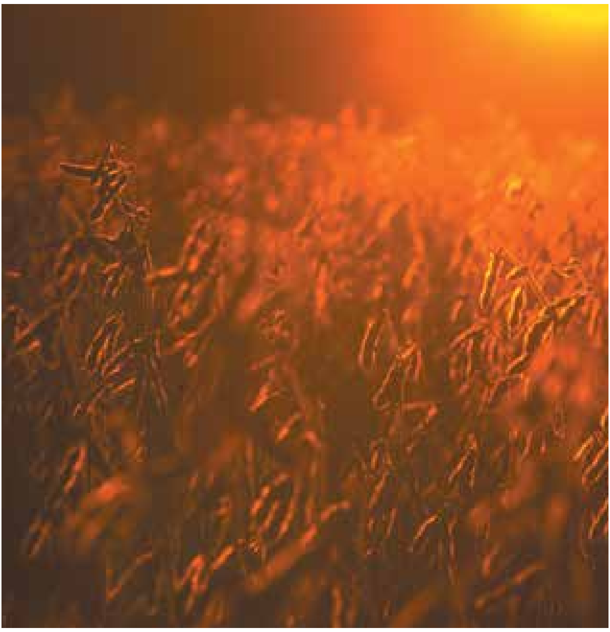
U.S. Soybean Diagnostic Guide

Developed by the Soybean Checkoff



A Pictorial Guide To Soybean Production Challenges

Our soybean checkoff.
Effective. Efficient. Farmer-Driven.

Developed for American soybean farmers through a grant from the United Soybean Board and in cooperation with the Missouri Soybean Merchandising Council.

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Certain photos and revised descriptions of soybean diseases, insects and other abnormalities are from the Soybean Diagnostic Guide *published initially by the American Soybean Association.*

UNITED SOYBEAN BOARD
Making Your Checkoff Pay Off.

Contents

Producing soybeans is a challenge. Soybean plants must compete with an array of pests and other stresses that decrease yield and profitability. But U.S. soybean producers are not defenseless. A properly designed integrated crop management program uses field-specific information acquired through scouting to protect soybean plants from pests and other stresses.

This diagnostic guide is designed for in-field use. Information presented in this guide is necessarily brief and is not meant to be a definitive diagnosis. Additional information can be found on the companion CD-ROM available from the United Soybean Board (USB). Proper diagnosis often requires laboratory analyses of soil and/or plant parts. Please contact your local public or private laboratory for additional assistance.

While using this diagnostic guide, remember that multiple pests and stresses often affect soybean plants at the same time, so the correct diagnosis may include several possibilities. Several different agents can cause similar signs or symptoms. Production problems have been grouped by location on the plant where symptoms occur. Carefully examine all the possibilities before making a decision.

Here's Your Checkoff-Funded Soybean Diagnostic Guide

Use this simple, comprehensive guide to diagnose emerging problems in your soybean fields. Packed with photographs, disease and pest descriptions and other diagnostic information, this guide can help you identify and treat problems early, before they cause lasting yield damage.

The U.S. *Soybean Diagnostic Guide*, also available on CD-ROM or online at *www.unitedsoybean.org,* was developed through soybean checkoff investments in production research. The goal of the production programs is to help U.S. producers grow soybeans more efficiently and in an environmentally responsible manner that meets the needs and desires of end users.

Achieving Positive Results for Every U.S. Soybean Farmer

Our Soybean Checkoff: *Effective. Efficient. Farmer-Driven.*

Created by soybean farmers for soybean farmers, the soybean checkoff works to help each individual U.S. soybean farmer by increasing demand for U.S. soybeans and soy products.

Our checkoff is successful because it's supported by every soybean farmer. At a rate of 0.5 percent of the market price per bushel sold, soybean farmers across the nation invest in their future. Half of the funds go to work at the state level, supporting marketing and research programs right where the beans are grown. The other half is invested by USB in five major areas: Production, Domestic Marketing, New Uses, International Marketing and Communications.

