have pods that are beginning to mature. Insect damage to pods favors development of seed infections.

Phomopsis-infected seed are cracked and shriveled and are often covered with chalky, white mold. If infected seeds are planted, emergence may be low due to seed rot or seedling blight. Infected seedlings have reddish-brown, pinpoint lesions on the cotyledons or reddish-brown streaks on the stem near the soil line.

Disease Development

The fungi survive winter in infected seed and infested crop residue. Certain weeds may serve as hosts to some pathogenic *Diaporthe* and *Phomopsis* species. Infection can occur early in the growing season without causing symptoms. Disease is favored by warm, humid weather, when soybean plants are maturing. Also, disease is more severe if harvest is delayed.

Management

Variety selection: Sources of resistance have been identified, and variation in seed infection has been reported among commercial soybean varieties. Unfortunately, there currently are no resistant varieties or lists of seed reactions of current varieties available. Varieties with an earlier relative maturity for a region are at greater risk of Phomopsis seed decay and pod and stem blight than fuller-season varieties.

Linear rows of black specks on stem

***Phomopsis*-infected seed**

***Phomopsis*-infected seed in the pod**

Seed selection: Do not plant seed with a high incidence of infection.

Crop rotation and tillage: Crop rotation and tillage will reduce survival of *Diaporthe* and *Phomopsis* species. Non-host crops include corn. If tillage is considered to promote decay of pathogen-infested residue, be careful to minimize soil erosion and maintain soil quality.

Foliar fungicides: Application of foliar fungicides near R5 can protect seed quality, but may not affect yield.

Harvest: Harvest early maturity varieties first to lower the incidence of seed rot.

Fungicide seed treatment: Most fungicide seed treatments, except metalaxyl/mefenoxam, are effective against *Phomopsis* species. Treating *Phomopsis*-infected seed lots may increase germination and improve plant establishment.

Pythium Root Rot
Pythium species

Pythium is primarily a seedling disease. Early planting dates increase the risk of disease in Iowa. Diseased plants often occur singly or in small patches in low-lying areas of the field that are prone to flooding.

Symptoms
Pythium species cause pre- or post-emergence damping off. Infected seed appear rotted and soil sticks to them. Infected seedlings have water-soaked lesions on the hypocotyl or cotyledons that develop into a brown soft rot. Diseased plants are easily pulled from the soil because of rotted roots. Older plants become resistant to soft rot, but root rot may cause plants to become yellow, stunted or wilted if infection is severe.

Disease Development
The pathogen survives either in plant residue or in soil as oospores. Severity of disease depends on the amount of the pathogen in the soil, plant age and environmental conditions at the time of infection. Saturated soil is critical for infection for all *Pythium* species. Like *Phytophthora*, *Pythium* produces zoospores that swim in free water and infect the roots of plants. In general, *Pythium* species that are prevalent in the north infect plants at lower temperatures (50 to 60ºF), and *Pythium* species in the south infect plants at warmer temperatures (85 to 95ºF), although there are exceptions.

Management
Planting date: Planting in cold, wet soils should be avoided to reduce infection by *Pythium* species that infect at low temperatures.

Seed treatments: Where *Pythium* is a problem, seed treatments with mefenoxam (Apron formulation), metalaxyl or strobilurins as active ingredients can provide some protection. Resistance to metalaxyl/mefenoxam has been documented; however, they are generally considered more effective than strobilurins.

Tillage: No-till soils often have higher soil moisture and lower soil temperatures, factors that increase the risk of *Pythium* infection. If tillage is considered to improve drainage, use conservation tillage practices to maintain soil quality.

Damping off of very small seedlings

Field with poor emergence

Damping off of seedling

Rhizoctonia Root Rot
Rhizoctonia solani

Rhizoctonia root rot is one of the most common soilborne diseases of soybeans. Diseased plants usually occur singly or in patches in the field. Disease is typically more common on the slopes of fields.

Symptoms
Rhizoctonia infects young seedlings, causing pre- and post-emergence damping off. Infected seedlings have reddish-brown lesions on the hypocotyls at the soil line. These lesions are sunken, remain firm and dry and are limited to the outer layer of tissue. If seedlings survive the damping off phase, infections may expand to the root system, causing a root rot. The root rot phase may persist into late vegetative to early reproductive growth stages. Older infected plants may be stunted, yellow and have poor root systems.

