

Integrated Pest Management

SOYBEAN DISEASES

Plant Protection Programs

*College of Agriculture, Food
and Natural Resources*

This publication is part of a series of IPM Manuals prepared by the Plant Protection Programs of the University of Missouri. Topics covered in the series include an introduction to scouting, weed identification and management, plant diseases, and insects of field and horticultural crops. These IPM Manuals are available from MU Extension at the following address:

Extension Publications
2800 Maguire Blvd.
Columbia, MO 65211
1-800-292-0969

Authors

- Laura E. Sweets
Commercial Agriculture Crops Focus Team
Division of Plant Sciences
University of Missouri
- Allen Wrather
Division of Plant Sciences
University of Missouri
- Simeon Wright
Plant Diagnostic Laboratory
University of Missouri

Photo credits

- Melissa Goellner Mitchum, University of Missouri Life Sciences Center, provided photographs 43 and 44.
- Robert Heinz, University of Missouri Plant Nematology Laboratory, provided photograph 45.
- Tom D. Wylie, University of Missouri (retired) provided photographs 58 and 60.
- Ward C. Stienstra, University of Minnesota (retired) provided photograph 62.
- All other photographs are by Laura E. Sweets.

Production

- MU Extension and Agricultural Infomation
Dale Langford, editor
Dennis Murphy, designer and illustrator



© 2008 University of Missouri

CONTENTS

Seed and seedling diseases	3
Pythium seed decay and damping-off	3
Phytophthora seedling blight	4
Rhizoctonia seedling blight	6
Fusarium seedling blight	7
Charcoal rot	8
Phomopsis seedling blight.....	8
Foliage diseases.....	8
Septoria brown spot.....	8
Bacterial blight.....	10
Bacterial pustule	11
Frogeye leaf spot.....	11
Downy mildew	12
Powdery mildew.....	13
Soybean rust	14
Virus diseases	15
Bean pod mottle.....	15
Soybean mosaic	16
Tobacco ringspot	16
Bean yellow mosaic.....	16
Root and lower stem diseases	17
Soybean cyst nematode	17
Root-knot nematode	18
Late-season Phytophthora root and stem rot	18
Rhizoctonia root rot	19
Fusarium root rot	19
Sudden death syndrome	20
Charcoal rot	21
Sclerotium blight (southern blight)	22
Sclerotinia stem rot (white mold)	22
Brown stem rot.....	23
Stem, pod and seed diseases	24
Pod and stem blight and Phomopsis seed decay	24
Anthracnose.....	24
Cercospora blight, leaf spot and purple seed stain	25
Stem canker	26

Soybean diseases can and do occur each year in Missouri. Problems with germination and stand establishment that are related to seed decay, damping-off and seedling blights are often encountered in the field. These losses can be costly, especially if replanting is necessary. Diseases may cause leaf spots or leaf blights, wilts or premature death of plants. Soybean diseases also can affect the quality of the harvested crop and cause storage losses. The extent of the damage due to soybean diseases in a given season depends on a number of factors, including the susceptibility of the soybean variety to the specific disease, the level of pathogen inoculum present and the environmental conditions during that season.

To minimize losses due to field crop diseases, it is important to correctly identify the disease or diseases present so that appropriate management steps can be taken. This bulletin is designed to aid in the identification of the soybean diseases most commonly occurring in Missouri. In some cases different diseases may have similar symptoms, so it may be necessary to submit samples to a plant diagnostic laboratory for an accurate diagnosis of the disease.

Since there are few rescue treatments for soybean diseases, the importance of scouting fields for soybean diseases might be questioned. Scouting fields early in the season to determine the extent and cause of stand establishment problems can provide valuable information for making replant decisions, particularly in relation to the use of resistant varieties or the use of fungicide seed treatments. In seasons with weather conditions favorable for development of foliage diseases or stem diseases, scouting will provide information necessary to make decisions on the use of foliar fungicides. Finally, recording information on incidence and severity of soybean diseases in all fields over the course of the growing season will provide information that can be used to make decisions on variety selection, crop rotation and other cultural practices to prevent or reduce these diseases in future years.

The soybean diseases most likely to occur in Missouri include early-season seed and seedling diseases, foliage diseases, virus diseases, root and lower stem diseases and stem, pod and seed

diseases. This publication covers the common diseases and management strategies for each of these categories.

SEED AND SEEDLING DISEASES

The early-season soybean diseases include those that cause seed decay, seedling blights and root rots of soybeans. Most of these early-season soybean diseases are caused by fungi in the soil that are found wherever soybeans are grown. *Pythium*, *Phytophthora*, *Rhizoctonia* and *Fusarium* are the most common of these early-season pathogens, although *Phomopsis* (pod and stem blight fungus) and *Macrophomina* (charcoal rot fungus) may also cause early-season seedling problems. Symptoms of these early-season soybean diseases may range from seed decay to preemergence or post emergence damping-off to wilt and death of established seedlings.

Pythium seed decay and damping-off

Pythium seed decay and damping-off are caused by as many as six different species of the fungus *Pythium*. These *Pythium* species are present in most soils, and they can attack a wide range of host plants. These fungi survive on organic matter in the soil, in crop residues or as survival structures called oospores. *Pythium* species are more likely to cause seed decay, pre-emergence damping-off or early post emergence damping-off.

Seed may decay before germination. Infected seed becomes soft and rotted. These rotted seeds may have soil adhering to them or may have completely decomposed, making it difficult to find the diseased seed in the soil. Seedlings can also be killed before they emerge through the soil surface or just after they emerge. Areas of brown discoloration and soft, watery rot develop on infected hypocotyls and cotyledons. Infected seedlings wilt, collapse and shrivel up. Over time, infected or dead seedlings become dry and stringy or shredded. Diseased plants are easily pulled from the soil because few roots have developed



Figure 1. Pythium damping-off.



Figure 2. Stand loss due to Pythium damping-off.

and the hypocotyls are shriveled and deteriorated (Figures 1 and 2).

Pythium diseases are generally associated with wet soil conditions. At least three of the *Pythium* species involved in these early-season diseases on soybean have an optimum temperature range for infection of 50–59 degrees F.

Because of this lower optimum temperature range, these species are more common problems in northern areas or on early-planted soybeans. The other *Pythium* species prefer soil temperatures in the range of 86–95 degrees F and are more common in southern areas, in late planted fields or on plants later in the season. Crusting, deep planting, compaction,

Management options for Pythium seed decay and damping-off

- Plant good quality seed with a good germination rate.
- Plant in good seedbed conditions. Delaying planting until soil temperatures are above 59 degrees F may reduce infection by some *Pythium* species.
- Pythium diseases may be more likely to develop in low, wet areas or compacted areas of a field. Tiling to improve drainage and taking steps to reduce or prevent compaction may help minimize problems with this disease.
- Fungicide seed treatment or at planting fungicide treatment may help protect seedlings from this disease. Products containing either metalaxyl or mefenoxam as an active ingredient are particularly effective against water mold fungi such as *Pythium* species.

herbicide injury and similar factors that delay germination and seedling emergence may lead to an increase in incidence and severity of Pythium seed decay and damping-off.

Phytophthora seedling blight

Phytophthora sojae is another soil-inhabiting fungus that causes seed decay, preemergence or postemergence damping-off and seedling blight of soybeans. This fungus produces structures called oospores, which enable it to survive from year to year in crop residues or in the soil. In the spring, the oospores germinate to produce sporangia. When soils are flooded or saturated, the sporangia release zoospores, which are attracted to the growing soybean root tip, where infection occurs.

Phytophthora can rot soybean seed before germination. Infected seed will have a soft, mushy, fuzzy appearance similar to seed infected with *Pythium* species.

Phytophthora can also kill young seedlings either before they emerge from the soil or just after they have emerged (Figure 3). Dark, reddish brown to black, water-soaked lesions are evident on the hypocotyls. Cotyledons and hypocotyls turn brown to black and have a wet, rotted appearance. Over time, infected or dead seedlings become dry and stringy or shredded. These symptoms are similar to those caused by Pythium damping-off.

Another symptom of *Phytophthora* is the seedling blight phase of the disease in which young seedlings that appear to be established turn off-color to yellow, wilt and die (Figure 4).



Figure 3. Young seedlings killed by Phytophthora.

The stems of these plants may show a brown discoloration that begins at the soil line and extends up the stem (Figure 5). The brown, dead leaves remain attached to the plant, and the dead seedlings remain evident in the field until the rows close. Seedlings of highly tolerant varieties may be stunted but not killed.