Our checkoff consistently achieves positive results and remains accountable to farmers. With automatic farmer reviews, equitable representation and a strong track record of building demand, our soybean checkoff is unique — and uniquely successful. Through effective, efficient and farmer-driven activities, the soybean checkoff provides every U.S. soybean farmer the opportunity to be competitive in a global marketplace.

Production

Developing a Better U.S. Soybean

Opportunity: Produce U.S. soybeans more efficiently and in an environmentally responsible manner that meets the needs and desires of end users.

Checkoff Solution: U.S. soybean farmers face intense competition from other soybean-producing countries and other sources of protein and oil. Through our soybean checkoff-funded Better Bean Initiative (BBI), we are funding research to develop higher-value U.S. soybeans and help maintain and increase our share of the global soybean market.

By coordinating research from the public and private sectors, the BBI works to accelerate the development and availability of soybean varieties with enhanced compositional traits, such as improved protein and oil content, while maintaining or increasing yield. Improving the compositional quality of our soybeans enables us to better meet the needs of our customers and enhance the economic value of our soybeans.

The Better Bean Initiative. It's just another one of the ways our effective, efficient and farmer-driven soybean checkoff helps every U.S. farmer be competitive in the global marketplace.

Domestic Marketing

Fueling Our Future with Soy Biodiesel

Opportunity: Increase the domestic utilization of U.S. soybeans from 1.2 billion bushels to more than 1.75 billion bushels by 2005, ensuring soybean farmers of long-term potential for profit growth.

Checkoff Solution: Our soybean checkoff is helping companies, fleets and individuals nationwide discover the benefits of using soy biodiesel like cleaner air, increased energy security and superior engine performance. Through soybean checkoff investments in soy biodiesel research, it's the only renewable fuel to have completed the health-effects testing requirements of the federal Clean Air Act.

National Biodiesel Board statistics show that biodiesel is now the fastest-growing renewable fuel in the country. If every farmer used a B2 blend (2 percent soy biodiesel and 98 percent petroleum diesel), we would use over 50 million bushels of soybeans a year.

Biodiesel. It's just another one of the ways our effective, efficient and farmer-driven soybean checkoff helps every U.S. farmer be competitive in the global marketplace.

New Uses

Using Innovation to Increase Demand

Opportunity: Commercialize a sufficient number of new industrial applications each year that collectively have the potential to utilize 10 million bushels per year within five years of market launch.

Checkoff Solution: Thanks to our soybean checkoff, we are investing in the development of new products that increase demand for U.S. soybeans. One of the new products introduced in 2002 is soy-based carpet backing. Soybean checkoff investments have funded, in part, the development of a soy-based polyol, known as SoyOyl™, a component of the new soy-based carpet backing. And, if soybean oil were used to make polyurethane backing for all commercial carpet, it would utilize the oil from over 47 million bushels of soybeans.

U.S. soybean farmers are creating demand for their product through checkoff investments in five key areas: soy-based plastics, coatings and inks, lubricants, adhesives and solvents.

Discovering new uses for U.S. soybeans. It's just another one of the ways our effective, efficient and farmer-driven soybean checkoff helps every U.S. soybean farmer be competitive in the global marketplace.

International Marketing

Increasing Global Competitiveness

Opportunity: Increase U.S. soy exports from 1 billion to 1.5 billion bushels by the year 2005.

Checkoff Solution: Today, U.S. soybeans are an integral part of the global marketplace, thanks to our soybean checkoff. China is the world's largest customer of U.S. soybeans, importing 168 million bushels last year. That's about 280 bushels from each of the 600,000 soybean farms in America. China's aquaculture industry consumes the equivalent of about 140 million bushels of soybeans annually, a market that could never have been realized without U.S. soybean farmers' checkoff investments. And that number is growing each year.

Leveraged with market development funding from the USDA, soybean checkoff investments help U.S. soybean farmers increase export opportunities to stay competitive in major international markets.

Finding new export opportunities for U.S. soybeans. It's just another one of the ways our effective, efficient and farmer-driven soybean checkoff helps every U.S. farmer be competitive in the global marketplace.