Disease Development
The fungus survives on plant residue or in soils as sclerotia. When soils warm, the fungus becomes active and infection may occur soon after seed is planted. The fungus grows better in aerated soils; thus, disease is more severe on light and sandy soils. Symptoms may disappear if infected plants grow out of the root rot problems although plants may remain stunted.

Management
Variety selection: Resistance has been reported in some varieties; however, there are no varieties being developed for resistance to Rhizoctonia root rot.

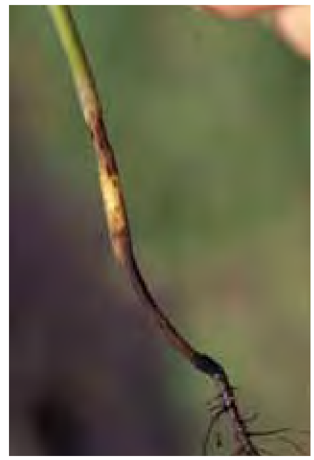
Crop rotation: Unfortunately, many strains of *Rhizoctonia* can infect corn, alfalfa, dry bean and some cereal crops.

Stress factors: Eliminating stress factors, such as use of herbicides that cause injury to soybean roots, can help reduce root rot problems.

Seed treatments: Most fungicide seed treatments, except metalaxyl/mefenoxam, are effective against *Rhizoctonia*.

Rhizoctonia root rot in the field

Early *Rhizoctonia* symptoms



Reddish-brown, sunken lesions on hypocotyl at soil line

Healthy root (left); *Rhizoctonia*-infected roots (right)

Soybean Cyst Nematode
Heterodera glycines

The soybean cyst nematode (SCN) is the most important pathogen of soybean in Iowa. In high-yielding production fields or during years when soil moisture is plentiful, damage from SCN may not be obvious. However, yield losses up to 40 percent on susceptible varieties are still possible. When symptoms are associated with damage, infected plants usually occur in patches within a field.

Symptoms and Signs

Obvious symptoms may not develop, even though yield loss occurs. Noticeable symptoms of SCN include stunting, slow or no canopy closure and chlorotic foliage. Infected plants have poorly developed root systems. Soybean cyst nematode infection also may reduce the number of nodules formed by the beneficial nitrogen-fixing bacteria necessary for optimum soybean growth. Signs of SCN include white females that are most readily seen in the field starting about six weeks after crop emergence. To see them, roots must be dug and soil carefully removed. However, the only way to get a reliable diagnosis as to the amount of SCN in the soil is through analysis of a properly collected soil sample by a diagnostic laboratory.

Plant damage is not just limited to direct and indirect effects of feeding by the nematodes. Wounds caused by infecting nematodes and by maturing females serve as entry points for other soilborne pathogens. Diseases such as brown stem rot, Rhizoctonia root rot, sudden death syndrome and charcoal rot are more severe in the presence of SCN.

Disease Development

SCN survives in the soil as eggs within dead females called cysts. These eggs can survive several years in the absence of a soybean crop. The second-stage juvenile (J2) hatches from the eggs and infects soybean plants. After infection, these juveniles migrate to the vascular system before setting up specialized feeding cells within the root. As they feed, the nematodes become immobile. The juveniles molt three more times before maturing into adults, with females becoming so large they burst through the outer surface of the roots. A female will produce 200 to 300 eggs that are deposited in an external egg mass or are retained within her body. Soybean cyst nematode can complete four or more generations during the growing season,

Midseason yellowing caused by SCN

Severe stunting and overall foliar yellowing caused by SCN

Adult SCN females are about the size of a period at the end of a sentence (yellow arrows) and much smaller and lighter in color than nitrogen-fixing nodules (red arrows).

depending on planting date, soil temperature, length of the growing season, host suitability, geographic location and maturity group of the soybeans.

Conditions that favor soybean growth are also favorable for SCN development. High soil pH may be used to predict where SCN is more problematic. Areas of fields with soil pH levels of 7.0 to 8.0 typically have more SCN compared to areas with soil pH 5.9 to 6.5.

Management

The number of SCN in a field can be greatly reduced through proper management, but it is impossible to eliminate SCN from a field once it is established. Soil tests are recommended prior to every third or fourth soybean crop to monitor SCN population densities (numbers).