Phytophthora root rot is more severe in areas that are low or poorly drained, in compacted areas or in clay or heavy soils, but the disease can appear on plants growing in lighter soils or higher ground if the soil remains wet after planting (Figure 6). Significant rain after planting favors the development of *Phytophthora*



Figure 4. *Phytophthora* seedling blight causing wilting of older seedlings.



Figure 5. Brown discoloration of stem due to *Phytophthora* seedling blight.

in all sites. A dry period after planting drastically reduces this disease. *Phytophthora* may occur at soil temperatures as low as 50 degrees F, but greatest root damage occurs when soil temperatures are 59 degrees F or above.

Management options for *Phytophthora* seedling blight

- Select varieties with either race-specific resistance, tolerance or a combination of race-specific resistance and tolerance in fields with a history of *Phytophthora*. Numerous races of *Phytophthora sojae* have been identified based on their ability to overcome specific Rps genes or combinations of Rps genes in soybean varieties. Race-specific varieties contain a single gene or combination of genes (i.e., Rps1c, Rps1d, Rps1k or Rps3a) that confer resistance to specific races of *Phytophthora sojae*. Tolerant varieties have a non-race-specific, partial resistance and may also be called field-resistant varieties.
- Plant in good seedbed conditions.
- *Phytophthora* is more likely to occur in low, wet areas, poorly drained areas or compacted areas of a field. Tiling to improve drainage and taking steps to reduce or prevent compaction may help minimize disease problems.
- Avoid the application of high levels of manure or fertilizer (KCl) just before planting.
- Rotate crops to prevent the increase of inoculum levels in a field.
- Use an appropriate fungicide seed treatment or an at-planting fungicide treatment. Products containing either metalaxyl or mefenoxam as an active ingredient are particularly effective against water mold fungi such as *Phytophthora sojae*.



Figure 6. Stand loss due to *Phytophthora* seedling blight.

Rhizoctonia seedling blight

Rhizoctonia solani is another common soil-inhabiting fungus with a wide host range that includes field crops, vegetables, fruits and ornamentals. This fungus can survive well in the absence of host plants because it grows well in the soil, colonizes all types of plant debris and survives as resting mycelium or sclerotia.

Rhizoctonia can cause seed decay and pre-emergence damping-off of soybean seedlings. The infected seed or seedling root is discolored and decayed. The discoloration is usually a red to reddish brown color and the decay may be a dry type of rot. The hypocotyls and roots may be dry, stringy or shredded. Seedlings can be killed.

More typically, symptoms of *Rhizoctonia* are found on seedlings, young plants and even older plants. Localized red to reddish brown lesions develop on the hypocotyl near the soil line. The red color of lesions on the hypocotyls (Figure 7) is a good symptom to use in diagnosing *Rhizoctonia*, but it is best observed immediately after plants are removed from the soil



Figure 7. Rhizoctonia lesions on soybean hypocotyls.

because the color fades as plants are exposed to air. Lesions are usually confined to the cortical layer (outer layer) of the main root and hypocotyl. If the lesions remain localized, the stem usually remains firm and plants will survive although they may be stunted. If lesions girdle the entire stem, plants may be extremely stunted and die, especially during periods of moisture stress (Figure 8). Infected plants may be stunted or less vigorous than healthy plants, resulting in uneven stands (Figure 9). The foliage of infected plants may have an off-color or yellow cast, and the root systems may be poorly developed with decayed lateral roots.

Rhizoctonia solani can survive under a wide range of soil moistures and soil temperatures. Populations of the fungus may decline when soils are flooded or when soil temperatures are unusually high. Symptoms, especially on aboveground portions of the seedlings, are usually more severe during periods of drying winds or warm to hot



Figure 8. Seedlings killed by Rhizoctonia.



Figure 9. Uneven stand due to Rhizoctonia seedling blight.

Management options for Rhizoctonia seedling blight

- Plant good-quality seed with a good germination rate.
- Plant in good seedbed conditions.
- Minimize or avoid stresses that delay germination or emergence, i.e., avoid or prevent herbicide injury and insect injury, correct soil compaction and hard pan layer problems and reduce injury from soybean cyst nematode.
- Use an appropriate fungicide seed treatment.
- Cultivate to ridge soil around the base of plants, thereby promoting root growth above the area of the stem that is diseased. This may be helpful only if there is sufficient soil moisture after cultivation for roots to grow.

weather. During such conditions seedlings may wilt, yellow or die.

Crusting, hard pan layers, herbicide injury, deep planting, poor seed quality, hail damage, insect damage, mechanical injuries, poor fertility or other factors that delay germination and emergence favor the development of Rhizoctonia root rot. Rhizoctonia root rot is frequently found in combination with other diseases such as soybean cyst nematode or Fusarium root rot. Damage from *Rhizoctonia* may be more severe when it occurs in combination with other diseases.

Fusarium seedling blight

Both *Fusarium oxysporum* and *Fusarium solani* cause seedling blight and root rot of soybean. These two fungi can persist in the soil, colonize various plant residues and survive as chlamydospores (fungal survival structures) or mycelium.

In fields with Fusarium seedling blight, stands may be uneven, there may be skips in the rows and seedlings may be stunted and weak. The pathogens cause a rot of lateral roots, taproot and lower stem (Figure 10). Lesions developing on the taproot range from a nondescript brown to a dark purple brown or black. These lesions may increase in size until they girdle the taproot. The lower part of the taproot and the lateral root system may be rotted or destroyed. If plants are pulled from the ground, the taproot may break at this rotted area. A proliferation of secondary roots may develop above the damaged main taproot giving the plants a shallow, fibrous root system. The above-ground portions of infected plants may have an off-color to yellow cast. Foliage may dry and plants wilt and die during periods of drying winds or warm to hot weather (Figure 11).

Fusarium root rot can occur at any time during the growing season, but is most common on seedlings and young plants. Disease is most severe when the soil is saturated and soil temperatures are around 57 degrees F. Crusting, hard pan layers, herbicide injury, deep planting, poor seed quality, hail damage, insect damage, mechanical injuries, poor fertility or other factors that delay germination and emergence favor the development of Fusarium seedling blight and root rot. Fusarium root rot is frequently found in combi-

nation with other diseases such as Rhizoctonia root rot or soybean cyst nematode. Damage from *Fusarium* may be more severe when it occurs in combination with other diseases or stresses.



Figure 10. Progression of symptoms caused by Fusarium seedling blight and root rot (plant on left shows initial discoloration and rotting of taproot; at right, taproot has broken at rotted area).



Figure 11. Marginal browning and desiccation of foliage due to Fusarium root rot and environmental stress.

Management options for Fusarium seedling blight

- Plant good-quality seed with a good germination rate.
- Plant in good seedbed conditions.
- Minimize or avoid stresses that delay germination or emergence, i.e., avoid or prevent herbicide injury and insect injury, correct soil compaction and hard pan layer problems and reduce injury from soybean cyst nematode.
- Use an appropriate fungicide seed treatment.
- Cultivate to ridge soil around the base of plants, thereby promoting root growth above the area of the stem that is diseased. This may be helpful only if there is sufficient soil moisture after cultivation for roots to grow.

Charcoal rot

Charcoal rot, caused by the fungus *Macrophomina phaseolina*, occurs worldwide. The fungus is widely distributed in soils and has a wide host range attacking a number of crops, including soybeans, corn and sorghum. *Macrophomina phaseolina* produces small survival structures called microsclerotia, which allow it to survive in soil or in host residues for long periods of time.

Charcoal rot may be more commonly recognized as a mid- to late-season disease on maturing soybeans (see charcoal rot in section on Root and Lower Stem Diseases), but it can also occur early in the season on young seedlings. Infected seedlings tend to show a reddish brown discoloration from the soil line up the stem. The discolored area changes from reddish brown to dark brown or black. Foliage may appear off-color or begin to dry out and turn brown. If the growing point is killed, a twin-stem plant may develop. Under hot, dry conditions, infected seedlings may die. Under cooler, wetter conditions, infected seedlings may survive but carry a latent infection. Then symptoms may reappear later in the season with hot, dry weather.

Management options for charcoal rot

- Rotate to cereals, cotton or other nonhost crops for one to two years.
- Maintain good crop vigor to reduce losses from charcoal rot.
- In irrigated fields, watering during periods of high temperatures and drought stress between the time when soybean plants are in bloom and the time that pods fill may help reduce charcoal rot.