Roots

Like most broad-leaved plants, the soybean has a taproot system. The taproot emerges first during germination and elongates up to four or five feet, depending on soil conditions. Branch or secondary roots extend laterally from the taproot. These roots also extend downward in response to gravity. Most water and mineral absorption occurs in a small region near the tip of each root that is covered with root hairs. Functions of soybean roots include anchorage of the plant to

keep it upright, absorption of water and mineral nutrients, and location of nitrogen fixation when rhizobia bacteria are present.

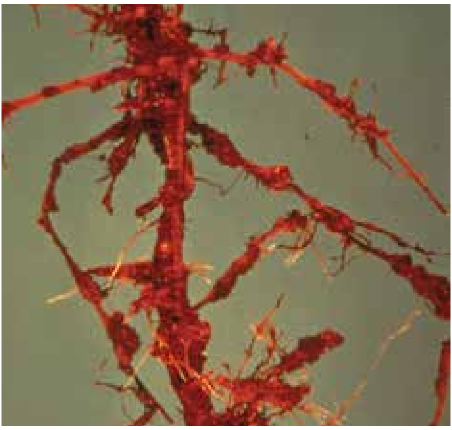
Soil compaction can result in poor crop growth and possibly reduced yields. Symptoms of damage include restricted or distorted (L-shaped) taproot growth that may result in moisture stress and/or nutrient deficiencies.

Fertilizer salt burn can occur when excess fertilizer salts come in contact with the developing root system of young plants. This problem is more likely to occur when banding fertilizer materials containing nitrogen and/or potassium too close to the seed. Roots are stunted and may appear "burnt." Other seedling parts may appear bluish and wilted.

Charcoal rot may cause a seedling disease but is more commonly considered a mid- to late-season soybean disease. The taproot and lower stem develop a gray to silvery discoloration of the epidermis (outer layer of the soybean stem). Internal stem and taproot tissues are reddish brown and become grayish black at maturity. Symptoms may also occur on stems and leaves.

Both *Fusarium oxysporum* and *Fusarium solani* cause **fusarium seedling blight** and **root rot** of soybeans. The pathogens cause a brown to dark purple-brown or black rot of lateral roots, taproots and lower stems. The lower part of the taproot and the lateral root system may be rotted or destroyed. A proliferation of secondary roots may develop above the damaged main taproot, giving the plants a shallow, fibrous root system. Symptoms may also be visible on leaves.

Symptoms of **rhizoctonia root rot** often occur on stems and leaves, but root systems may also be poorly developed with decayed lateral roots. A red to reddish-brown discoloration may be evident on taproot and near soil line. Symptoms also appear on stems and leaves.



There are four species of **root-knot nematodes** known to parasitize soybeans. The presence of root galls is the characteristic symptom of root-knot nematode. Galls vary in size and shape depending on species and number of nematodes in the galls.

Soybean cyst nematode injures soybean roots, which can cause stunting of the plant. Adult females and cysts (dead females) of this nematode are lemon-shaped and vary in color from white to brown. The females and cysts are filled with eggs from which juveniles hatch, penetrate the roots and develop into adults in 14-21 days. As they develop, the female nematodes enlarge until they rupture the root, but maintain root attachment for some time, and then die and fall off into the soil.

The **grape colaspis** is a beetle about $^{3}/_{16}$ inch long with yellow-brown wing covers having a striped appearance. The white or tan larvae are grub-shaped and up to $^{1}/_{4}$ inch in length with a brown head and distinct legs. Adults feed on foliage but rarely cause significant injury. Larvae feed on roots and the underground stem, causing stunted plants.

White grubs are up to $1^1/_4$ inches in length with a creamy white body and reddish-brown legs and head. These grubs are the larvae of scarab beetles, including May beetles, Japanese beetles, masked chafers and others. Typically, they are found curled into a C-shape. Damage is due to feeding on seedling roots, with extensive feeding causing wilting and seedling death.

Some **ALS-inhibitor herbicides** such as imazaquin affect roots. Root hairs and secondary roots may be sparse or exhibit a bottle-brush appearance, and the taproot may be damaged at the growing point.