Variety selection: Resistant varieties are available to manage SCN. The three most common sources of resistance are PI 88788 (most common), PI 548402 (Peking) and PI 437654 (also referred to as Hartwig or PUSCN-14). Resistant varieties are not resistant to all SCN populations. Most resistant varieties contain only one source of genetic resistance. Rotating sources of SCN resistance may help prevent the development of more damaging SCN populations. SCN-resistant varieties, even high-yielding varieties, can vary considerably in how well they control nematode population densities. Greater SCN reproduction will result in a higher SCN egg population in the soil at the end of the growing season, and consequently, higher numbers of SCN in subsequent seasons. Thus, growers must consider how SCN-resistant soybean varieties affect SCN population densities, in addition to how well the varieties yield, to maintain the long-term productivity of the land for soybean production.

Crop rotation: If SCN is a problem, rotation should include non-host crops (usually corn) and resistant soybean varieties. Years of non-host crops may decrease SCN numbers by as much as 90 percent in the southern United States, but only 10 to 40 percent in the north (some of the differences may be due to poor winter survival in the south). Years with a resistant variety will keep SCN numbers from increasing.

Stress factors: Maintaining adequate soil fertility, breaking hardpans, irrigation (if available) and controlling weeds, diseases and insects improves soybean plant health. These practices help plants compensate for damage by SCN, but do not decrease SCN numbers.

Aerial perspective of SCN-infected field, showing stunting and early senescence

Healthy roots (left); stunted SCN-infected roots (right)

Tillage: No-till practices may slow SCN movement and lower population densities.

Clean equipment: Soil that remains on tillage and harvest equipment can move SCN and should be removed before equipment is relocated from an infested to a non-infested field.

Seed treatments: Seed treatments labeled for use on SCN may provide early season protection.

Soil-applied nematicides: A limited number of nematicides labeled for use on SCN can be applied at planting.

Stem Canker

*

Diaporthe phaseolorum var. *caulivora* (northern stem canker) and *D. phaseolorum* var. *meridionalis* (southern stem canker)

SEED transmitted

There are two similar but distinct stem canker diseases. Northern stem canker is prevalent in northern regions. Southern stem canker is prevalent in the southern United States but has been reported in Wisconsin and Illinois as well. Infected plants usually occur in patches within the field.

Symptoms

Initial symptoms are small, reddish-brown lesions that appear soon after flowering near the nodes in the lower third of the soybean canopy. Lesions expand longitudinally and form sunken cankers that are gray-brown with reddish margins. Stem canker can be confused with Phytophthora stem rot; to distinguish them, stem canker has green stem tissue below the canker and does not cause root rot. Interveinal foliar chlorosis and necrosis may occur as a result of a toxin produced by the fungus. These symptoms can be similar to those of brown stem rot and sudden death syndrome.

Disease Development

The fungus survives in infested residue or in the soil for several years. Infection occurs when spores are splashed by rain onto plants in early vegetative growth stages. Northern stem canker is believed to be associated with cooler temperatures and extended periods of rainy weather occurring early in the growing season. Southern stem canker infection requires 24 to 96 hours of leaf wetness and warm temperatures (70 to 85ºF).

Management

Variety selection: Varieties with resistance to northern stem canker are available.

Tillage: Incorporation of infested crop residue into the soil will reduce survival of *Diaporthe* species. If tillage is an option, use proven conservation tillage practices to reduce erosion and maintain soil quality.

Seed treatments: Fungicide seed treatments, except for metalaxyl/mefenoxam, may reduce stem canker.

* *Southern stem canker is seed transmitted, but northern stem canker is not known to be seed transmitted.*

Stem canker lesions (Note green tissue below the canker)

Stem canker lesions

Stem canker lesion near a node

Sudden Death Syndrome
Fusarium virguliforme

Sudden death syndrome (SDS) is becoming increasingly prevalent throughout Iowa. Yield losses may range from a few percent to almost 100 percent.

Symptoms and Signs

Foliar symptoms rarely appear until after flowering. Leaves of infected plants initially show scattered, yellow spots between leaf veins. Spots grow to form large chlorotic and necrotic blotches between the leaf veins, while the midvein and major lateral veins remain green. Leaflets eventually drop, but the petioles remain on the stem.