Macrophomina phaseolina grows best at temperatures between 82–95 degrees F. Infection of seedlings is most likely to occur if conditions of high soil temperatures and low soil moisture exist during the first two to three weeks after planting.

Phomopsis seedling blight

Phomopsis longicolla and the other *Phomopsis* and *Diaporthe* species that cause Phomopsis seed decay and pod and stem blight (see Stem, Pod and Seed Diseases) can survive in infested crop residues and in the soil. These fungi can also survive on the seed and Phomopsis seedling blight is more likely to be a serious problem if infected seed is planted. Infected seed may fail to germinate or it may germinate slowly. On seed that does germinate, the seed coat may remain on the cotyledons rather than sloughing off as it does



Figure 12. Phomopsis seedling blight.

Management options for Phomopsis seedling blight

- Plant disease-free seed with a good germination rate.
- Plant in good seedbed conditions.
- Use an appropriate fungicide seed treatment.

on healthy plants. The seed coat adhering to the cotyledons may have a white moldy appearance (Figure 12). Severely infected seedlings may collapse and die. Phomopsis seedling blight tends to be more severe if weather conditions after planting are cool and wet.

FOLIAGE DISEASES

Foliage diseases such as Septoria brown spot, bacterial blight, bacterial pustule, frogeye leaf spot, downy mildew, powdery mildew and now soybean rust can occur on soybeans in Missouri. Generally these diseases occur in low levels and do not cause significant losses. However, under favorable conditions for disease development, losses can be serious.

Septoria brown spot

The fungus that causes this disease, *Septoria glycines*, survives in infested residues left on the soil surface. During periods of wet spring weather, spores produced on the residues are splashed or blown to cotyledons or unifoliolate leaves on soybean plants where they cause infec-

tion. Continuous soybeans are more likely to show damage.

Septoria brown spot causes small, angular to somewhat circular, red to brown spots on the unifoliolate and lower trifoliolate leaves (Figures 13 and 14). The individual spots can run together, forming irregularly shaped brown blotches on the leaves. In the dead tissue of older lesions, small dark specks (fruiting bodies of the causal pathogen, *Septoria glycines*) may be evident (Figure 15). Infected unifoliolate leaves will yellow and drop prematurely. Brown spot usually starts on the lower portion of the plant. Under favorable weather conditions (warm, wet weather), the disease may move up through the plant. When this occurs, the field may have a yellow or brown appearance (Figure 16). Late in the growing season, infected leaves may turn rusty brown or yellow and drop prematurely (Figure 17).

Warm, wet weather favors infection and disease development. Symptoms develop over a temperature range of 59–86 degrees F with 77 degrees F being optimum for symptom development. The spread of brown spot is restricted by dry weather.



Figure 13. Septoria brown spot.



Figure 14. More advanced symptoms of Septoria brown spot.

Because the pathogen survives in infested residues left on the soil surface, the disease is more severe in continuous soybean fields.

Management options for Septoria brown spot

- Rotate crops with at least one year between soybean crops.
- Use of foliar fungicides from bloom to early pod development may be warranted in high value fields (e.g., seed production fields).

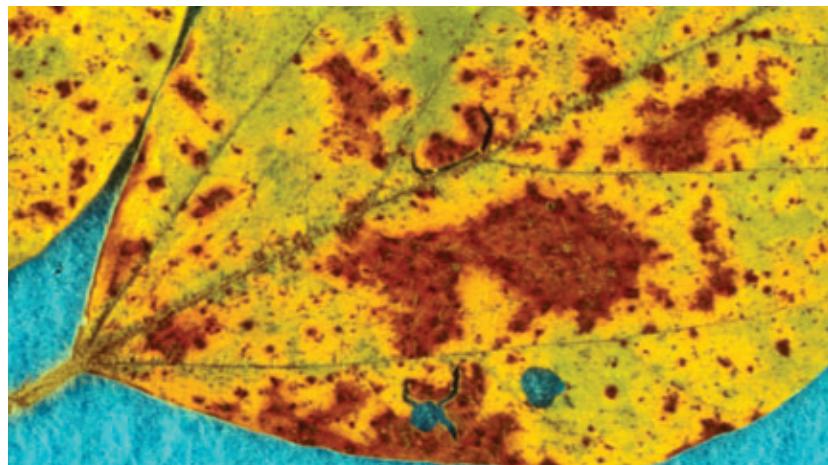


Figure 15. Closeup of Septoria brown spot lesions showing black fungal fruiting bodies (pycnidia) embedded in dead tissue in center of lesions.



Figure 16. Yellowing of foliage across field due to Septoria brown spot.



Figure 17. Premature yellowing and dropping of lower leaves due to Septoria brown spot.

Bacterial blight

Bacterial blight, caused by the bacterium *Pseudomonas savastanoi* pv. *glycinea*, occurs worldwide and is common during cool, wet weather. The causal bacterium may be carried in seed or can survive in crop residues. Bacteria on the seed may cause cotyledon infection. Bacteria can then be spread from infected cotyledons or infested residues by wind driven rain or splashing rain. Further spread occurs during rainstorms and hail storms or during cultivation when plants are wet.

Dark brown to black lesions develop along the margins of the cotyledons. As these lesions enlarge, the entire cotyledon collapses and becomes dark brown. Seedlings may be stunted and if the growing point is infected, the seedling may die.

Bacterial blight also produces lesions on the leaves. The lesions usually begin as small, angular, yellow lesions (Figure 18). Lesions usually have a translucent or water-soaked appearance that may be more easily seen if leaves are held up to the light (Figure 19). Lesions progress in color from yellow to light brown and eventually to a dark reddish brown. Older lesions have a dark

center surrounded by a water-soaked margin and a yellow halo. In cool, rainy weather the small, angular lesions may enlarge and merge, producing large, irregular dead areas in the leaf. With wind and rain these large dead areas drop out or tear away, giving the leaf a ragged appearance (Figure 20). Symptoms typically occur several days after a rain with driving winds or a hailstorm. If there are alternating periods of wet and dry weather, plants may show bands of leaves with symptoms, that is, leaves that expanded during wet periods show bacterial blight symptoms, and leaves that expanded during dry periods are free of disease.

Pods may also be infected. Initial pod lesions are small and water soaked. They may enlarge and coalesce to cover much of the pod. Pods may turn brown to black. Infected seed may be shriveled, sunken and discolored or they may show no symptoms at all.

Bacterial blight is favored by cool, rainy weather. During early to midseason, disease outbreaks usually occur five to seven days after wind driven rains. Hot, dry weather checks disease development.



Figure 19. Water-soaked appearance of bacterial blight lesions.



Figure 18. Initial symptoms of bacterial blight.



Figure 20. Ragged appearance of foliage resulting from bacterial blight.

Bacterial pustule

Bacterial pustule, caused by the bacterium *Xanthomonas axonopodis* pv. *glycines*, occurs in most soybean-growing areas. Although bacterial pustule can occur in Missouri, it is not found as frequently as the other foliage diseases. Bacterial pustule is common during warm, wet weather. The causal bacterium may be carried in seed or can survive in crop residues. Bacteria are spread from infested residues or infected plant tissues by wind driven rain or splashing rain. Further spread occurs during rainstorms and hailstorms or during cultivation when foliage is wet.

Bacterial pustule lesions begin as small, light-green lesions. Lesions may range from small spots to large areas of brown tissue formed when smaller lesions merge. With wind and rain, these large dead areas drop out or tear away, giving the leaf a ragged appearance. Initially the center of the lesion may be slightly raised. The raised center or "pustule" may be more evident in older lesions or lesions on the lower leaf surface (Figure 21). Small, reddish brown, slightly raised pustules may occur on pods of susceptible varieties.

Symptoms of bacterial pustule may appear similar to those caused by bacterial blight. Typically bacterial pustule lesions do not show



Figure 21. Symptoms of bacterial pustule on upper and lower leaf surfaces.

Management options for bacterial pustule

- Plant disease-free seed.
- Select resistant varieties.
- Rotate crops with at least one year between soybean crops.
- Do not cultivate when foliage is wet.

the water soaking around the lesions that is common with bacterial blight. Also, the small, raised pustules in the centers of the lesions is characteristic of bacterial pustule but not of bacterial blight.