Some **dinitroaniline herbicides** such as trifluralin cause poorly developed roots with stubby lateral roots.

Stems

Soybean stems should be upright to properly display leaves for maximum sunlight interception. In this guide, we have included the hypocotyl as stem tissue. The hypocotyl elongates during germination and emergence. The elongating hypocotyl cells push against the anchored taproot, forcing the cotyledons upward and out of the soil. There are no buds on the hypocotyl, so major damage to the stem below the cotyledons causes seedling death. Analysis of plant stands and plant health should include careful observation of the hypocotyl.

Stems contain veins (vascular tissue) that move water, minerals and organic compounds to and from the other parts of the plant. Damage or clogging of these tissues impacts plant health and survivability.

Soil compaction often affects root growth, but can also result in thickened hypocotyls.

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A **soil crust** prevents or delays seedling emergence. Seedlings may be depleted of carbohydrate reserves, and the hypocotyl arch may break trying to emerge through the crust. Bending and twisting of seedlings are symptoms of crusting damage.

Deep planting of soybean seed increases the time needed for emergence, resulting in longer exposure of the seedling to soil insects and disease pathogens.

Anthracnose is most common as a pod and stem disease during later reproductive stages of growth. Irregularly shaped brown areas may develop on stems, petioles and pods. Infected plant parts exhibit spiny, black fruiting bodies scattered or clustered across diseased tissue. Symptoms may also occur on seeds.

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. Later in the season, the brown discoloration may be almost continuous within the stem. Foliage symptoms are also common.

The most characteristic symptom of **bud blight** is that infected plants tend to stay green after uninfected plants have matured and turned in color. Other symptoms include a curving of the terminal in the shape of a crook and a proliferation of axillary leaves and buds. Stems and branches may show a brown discoloration of the pith starting at the nodes and extending into the internodal areas.

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Charcoal rot may be a seedling disease but is more commonly considered a mid- to late-season soybean disease. The taproot and lower stem develop a gray to silvery 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. Internal stem and taproot tissues are reddish brown and become grayish black at maturity. When the epidermis is removed, numerous small, black microsclerotia are present. Symptoms may also appear on roots and leaves.

Phytophthora root and stem rot can rot soybean seed before germination, kill young seedlings before or just after emergence, or affect older plants later in the season. Young seedlings or older plants may turn yellow, wilt and die. The stems of these plants may show a brown discoloration that begins at the soil line and extends up the stem. Symptoms may also appear on leaves.

Pod and stem blight is caused by several *Diaporthe* and *Phomopsis* species. Infected plants may be stunted and their stems discolored. Stem symptoms are linear rows of brown to black fruiting bodies on mature or damaged tissues, generally clustered near stem nodes and scattered on pods. Disease on seeds is called Phomopsis seed decay.

Pythium seed decay and damping-off are caused by as many as six different species of the fungus *Pythium*. Seedlings can be killed either 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.

Red crown rot (black root rot) causes root and stem decay with superficial reddish-orange fungal fruiting bodies developing on the main stem or slightly above the soil line later in the season. Foliage symptoms are also common.

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Rhizoctonia root rot can result in seed decay, preemergence damping-off of soybean seedlings and root rot on plants of all ages. On seedlings and older soybean plants, localized reddish-brown lesions develop near the soil line. Lesions are usually confined to the cortical layer (outer layer) of the hypocotyl or stem. Roots and leaves may also be affected.

Sclerotinia stem rot or white mold may first be evident as a wilting of leaves in the upper canopy. Cankers may be evident on stems at the nodes. Initially these cankers 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 stems and may mat together infected leaves or even plants. Later in the season, the black sclerotia (small, hard black bodies of fungal material) may be found on the outside of the stems, in the center pith of stems and even in pods.