Diseased plants have rotted taproots and lateral roots. When stems are cut longitudinally, the woody tissue of the taproot is discolored light gray to brown (see page 23). This discoloration may extend up to two inches above ground. Bluish fungal growth may be seen on the surface of roots if soil moisture is high.

Foliar symptoms of SDS look similar to brown stem rot (BSR). A good way to distinguish between BSR and SDS is the presence or absence of internal stem browning. Stems of SDS-infected plants have white pith, while BSR causes brown discoloration of the pith. Another way to distinguish between the two is to check roots of diseased plants. Plants with SDS have root rot, while BSR does not cause root rot.

Disease Development

The fungus survives on infested crop residue or in soil for several years. Root infection can occur within days of planting and is favored by high soil moisture and cool temperatures. Significant rainfall at or near the flowering stage favors foliar symptom development. Foliar symptoms are a result of a toxin produced by the fungus moving from roots to the leaves. Soil compaction and the presence of soybean cyst nematode can increase disease severity.

Management

Variety selection: Several soybean varieties have partial resistance to SDS. Check with a local seed dealer to identify an appropriate variety.

Reduce soil compaction: Increased SDS severity has been associated with compacted soil. Deep tillage may reduce severity of SDS where the soil is compacted. Tillage may also promote earlier warming of soils. If tillage is considered to reduce soil com-

Early foliar symptoms of SDS

Foliar symptoms of SDS

Petioles remaining on stem after leaflets drop

paction, great care should be taken to minimize soil erosion and maintain soil quality.

Planting date: The fungus prefers cool soil for infection. Delaying planting by a week or two may reduce the risk of disease due to planting in warmer soils.

Reduce soybean cyst nematode (SCN) populations: Populations of SCN are usually, but not always, associated with SDS and may increase its severity, especially in varieties that are SCN susceptible. Management practices to reduce SCN population densities, including variety selection and preventing the spread of soil from field to field, may delay onset and spread of SDS.

Crop rotation: Crop rotation with corn is not effective. Residue such as corn kernels and corn roots harbor the SDS pathogen in the soil. SDS outbreaks can occur even after a few years of continuous corn.

Blue fungal bodies on SDS-infected plants near the soil line

Patch of SDS in a soybean field

White Mold (Sclerotinia stem rot)

Sclerotinia sclerotiorum

White mold is more correctly called Sclerotinia stem rot. The disease is prevalent in cooler growing regions and can cause significant yield losses, especially during cool, wet seasons.

Symptoms and Signs

White mold is often recognized by fluffy, white growth on soybean stems. Initial symptoms generally develop from R3 to R6 as gray to white lesions at the nodes. Lesions rapidly progress above and below the nodes, sometimes girdling the whole stem. White, fluffy mycelial growth soon covers the infected area, especially during periods of high relative humidity. Characteristic black sclerotia eventually are visible and embedded within mycelium on stem lesions, and inside the stem as the plant approaches death.

Initial foliar symptoms include tissues between major veins turning a gray-green cast, while vein tissues remain green. This can be mistaken for other diseases like brown stem rot, sudden death syndrome or stem canker. Eventually, leaves die and turn completely brown while remaining attached to the stem.

Disease Development

The fungus survives in the soil for several years as sclerotia. Rain, cool temperatures, high humidity and moist soil beneath a closed canopy during soybean flowering and early pod development favor the growth of the fungus. The disease cycle begins when mushroom-like structures called apothecia are formed on the soil surface from sclerotia. Apothecia are typically $^1/_4$ to $^1/_2$ inch in diameter. Shaded conditions favor the production of apothecia from sclerotia. Spores from apothecia infect senescing soybean flowers and the fungus eventually grows to the stem. The disease often develops in areas where moisture collects due to fogs and extended dew periods as well as in pockets of poor air drainage (along tree lines).

The fungus can spread to new fields with improperly cleaned seed and by the movement of infested soil.

Management

Variety selection: No soybean variety is completely resistant; varieties range from moderately resistant

Apothecia of *Sclerotinia sclerotiorum*

Dead leaves still attached to the stem

Fluffy, white growth on soybean stem

to very susceptible. Ratings are based on degree of premature plant death. The incidence of premature plant death is predictive of yield loss, but the rate of plant death is slower for some varieties and allows an acceptable yield even in the presence of disease.