The raised center or "pustule" on the lower leaf surface might be mistaken for soybean rust pustules. Bacterial pustules do not produce spores, and they may show cracking or fissures across the pustule rather than the circular openings characteristic of soybean rust pustules. A high-power hand lens may be necessary to distinguish between bacterial pustule and soybean rust when examining leaves in the field.

Bacterial pustule is favored by wet or rainy weather. Disease outbreaks usually occur five to seven days after wind driven rains. Bacterial pustule is not slowed by high temperatures as is bacterial blight.

Frogeye leaf spot

Frogeye leaf spot, caused by the fungus *Cercospora sojina*, occurs worldwide. However, the disease is most serious in warm regions or during periods of warm, humid weather. The fungus that causes frogeye leaf spot survives in infested soybean residue and infected seeds. Spores produced on infested residues or infected plant tissues are spread by splashing rain or winds.

Symptoms of frogeye leaf spot occur primarily on leaves, although the causal fungus may also infect stems, pods and seed. Lesions are small, circular to somewhat irregular spots that develop on the upper leaf surfaces. Initially the spots are dark and water soaked in appearance (Figure 22). As the lesions age, the center becomes light brown



Figure 22. Initial symptoms of frogeye leaf spot.

Management options for frogeye leaf spot

- Plant disease-free seed.
- Select resistant varieties.
- Rotate crops with at least one year between soybean crops.
- Use of a foliar fungicide is seldom warranted, except on high-value fields (e.g., seed production fields) or in years when weather is especially favorable for disease development.

to light gray in color. Older lesions have a light center with a darker red to purple-brown border (Figure 23). Lesions may merge to kill larger areas of the leaf surface. These areas may drop out, giving the leaves a very tattered or shot-hole appearance (Figure 24). Heavily spotted leaves usually wither and drop prematurely. Fields with high levels of frogeye leaf spot may look brown and desiccated (Figure 25).



Figure 23. Older lesions of frogeye leaf spot.



Figure 24. Tattering of leaf from severe frogeye leaf spot.



Figure 25. Tattering of leaf from severe frogeye leaf spot.

Stem lesions can develop later in the season. Young stem lesions are reddish brown with a narrow, dark margin. As the stem lesions age, the centers become brown to gray in color. Lesions on pods are circular to elongate, reddish brown in color and may be slightly depressed. The fungus can grow through the pod wall to infect maturing seeds. Infected seeds may show discoloration of the seed coat that ranges from small specks to large blotches of light gray to dark gray to brown.

Disease development is favored by

warm, humid weather. Leaves that expand and develop during periods of warm, wet weather are more likely to be infected than leaves that expand during dry periods. Dry weather severely limits disease development.

Downy mildew

Downy mildew, caused by the fungus *Peronospora manshurica*, is reported wherever soybeans are grown. The downy mildew fungus survives as oospores in infected leaf residues and on seeds. Spores produced in diseased areas on lower leaf surfaces are wind-blown and serve to infect additional leaves on that plant or other plants.

Initial symptoms of downy mildew are pale green to light yellow spots or blotches on the upper surface of young leaves (Figure 26). These areas enlarge into pale to bright yellow lesions of indefinite size and shape (Figure 27). Eventually the lesions turn grayish brown to dark brown with a yellow margin. During periods of heavy dew or wet weather, a gray to purple fuzz that is visible growth of the downy mildew fungus develops on the lower leaf surface beneath the diseased areas (Figure 28). Severely infected leaves turn yellow and then brown. Premature defoliation may occur.



Figure 26. Initial symptoms of downy mildew.

Management options for downy mildew

- Plant disease-free seed.
- Rotate crops with at least one year between soybean crops.
- If infected seed must be planted, use a fungicide seed treatment.

Pod infections occur without visible external symptoms. However, the inside of the pod and the seed coats of the beans are usually covered with a white, powdery coating of fungal material (Figure 29). Infected seeds may be smaller in size and lighter in weight than healthy seeds.

Downy mildew is favored by high humidity and temperatures of 68–72 degrees F. Downy mildew seldom causes significant losses. However, under ideal conditions for disease development, it can cause defoliation, reduce seed quality and lower yields.



Figure 27. Symptoms of downy mildew on upper leaf surface.



Figure 28. Symptoms of downy mildew on lower leaf surface.

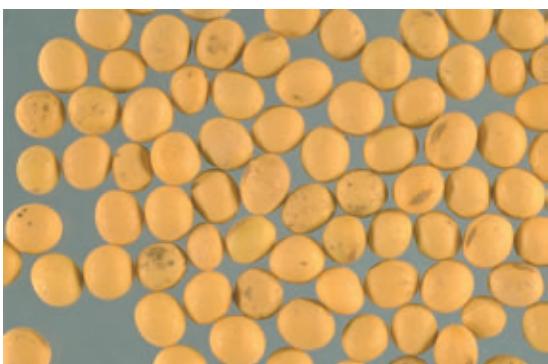


Figure 29. Downy mildew encrusted soybean seed.

Powdery mildew

Powdery mildew is caused by the fungus *Microsphaera diffusa*. This species of powdery mildew affects other legumes such as garden bean, pea, cowpea and mung bean as well as members of two other plant families (honeysuckle and nightshade families). Ascospores (sexual spores) released in the spring are the most likely source of primary inoculum. Wind-borne spores start new infections and repeat the disease cycle until soybean plants mature or temperatures increase above 86 degrees F.

Powdery mildew begins as small, circular areas of white, powdery mold growth on the upper leaf surface. These areas enlarge to cover larger areas of the leaf surface (both upper and lower surfaces) and may develop on stems, petioles and pods as well (Figure 30). When severe, all aboveground portions of the plant appear to be covered with white to grayish white, powder-like mold growth. Heavily infected leaves may yellow and drop prematurely.

Powdery mildew is favored by cooler than normal temperatures, that is, temperatures in the range of 65–75 degrees F. Temperatures above 86 degrees F restrict disease development.



Figure 30. Powdery mildew.

Management options for powdery mildew

- Select resistant varieties.
- Use of foliar fungicides is seldom warranted.

Soybean rust

Soybean rust, caused by the fungus *Phakopsora pachyrhizi*, was first confirmed in the continental United States on soybean leaf samples collected in Louisiana on November 10, 2004. Over the following few weeks the fungus was detected on plants from a number of states including Missouri. Soybean rust has occurred on soybean and kudzu plants in various states each year since 2004. In Missouri, soybean rust was confirmed in southeastern Missouri counties in 2004 and 2006 and 37 counties scattered throughout the state



Figure 31. Soybean rust lesions on upper leaf surface (left) with corresponding cluster of rust pustules on lower (right) leaf surface.



Figure 32. Moderate to heavy infection of soybean rust. Extensive flecking and browning of leaf tissue on upper leaf surface (left) with numerous rust pustules on lower leaf surface (right).



Figure 33. A single rust pustule circled in black (left) compared with a cluster of sporulating rust pustules (right), both on lower leaf surfaces.

during the fall of 2007. Although soybean rust is a serious foliage disease that has the potential to cause significant yield losses, thus far, in Missouri, it has developed late enough in the season that yield has not been adversely affected.

The most common symptom of soybean rust is a foliar lesion. On the upper leaf surface, initial symptoms may be small, yellow flecks or specks in the leaf tissue. These lesions darken and may range from dark brown or reddish brown to tan or gray-green in color. The lesions tend to be angular to somewhat circular in shape and may be concentrated near leaf veins. Initially the lesions are small, barely larger than a pin point (Figure 31). With heavy infection levels, lesions (Figure 32) may be larger and may merge or run together, killing larger areas of leaf tissue.

Symptoms may be more prevalent and more severe on the lower leaf surface. The fungus produces spores in cone-shaped pustules on the lower leaf surface (Figure 33). At first these pustules might appear to be small, raised blisters or callous bumps on the lower leaf surface. But as the rust pustules mature, they begin to produce large numbers of light-colored, powdery spores which emerge through a distinct hole or pore in the cone-shaped pustule (Figure 34). Masses of the light-colored spores may lodge in the opening or mound up around the opening. The pustules and emerging spores are difficult to see without magnification. A high-power hand lens or dissecting microscope will greatly aid in the detection of these structures and in identification of soybean rust.