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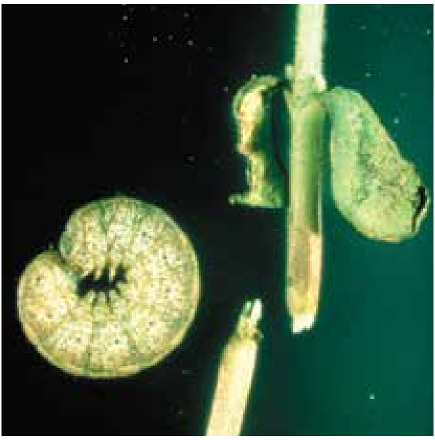
The first symptom of **Southern blight** (Sclerotium blight or white mold) may be a yellowing or wilting of scattered plants in the field. Light-brown to brown lesions may be present on the lower stem close to the soil line. A mat of white mold growth may cover the lower stem and spread out from the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

Northern **stem canker** and Southern stem canker are similar yet distinctly different diseases caused by two closely related fungi. Initial symptoms of stem canker are small reddish-brown lesions on stems near a leaf node that expand to form larger, sunken cankers brown to black in color. The lesions caused by Northern stem canker tend to girdle the stem, causing wilting and death of the plant above the cankered area of the stem. The lesions of Southern stem canker rarely girdle the stem. Foliage symptoms may also be present.

Symptoms of **sudden death syndrome** are most evident on leaves. Internal tissues of the taproot and lower stem may show a light-gray to light-brown discoloration. Symptoms also appear on leaves.



Cutworms are stout-bodied larvae, up to $1^{1}/_{2}$ inches long, which curl into a C-shape when disturbed. They feed at night and are usually found under soil clods or debris during the day. These insects cause damage by cutting off seedlings near the soil line, with some species climbing the plant and feeding on foliage.

The **lesser cornstalk borer** is up to $^{3}/_{4}$ inch long and has a blue-green body with distinct purple or brown bands. This insect is often found in a sand-covered, silken tube attached to the plant at the feeding site. Larvae kill seedlings by girdling and tunneling into plants at the soil line.

The **seedcorn maggot** is up to $^{1}/_{4}$ inch in length. It is a carrot-shaped, legless larva that is white to creamy yellow in color. Damage is caused by burrowing into seeds and seedlings in cool wet soils.

The **three-cornered alfalfa hopper** is about $^1/_4$ inch long and has a wedge-shaped body. Adults are green; nymphs are tan or green and spiny. Damage is caused by nymphs and adults piercing stems and leaf petioles with needle-like mouth parts. A dark ring appears at the point of attack. Callus tissue and adventitious roots develop at the feeding site. Later in the season, plants may snap off when stressed by storms or field-sampling procedures.

Wireworms are cream to brown, slender larvae up to $1^1/_4$ inches long. The body covering is shiny and somewhat hardened. Feeding damage to seeds, roots and the underground stem causes stand reductions.

ALS-inhibitor herbicides may cause the pith of soybean stems to darken.

ALS-inhibitor herbicides may cause shortened internodes. This shortening is more pronounced with carry-over of herbicides not labeled for soybean.

A soil-applied **cell-membrane-disruptor herbicide** (e.g., sulfentrazone) may injure seedlings if the chemical comes in contact with the hypocotyl or other stem tissue by rain splash or other mechanisms.

Growth-regulator herbicides may cause uneven growth of stems so that the stems twist and curl.

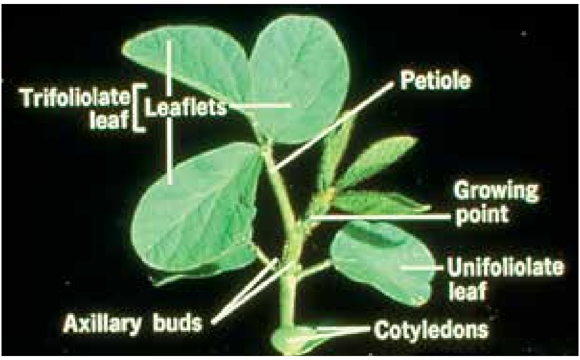
Surface application of herbicides containing **pendimethalin** causes callus tissue to form on the stem at the soil surface. Often, the stem becomes brittle at this site. Brittle stems are prone to breakage.