Crop rotation: At least two or three years of a non-host crop such as corn, small grains and forage legumes can reduce the number of sclerotia in soil. Crops that should not be in rotation with soybean in fields with white mold risk are beans, peas, sunflowers and cole crops.

Tillage: More sclerotia are found near the soil surface in no-till systems, but sclerotia numbers begin to decline if left undisturbed. However, viability is maintained if sclerotia are buried 8 to10 inches in the soil. Greater tillage also promotes earlier canopy development, thus increasing the risk of white mold.

Canopy management: Early planting, narrow row width and high plant populations all accelerate canopy closure and favor disease development. However, modification of these practices also may reduce yield potential. The history of white mold in fields should be considered before growers modify practices that promote canopy closure. Bushy soybean varieties and lodging also create a dense, closed canopy which favors white mold growth.

Weed control: Weed control is critical as many broadleaf weeds are hosts of the white mold pathogen. Also, some herbicides (e.g., Cobra®) may suppress the activity of the fungus or disrupt germination of sclerotia.

Biocontrol: Some antagonistic fungi may be applied to the soil to colonize and reduce sclerotia numbers. For example, the product Contans® can reduce white mold sclerotia populations.

Fungicides: Foliar fungicides can effectively manage white mold, or at least reduce disease severity; however, application timing is critical. Fungicides are most effective when applied immediately before infection.

White mold with sclerotia on the stem

White mold sclerotia in the stem

Pod and seed infected with white mold

Apothecia (sing. apothecium)- Saucer-shaped, mushroom-like fungal structures that produce spores.

Chlorotic- The yellowing of a plant's normally green leaf tissue, due to the absence of chlorophyll.

Conservation tillage- Any tillage or planting system that leaves 30 percent or more of the soil surface covered with crop residue after planting, to reduce soil erosion by water.

Cotyledons- The first emerging pair of leaves of the soybean seedling.

Damping off- Seedling collapse due to rot of seeds before or after germination, generally due to fungal infection.

Epidermis- The outer surface of a leaf, stem or root.

Hypocotyl- Component of a seedling soybean stem located beneath the cotyledons.

Longitudinal- Running lengthwise.

Microsclerotia (sing. microsclerotium)- Tiny, dark bodies (masses of hyphae with a thick rind) formed by certain fungi as survival structures.

Mosaic- A pattern of light and dark areas in a leaf that is frequently a symptom of a virus infection.

Mottle- Irregular light and dark-colored areas on plant parts that are frequently caused by a virus.

Necrotic- Dead; chlorotic areas may become necrotic as disease progresses.

Oospore- Thick-walled survival spore of some fungi.

Partial resistance- A term used to describe resistance made up of more than one gene. Also known as horizontal resistance or field resistance.

Pathotype- A classification system used for *Phytophthora sojae*. Similar to race, but better suited to the increasing pathogen diversity of *Phytophthora sojae*.

Pycnidia (sing. pycnidium)- Spore containers that are the fruiting structures of some fungi, visible to the naked eye as tiny dots or bumps on the plant surface.

Race- A distinct population within the same species with relatively small morphological and genetic differences. Races differ in their ability to colonize potential host plants.

Sclerotia (sing. sclerotium)- Seed-like structures formed by some fungi to survive winter or remain dormant until conditions are favorable for growth and/or plant infection.

Senescence- The natural decline and death of plant tissues due to aging.

Stomates- Natural openings in leaves that allow the exchange of air.

Toxin- When pertaining to plants, this is a chemical compound that causes damage to plant cells. Sometimes released by disease-causing organisms.

Zoospores- Spores that can swim in water.

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Acknowledgements

Written and edited by Daren Mueller, Alison Robertson, Adam Sisson and Greg Tylka

Additional editing by Craig Grau, Leonor Leandro and LeAnn Strother

Graphic design by Gary Usovsky

Photo credits:
Iowa State University – Daren Mueller, Alison Robertson, Leonor Leandro, Mark Licht, Kyle Jensen, X.B. Yang, Gary Munkvold, Marlin Rice, Nenad Tatalovic and Greg Tylka, except where noted:

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