Soybean rust is usually found first on the lower leaves of plants, especially at or near flow-

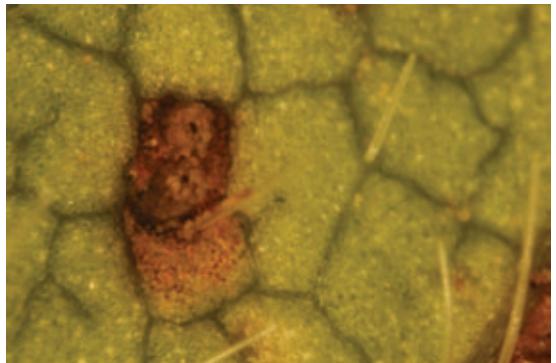


Figure 34. Microscopic closeup of two soybean rust pustules showing distinct hole or pore through which spores emerge.



Figure 35. Yellowing of lower leaves due to soybean rust.

ering. As the soybean plants mature, lesions may be found in the middle or upper canopy. When conditions are favorable for disease development, yellowing of foliage may be evident and defoliation and premature death of plants may occur (Figure 35).

Soybean rust is an obligate parasite that survives on living plant tissue. It is unlikely that the soybean rust pathogen will overwinter in central or northern soybean-production areas of the United States. It does appear to survive winter months in the southern United States on hosts such as kudzu. Soybean rust spores could then be carried north on wind currents and by storms. The development of soybean rust is favored by prolonged periods of leaf wetness (6–12 hours) and temperatures of 46–82 degrees F. For additional information on soybean rust see MU publication G4442, *Soybean Rust*.

Management options for soybean rust

- Scout fields on a regular basis during the growing season for soybean rust.
- Keep current on information on soybean rust movement in southern states and on weather conditions and forecasts for southern states and Missouri.
- If soybean rust is detected in your area, weather conditions are favorable for disease development and soybean plants are in vegetative or early reproductive stages of growth, application of a foliar fungicide may be necessary. Early detection and prompt fungicide application are critical for management of soybean rust.

VIRUS DISEASES

Several viruses commonly infect soybean plants in Missouri, including bean pod mottle, soybean mosaic, tobacco ringspot and bean yellow mosaic. These virus diseases tend to cause green to yellow mottling of leaf tissue, stunting of plant growth and deformation of plant tissues. Symptoms of bean pod mottle and soybean mosaic are similar, so the two are difficult to identify in the field. Also, these viruses may occur in combination. Laboratory tests are the only means of accurately identifying which virus or combination of viruses is present in infected plants.

Bean pod mottle

Bean pod mottle causes a green to yellow mottling of young leaves in the upper canopy (Figures 36 and 37). Bean pod mottle symptoms are most apparent during periods of rapid growth and cool conditions. Symptoms are usually not obvious during periods of high temperatures or after pod set. This virus is sap-transmissible and vectored by beetle species such as the bean leaf beetle. The host range of bean pod mottle virus is limited to legumes. In addition to the soybean plant, other hosts include lespedeza, alfalfa and clover. The bean pod mottle virus is not considered to be seedborne.



Figure 36. Bean pod mottle.



Figure 37. Bean pod mottle.

Soybean mosaic

Soybean mosaic virus causes a green to yellow mottling or mosaic pattern on leaf tissue as well as puckering and distortion of the leaf shape (Figure 38). On severely infected plants, leaves are curled downward along their margins and plants are stunted.

Symptoms vary with the susceptibility of the host, strain of the virus, age at which the plant became infected and environmental conditions. Soybean mosaic virus is sap-transmissible and vectored by several aphid species. Soybean mosaic virus may also be seedborne. Infected seed



Figure 38. Soybean mosaic.

may show a bleeding hilum symptom or a brown to black mottling of the seed coat. However, seed coat discoloration is not a definite indication of seed infection because infected seed can be symptomless and seed coat discoloration can be caused by factors other than soybean mosaic virus.

When bean pod mottle and soybean mosaic occur in combination in the same plant, symptoms are more severe and yield losses higher than those caused by either virus alone.

Tobacco ringspot

Soybean budblight, caused by the tobacco ringspot virus, results in the curving of the terminal in the shape of a crook (Figure 39). The plant may show axillary proliferation of leaves and bud tissue. Stems and branches may show a brown discoloration of the pith starting at the nodes and extending into the internodal areas. A



Figure 39. Tobacco ringspot causing crooking of terminal.



Figure 40. Green tobacco ringspot infected plant in field of maturing soybean plants.

brown discoloration of petioles and larger leaf veins may be evident. Plants are usually stunted with a bushy appearance, leaves are rugose and rolled and pods may be poorly developed or aborted. Plants tend to remain green after uninfected plants have matured and turned in color (Figure 40). Tobacco ringspot virus is readily sap-transmissible. Although no efficient insect vector has yet been discovered, thrips are implicated in the spread of the virus. The soybean budblight virus has a wide host range, including a number of weed species. Pastures or uncultivated areas containing other hosts for tobacco ringspot virus may serve as sources of inoculum for nearby soybean fields. The virus may also be seedborne.

Bean yellow mosaic

Soybean yellow mosaic is caused by the bean yellow mosaic virus. The leaves exhibit brilliant yellow mosaic patches. These yellow patches tend to occur along the major veins. In some cases, depending on the strain of the virus, leaves may show crinkling and puckering. Symptoms are more pronounced during periods of cooler temperatures. The virus has a wide host range and is transmitted by several aphids. Seed transmission has not been reported.

Management options for soybean virus diseases

- Plant disease-free seed.
- Select varieties resistant to soybean mosaic virus.
- Maintain good weed control.
- Control of insect vectors may be warranted in certain circumstances.

ROOT AND LOWER STEM DISEASES

Soybean cyst nematode

The soybean cyst nematode, *Heterodera glycines*, is a serious problem throughout Missouri and in most soybean-producing areas of the United States. Symptoms of soybean cyst nematode (SCN) range from no obvious symptoms to subtle differences in plant height and vigor or unexpected decreases in yield to severe stunting and discoloration of plants or dead plants (Figure 41). Foliage symptoms may include yellowing of leaves from the margin inward or a general yellowing of leaves. But such foliage symptoms are also caused by various other factors, including root rot diseases, nutrient deficiencies, herbicide injury and compaction, so foliage symptoms should not be used to diagnose SCN. Plants with SCN may have poorly developed root systems. If plants are carefully dug up, females may be evident on the roots. The females appear as tiny (smaller than nitrogen-fixing nodules), whitish to yellow to brownish, lemon-shaped structures on the roots (Figure 42 and 43). Symptom expression may be more severe if plants are subjected to other stresses such as moisture stress, nutrient deficiencies, herbicide injury, insect damage or other diseases.

The cysts are the bodies of the dead female nematodes (Figure 44). The cysts are actually protective egg cases that contain up to 250 SCN eggs. Eggs in cysts may survive in the soil for extended periods even in the absence of soybean crops.



Figure 41. Stunting and yellowing due to soybean cyst nematode.

Management options for soybean cyst nematode

- Employ a program of soil sampling to identify problem fields and to determine the extent and severity of the problem in the field.
- Select resistant varieties. It is important to rotate sources of genetic resistance to SCN in soybean varieties grown if at all possible.
- Rotate to nonhost crops (the length of time between soybean crops will depend on population levels of the soybean cyst nematode in a given field).
- Maintain good plant vigor.
- Maintain good weed control.
- Although several nematicides are labeled for use on soybeans, economic and environmental concerns limit their use.
- Avoid spreading SCN from infested fields to uninfested fields by working uninfested fields first before moving equipment to infested fields.

Anything that moves cyst-infested soil can spread SCN, including machinery, animals, migratory birds, people, wind, water and soil peds associated with seed. Once in a field, SCN may take several years to build up to damaging levels.

For more detailed information on SCN, soil sampling for SCN and strategies for managing SCN, refer to MU publication G4450, *Soybean Cyst Nematode: Diagnosis and Management*.

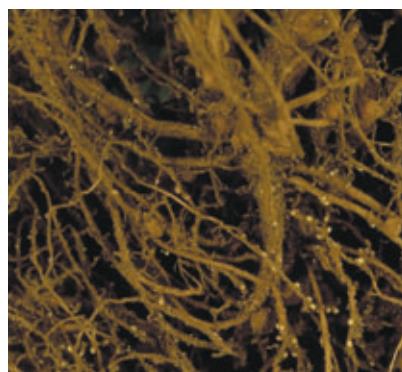


Figure 42. Soybean cyst nematode females on soybean roots.

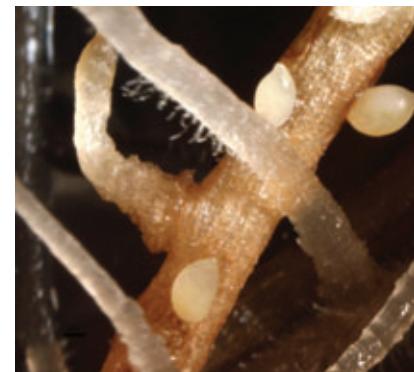


Figure 43. New females on soybean roots.

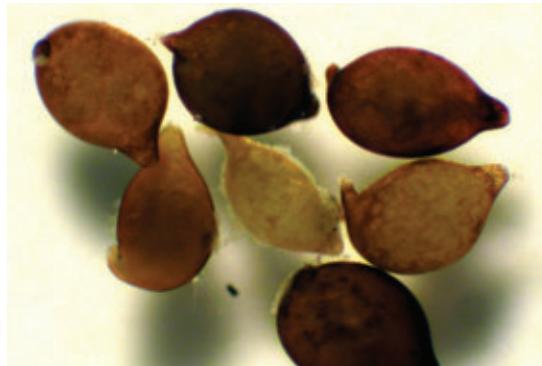


Figure 44. Cysts (bodies of the dead females) of varying ages and colors.

Root-knot nematode

There are several species of root-knot nematode that have been reported from many soybean-growing areas of the world. In Missouri, the southern root-knot nematode, *Meloidogyne incognita*, is the most commonly found of the root-knot nematode species. Root-knot nematode has been a serious problem in soybean production fields in southeast Missouri. More recently it has been increasing on corn in southeast Missouri and has been found on vegetable and ornamental crops in central areas of Missouri.

Aboveground symptoms of root-knot nematode are nondescript and could be mistaken for those caused by numerous other diseases and abiotic problems. Plants infected with root-knot nematode may show yellowing, wilting (especially during the hot part of the day) and stunting. Infected plants may occur in patches or irregularly shaped areas in the field that may be associated with surface water flow or the movement of machinery in the field. The characteristic symptom of root-knot nematode is the presence

of galls or swellings on the root system (Figure 45). The galls may vary in size and number. Small, individual galls may develop on the root system. When symptoms are severe, the galls may coalesce so that the entire root system appears swollen and distorted.



Figure 45. Soybean root system showing extensive swelling and galls caused by root-knot nematode.

Root-knot nematode may survive between susceptible crops as eggs in the soil. The worm-like second-stage juveniles invade at or near root tips. Gall formation may begin as soon as two to three days after the nematodes have entered the roots. Infection can occur throughout the growing season.

Late-season Phytophthora root and stem rot

Phytophthora sojae can cause seed decay and seedling blight as previously described in the section on Seed and Seedling Diseases. In some situations plants infected early in the season with *Phytophthora* may not show symptoms until later in the season. As plants begin to flower and set pods, symptoms of late-season Phytophthora root and stem rot may develop. Infected older plants show reduced vigor through the growing season or die gradually over the season. Lower leaves may show a yellowing between the veins and along the margins. Upper leaves may yellow (Figure 46). The stems show a characteristic brown discoloration (Figure 47) that extends

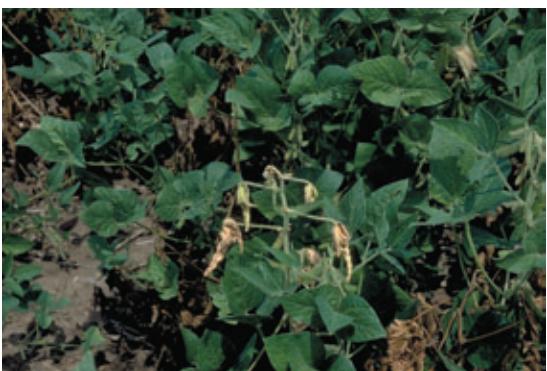


Figure 46. Late-season Phytophthora root rot.

Management options for root-knot nematode

- Employ a program of soil sampling to identify problem fields and to determine the extent and severity of the problem in the field.
- Plant root-knot nematode resistant or tolerant varieties.
- Rotate to nonhost crops. Graminaceous crops have been considered nonhost crops, but with the increase in root-knot nematode on corn in southeast Missouri, rotation to corn may not be effective in reducing root-knot nematode levels and may lead to losses in the corn crop.
- Maintain good crop vigor.
- Maintain good weed control.
- Avoid spreading root-knot nematode from infested to uninfested fields by working uninfested fields first before moving equipment to infested fields.



Figure 47. Stem discoloration due to Phytophthora root rot.



Figure 48. Death of older plants from Phytophthora root rot.

from below the soil line upward. Eventually the entire plant may wilt and die. Withered leaves remain attached even after the plant dies (Figure 48). Management would be as for early-season Phytophthora seed decay and seedling blight.

Rhizoctonia root rot

Rhizoctonia solani can cause seedling blight as previously described in the section on Seed and Seedling Diseases. *Rhizoctonia* can also cause a root rot of older plants. On older plants the lower leaves may begin to yellow. The yellowing may be from the margin in resembling symptoms of potassium deficiency or may be a more general yellowing. Plants may be stunted and appear less vigorous than adjacent plants (Figure 49). When plants are removed from the soil, the root system may be poorly developed, lateral roots may be discolored or rotted and the stem may have a brick red discoloration beginning at the soil line and extending in either direction from the soil line (Figure 50). If plants are stressed

by hot, dry conditions, severely infected plants may die. If cool, wet conditions occur after plants are infected with *Rhizoctonia*, a flush of secondary roots above the diseased stem area may be evident. Management would be as for *Rhizoctonia* seedling blight.



Figure 50. Red discoloration due to *Rhizoctonia* root rot.

Fusarium root rot

The two *Fusarium* species that cause seedling blight can also cause root rot on older plants. Older plants may be stunted, have an off-color or yellow cast and appear less vigorous than adjacent healthy plants. When plants are removed from the soil, the taproot will show varying degrees of discoloration and deterioration. Discoloration may range from brown to purple-brown to almost black. The taproot may show distinct lesions or may be rotted completely through. If the taproot is rotted through, it may break when the plant is pulled from the ground. If plants are stressed by hot, dry conditions, severely infected plants may die. If cool, wet conditions occur after plants are infected with *Fusarium* root rot, a flush of secondary roots above the rotted taproot may be evident (Figure 51). Management would be as for *Fusarium* seedling blight.



Figure 49. Uneven stand due to *Rhizoctonia* root rot.



Figure 51. Destruction of the main taproot by *Fusarium* root rot has been followed by a flush of secondary roots above the rotted taproot.

Sudden death syndrome

In Missouri, sudden death syndrome (SDS) has been a problem primarily in river bottom fields in the central and eastern portions of the state. However, the pathogen, *Fusarium virguliforme* (formerly called *Fusarium solani* f. sp. *glycines*), appears to be present in soybean-producing areas throughout the state. In years when environmental conditions are favorable for infection and symptom development, SDS may be found in most areas of the state.



Figure 52. Initial foliage symptoms of sudden death syndrome.



Figure 53. Foliage symptoms of sudden death syndrome.



Figure 54. Wilting of upper trifoliolates due to sudden death syndrome.

SDS has been associated with maximum yield potential soybean production, that is, fields with optimum fertility, irrigation and lime application. Field observations suggest that SDS is more likely to occur and to be more severe with high soil moisture, whether that is supplied by rainfall or irrigation. High soil moisture during vegetative stages of soybean growth seems to be the most conducive to disease development. Because early-planted fields have a longer exposure to spring rainfalls than later-planted fields, seedlings in early-planted fields have an increased susceptibility to infection by the SDS pathogen. Later-planted fields in which soybean plants miss early spring rains may have lower levels of root infection and lower levels of SDS through the season. The onset of SDS symptoms frequently is associated with wet conditions and below normal tempera-



Figure 55. Internal discoloration of lower stem from sudden death syndrome.

tures at or near bloom.

Symptoms of SDS may appear several weeks before flowering but are more pronounced after flowering. Foliage symptoms begin as scattered yellow blotches in the interveinal leaf tissue (Figure 52). These yellow blotches increase in size and merge to affect larger areas of leaf tissue. Veins typically stay green. The bright yellow blotches between the green veins give affected leaves a striking appearance (Figure 53). The yellow areas may turn brown. As the interveinal leaf tissue turns brown, it also dries out. Upper trifoliolates become brown and dry out. Severely affected leaflets may drop off the plant, leaving the petiole attached or they may curl upward and remain attached to the plant (Figure 54). Infected plants may wilt and die prematurely. Root systems may show deterioration and discoloration of lateral roots and taproot. When split open, internal tissues of taproot and lower stem may show a light-gray to light-brown discoloration (Figure 55).

Patterns of symptoms in the field range from



Figure 56. Yellow streaks across field from sudden death syndrome.



Figure 57. Discrete oval patch in field killed prematurely by sudden death syndrome.

distinct oval to circular patches to irregularly shaped bands or streaks across the field (Figures 56 and 57). In severe cases a majority of the field may show symptoms.

Management options for sudden death syndrome

- Select varieties that have performed well where SDS has been a problem.
- Improve drainage in poorly drained fields and avoid compacting soils.
- Stagger planting dates and delay planting until soils are warm and dry.
- Rotate crops; avoid continuous soybean cropping.
- Maintain good crop vigor and avoid crop stress, including soybean cyst nematode.
- Harvest fields with sudden death syndrome in a timely fashion.

Charcoal rot

Charcoal rot may cause a seedling infection as previously described in the section on Seed and Seedling Diseases, but is more commonly considered a mid- to late-season soybean disease. Symptoms typically begin to develop as plants move into reproductive stages of growth. Infected plants are less vigorous and have smaller leaves. Leaves may turn yellow and wilt. Leaves eventually turn brown and have a dry appearance (Figure 58). The taproot and lower stem develop a silvery gray to light-gray discoloration of the epidermis (outer layer of the soybean stem). The epidermis may flake or shred away from the stem, giving the stems a tattered appearance (Figure 59). Fine black specks or microsclerotia may be

evident in tissues below the epidermis and eventually in epidermal tissues. If the lower stem and taproot are split open, a reddish brown to blackish discoloration may be seen in woody tissues of the taproot and stem (Figure 60).

The fungus that causes charcoal rot, *Macrophomina phaseolina*, is a common soil fungus in Missouri. Corn and grain sorghum are also hosts of the charcoal rot fungus. Charcoal rot is favored by hot, dry weather, so symptoms usually appear when temperatures are in the range of 82–95 degrees F.



Figure 58. Soybean plants killed prematurely by charcoal rot.



Figure 59. Soybean stem showing microsclerotia (small, black specks) of the charcoal rot fungus in shredded epidermal tissue.



Figure 60. Internal discoloration of lower stem due to charcoal rot.

Management options for charcoal rot

- Rotate to cereals, cotton or other nonhosts for one or two years; with corn or grain sorghum, a rotation of three years may be necessary.
- Maintain good crop vigor to help reduce losses from charcoal rot.
- Irrigate properly from just before bloom to pod fill.

Sclerotium blight (southern blight)

Sclerotium blight, also called southern blight or white mold, is caused by the fungus *Sclerotium rolfsii*. This disease tends to be a problem primarily in the southeastern part of Missouri. *Sclerotinia rolfsii* produces small, tan to brown sclerotia (small survival structures) that allow it to survive for extended periods of time in the soil.

The first symptom of the disease may be a yellowing or wilting of scattered plants in the field. Light-brown to brown lesions may be present on the lower stem close to the soil line. A mat of white mold growth may cover the lower stem and spread out from the stem on leaf debris and the soil. Eventually the tan to brown sclerotia begin to form on the plant tissues and soil surface.

Sclerotium blight is favored by hot, wet weather; temperatures in the range 77–95 degrees F are optimum for fungal growth. High soil moisture levels and high humidity in the plant canopy also favor disease development.

Management options for Sclerotium blight

- Rotate crops with at least one year between soybean crops. If Sclerotium blight has been severe, a three- to four-year rotation may be necessary.

Sclerotinia stem rot (white mold)

Sclerotinia stem rot or white mold is a problem for soybean farmers in Michigan, Wisconsin, Minnesota, northern Iowa and northern Illinois. It has been reported in Missouri but has not been a widespread or serious problem in the state's soybean crop. Sclerotinia stem rot is caused by the fungus *Sclerotinia sclerotiorum*. This fungus has a wide host range including dry beans, potatoes, canola, sunflower, peas and many broadleaf weeds. *Sclerotinia sclerotiorum* produces small, black survival structures called sclerotia. These sclerotia can survive in the soil for years.

In the field, white mold may first be evident as a wilting of leaves in the upper canopy (Figure 61). Leaves may have a gray-green or off-color and wilted appearance. Cankers may be evident on stems at the nodes. Initially, these cankers



Figure 61. Individual plant showing wilting and off-color due to Sclerotinia white mold.

are gray-green and water soaked. The cankers eventually turn brown to tan or even a bleached white with reddish brown borders. White mold growth may be present on the stems and may mat together infected leaves or even plants (Figure 62). Later in the season, the black sclerotia may be found on the outside of stems, in the center pith of stems and even in pods (Figure 63). The fungus may move to the pods, and infected pods and seeds may be covered with white mold growth.



Figure 62. Sclerotinia white mold of soybean.



Figure 63. Sclerotia of Sclerotinia white mold forming on soybean stem.

Sclerotinia stem rot or white mold has caused high yield losses in fields with high yield potential. The disease appears to be favored by moderate temperatures in the canopy (less than 82 degrees F) and frequent rainfalls especially as the crop begins to flower and set pods.

Management options for Sclerotinia stem rot

- Select resistant varieties.
- Rotate crops with at least one year between soybean crops and do not plant soybean after common bean, sunflower or other susceptible crops.
- Plant disease-free seed that is free of sclerotia.
- Maintain good weed control.

Brown stem rot

Although brown stem rot has been reported in Missouri, it is not a widespread or serious problem in the state. When brown stem rot is found in Missouri it tends to be in the northern part of the state. Brown stem rot is caused by the fungus *Cadophora gregata* (formerly *Phialophora gregata*), which survives in infested crop residues and in the soil.

When foliage symptoms occur, they usually develop as plants are beginning to set pods. Light green to yellow blotches develop in the interveinal leaf tissue. These blotches may increase in size and merge to affect larger areas of leaf tissue (Figure 64). Over time, the yellow areas may turn brown. Veins typically stay green. These foliage symptoms resemble those of sudden death syndrome. Upper trifoliolates may become brown



Figure 64. Foliage symptoms of brown stem rot.

and dry out. Brown stem rot causes a brown discoloration of the vascular tissues and center pith of the soybean stem that is evident when stems are split open. Initially the brown discoloration may be found in stem tissues close to the soil line and near nodes higher up on the plant (Figure 65). Later in the season, the brown discoloration may be almost continuous within the stem (Figure 66).

Development of brown stem rot is favored by temperatures in the range of 59–81 degrees F. As air temperatures increase above 81 degrees F, both incidence and severity of brown stem rot decrease. Leaf symptoms are most pronounced if cool weather occurs as the crop enters the reproductive stages of growth. Internal browning of stem tissues is greatly reduced at higher temperatures.



Figure 65. Brown stem rot causing discoloration of vascular tissues and center pith in green soybean stem (discoloration at nodes).



Figure 66. Brown stem rot causing discoloration of vascular tissues and center pith in mature soybean stem (discoloration almost continuous up stem).

Management options for brown stem rot

- Select resistant varieties.
- Rotate crops with at least one year between soybean crops. Longer rotations may be necessary in fields with established brown stem rot problems.

STEM, POD AND SEED DISEASES

Pod and stem blight and Phomopsis seed decay

Phomopsis longicolla and the other *Diaporthe* and *Phomopsis* species that cause pod and stem blight and Phomopsis seed decay can survive in infested crop residues, in the soil and in seed. Symptoms usually develop on stems of plants during later reproductive stages of growth.

Pod and stem blight infected plants may be

stunted and their stems discolored. Black pycnidia or fruiting bodies of the causal fungi develop on the lower portion of the main stem, branches and pods as plants reach maturity. The pycnidia may be limited to small patches near the nodes or may cover dead stems and pods. On stems, the pycnidia are usually arranged in linear rows while on pods they are randomly scattered across the pods (Figure 67). The fungi may grow through the pod walls and infect the seed, causing Phomopsis seed decay. Infected seed is usually oblong in shape, somewhat shrunken or



Figure 67. Pod and stem blight (note pycnidia developing in lines up the stem).



Figure 68. Phomopsis seed decay.

Management options for pod and stem blight

- Rotate crops with at least one year out of soybeans.
- Use disease-free seed (pathogen may survive on infested seed and cause seedling blights if that seed is planted the next year).
- Use an appropriate fungicide seed treatment.
- Use of a foliar fungicide during the growing season is seldom warranted, except in seed production fields in seasons favorable for pod infection.

shriveled and covered with a white mold growth (Figure 68).

Prolonged periods of warm, wet weather during flowering and pod fill favor the development of pod and stem blight. If wet weather continues through harvest, levels of *Phomopsis* seed decay may be high.

Anthracnose

Colletotrichum truncatum and several other *Colletotrichum* species cause anthracnose of soybean. Typically, anthracnose develops as a stem and pod disease on soybean plants during later reproductive stages of growth. However, in some seasons anthracnose may cause a tip blight on plants in early pod filling stages of growth.

On stems, anthracnose causes symptoms that are somewhat similar to those caused by pod and stem blight. Irregularly shaped brown areas may develop on stems, petioles and pods. The anthracnose fungus also produces small black fruiting bodies in infected tissue, although the pycnidia tend to be scattered across diseased tissue rather than in rows as are the pycnidia of *Phomopsis* species.

The tip blight phase of anthracnose causes a yellowing or browning of the uppermost leaves and pods. The blighted tips may dry up and die prematurely.

Anthracnose is favored by warm, wet weather. Symptoms on stems will be more severe if wet weather continues through harvest. The tip blight phase tends to occur when warm to hot weather in midseason is followed by a period of rainy weather.

Management options for anthracnose

- Rotate crops with at least one year between soybean crops.
- Plant disease-free seed (pathogen may survive on infested seed and cause seedling blights if that seed is planted the next year).
- Use an appropriate fungicide seed treatment.
- Use of a foliar fungicide during the growing season is seldom warranted except in seed-production fields in seasons favorable for pod infection.

Cercospora blight, leaf spot and purple seed stain

Cercospora kikuchii can infect soybean seeds, pods, stems and leaves but is most commonly found on the seed. The pathogen survives in infested crop residues and on seed.

Initial symptoms of Cercospora blight may appear as plants are beginning to set seed. Upper leaves in the canopy that are exposed to sun start to show a pink to red to purple discoloration from the leaf tip extending back toward the base of the leaflet (Figure 69). The discoloration may darken and eventually cover the entire upper surface of the leaflet. Leaflets may have a leathery texture and a dark, reddish purple color highlighted with bronze (Figure 70).

In years in which dry conditions during pod fill are followed by a period of rainy weather, Cercospora leaf spot may develop. Infection occurs primarily on the uppermost leaves and begins as reddish purple to reddish brown, angular to somewhat circular lesions (Figure 71). These lesions may coalesce to kill larger areas



Figure 69. Initial symptoms of Cercospora blight.



Figure 70. Soybean leaflet showing more extensive purpling and leathery texture due to Cercospora blight.

of leaf tissue. The entire uppermost trifoliolate leaf and petiole may be blighted and brown. The most striking symptom of this disease is the premature yellowing and then blighting of the youngest, uppermost leaves over large areas of affected fields (Figure 72). Symptoms typically do not progress down the plants more than one to two nodes. Pods at the uppermost node may develop round, reddish purple to reddish brown lesions.

When this fungus infects the seed, the disease is called purple seed stain. Infected seed shows a conspicuous discoloration varying in



Figure 71. Initial symptoms of Cercospora leaf spot.



Figure 72. Yellowing across field due to Cercospora leaf spot.

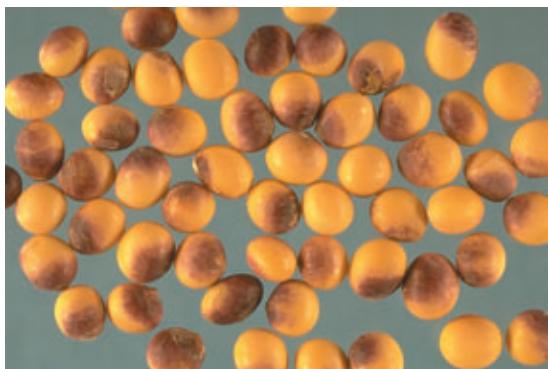


Figure 73. Purple seed stain.

color from pink to pale purple to dark purple. The discoloration may range from small specks to large blotches that cover the entire surface of the seed coat (Figure 73).

Warm, humid weather favors disease development. Yields are not usually reduced, but a high percentage of seed stain may be evident at harvest. Heavily infected seed, if planted, could produce diseased seedlings resulting in stand problems.

Management options for Cercospora blight, leaf spot and purple seed stain

- Rotate crops with at least one year between soybean or other legumes.
- If infected seed must be planted, use an appropriate fungicide seed treatment.

Stem canker

Although stem canker can occur in Missouri, this disease is usually not widespread or serious in the state. *Diaporthe phaseolina*, the fungus that causes stem canker, survives in infested residues. Infection by the stem canker pathogen is favored by extended periods of rainy weather during early vegetative stages of soybean growth. However, symptoms may not be evident until later in the season.



Figure 74. Stem canker causing reddish brown lesion on main stem.

Initial symptoms of stem canker are small reddish brown lesions on stems near a leaf node. Over time the lesions expand to form larger, sunken cankers that are brown to black in color (Figure 74). Since the lesions tend to develop around leaf nodes, the discoloration of the stem is not continuous over the entire stem. The stem near the soil line may be green with bands of discolored tissue at infected leaf nodes separated by green healthy tissue at healthy nodes. Foliage symptoms of interveinal yellowing or browning of leaf tissue may also develop. These foliage symptoms are similar to those caused by sudden death syndrome or brown stem rot.

Management options for stem canker

- Rotate crops with at least one year between soybean crops.
- Select resistant varieties.

University of Missouri Plant Nematology Laboratory

The University of Missouri Plant Nematology Laboratory provides nematode identification, population levels and management information on samples submitted.

Services provided

- SCN egg count test to determine the SCN population level
- Vermiform nematode identification test to identify plant parasitic nematodes present in the wormlike stage (including root-knot nematode)
- HG type test (race test) for SCN

How to submit a sample

- Sample 6 to 8 inches deep with a soil probe or spade.
- Break up cores and mix, then take a pint subsample for testing.
- Place the sample in a sealed plastic bag and label the sample with identifying information.
- For the vermiform test, include some roots with the samples as well as soil.
- The HG type test is for producers who have had high SCN egg counts after growing SCN-resistant soybean cultivars for several years. See Web site for further information on this test.
- Keep samples cool in a refrigerator or a cooler if you cannot send them immediately.
- Fill out appropriate form completely (forms are available online and at MU Extension offices).
- Mail samples early in the week. Always use at least first-class mail.

More information on services, fees and submission forms is available online at
soilplantlab.missouri.edu/nematode

Plant Nematology Laboratory
23 Mumford Hall
University of Missouri
Columbia, MO 65211
E-mail: heinzr@missouri.edu
Phone: 573-884-9118

University of Missouri Plant Diagnostic Clinic

The University of Missouri Plant Diagnostic Clinic provides an accurate and timely diagnosis and management information for submitted samples.

Services provided

- visual examination
- microscopic examination
- incubation in a moist chamber
- pathogen isolation
- serological testing
- insect and weed identification

How to submit a sample

- Collect sample plants or plant parts showing range of symptoms from mild to severe.
- Send an entire plant or portions including the roots because aboveground symptoms may originate with lower stems or roots.
- Try to get samples that are not dead and are as complete as possible (try to include roots, stems etc.)
- Send the best quality specimen(s), and more than one if several are available.
- Send materials as soon as possible after collecting.
- Don't add wet paper towels and extra moisture to packages.
- Keep samples cool in a refrigerator or a cooler if you can't send them right away.
- Do not leave samples in direct sunlight or in an enclosed vehicle. Degraded samples are useless.
- Fill out appropriate form completely (forms are available online and at MU Extension offices)
- Mail early in the week. Always use at least first-class mail. A next-day service or delivery in person is the best way to ensure that the sample arrives in good order.

More information on services, fees and submission forms is available online at
soilplantlab.missouri.edu/plant

Plant Diagnostic Clinic
23 Mumford Hall
University of Missouri
Columbia, MO 65211
E-mail: plantclinic@missouri.edu
Phone: 573-882-3019
Fax: 573-884-4288