High soil temperatures during emergence may produce a **heat canker** or pinched stem at soil surface.

When **lightning** strikes kill plants, the dead plants are usually configured in circles up to 40 or more feet in diameter. Plants on edge may not be killed but will be discolored.

Leaves

Leaves are the primary sites for photosynthesis, the process by which sugars are made. These sugars are used by the plant to produce energy that is necessary for all of the other life processes, including the manufacture of carbohydrates, proteins and oils stored in seeds and harvested as yield. Reduction of leaf area and leaf function may reduce yield.



The two cotyledons found in seeds and on seedlings are leaves modified to be storage organs. After emergence, cotyledons turn green for a short period of time before senescing and falling from the plant. Two unifoliolate leaves develop on opposite sides of the stem at the first node. All other leaves on a soybean plant are trifoliolate, meaning that they contain three leaflets. All leaves are attached to stems by petioles.

Symptoms of **bacterial blight** include angular, yellow to light-brown lesions, or spots, on leaves. Lesions enlarge to produce irregular areas of dead tissue surrounded by yellow halos. Dead areas tear away, giving the leaves a ragged appearance. The disease is common during cool, wet weather, and symptoms typically occur several days after a rain with driving winds or a hailstorm. Symptoms may appear on seeds.

Symptoms of **bacterial pustule** include pale green spots with raised centers on lower leaf surfaces. Leaves become ragged as dead areas are torn by wind.

Bean pod mottle causes a green to yellow mottling of young leaves in the upper canopy of the infected plant. Severe strains of the virus may cause leaf distortion and puckering of leaves. Bean-pod-mottle symptoms are most apparent during periods of rapid growth and cool temperatures.

Bean yellow mosaic causes bright yellow, mosaic patches on the leaves. These patches tend to occur along the major veins. With some strains of the virus, leaves may show crinkling and puckering. Symptoms are more pronounced during periods of cooler temperatures.

When foliage symptoms of **brown stem rot** occur, they usually develop as plants are beginning to set pods. Light green to yellow blotches develop in the interveinal leaf tissue. Over time, the yellow areas turn brown. Symptoms also appear in stems.

Foliage symptoms of **Cercospora leaf blight** (leaf spot) develop primarily on the uppermost leaves and begin as reddish-purple to reddish-brown, angular to somewhat circular lesions. Leaves may show a yellowing from the leaf margin in toward the center of the leaf.

Plants infected with **charcoal rot** are less vigorous and have smaller leaves than healthy plants. Leaves turn yellow and wilt. Eventually leaves turn brown and have a dry appearance. Symptoms also appear on roots and stems.

Initial symptoms of **downy mildew** are pale-green to light- yellow spots or blotches on the upper surface of young leaves. These areas enlarge into pale- to bright-yellow lesions of indefinite size and shape. 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 develops on the lower leaf surface beneath the diseased areas. Symptoms may also appear on seeds.

Symptoms of **frogeye leaf spot** occur primarily on leaves. 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. As the lesions age, the center becomes light brown to light gray in color. Older lesions have a light center with a darker red to purple-brown border. Lesions may merge and drop out, giving the leaves a very tattered or shot-hole appearance.

The above-ground portions of infected plants with **fusarium seedling blight** may have an off-color to yellow cast. Foliage may dry and plants wilt or die during periods of drying winds or warm to hot weather. Symptoms also appear on roots and stems.

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On young infected plants, symptoms of **peanut mottle** include a yellow line or ring-patterned patches on the third and fourth trifoliolate leaves. A mosaic pattern is produced on older leaves. Leaves of infected plants may pucker and curl down at the edges.

Phytophthora root and stem rot can affect germinating seeds, young seedlings or older plants. Lower leaves may show a yellowing between the veins or along the margins before turning brown. The brown, dead leaves remain attached to the plant. Symptoms also appear on stems.

Powdery mildew begins as small, circular areas of white, powdery mold growth on the upper leaf surface. These areas enlarge to cover large areas of the leaf surface (both upper and lower surfaces) and may develop on stems, petioles and pods.

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The initial symptom of **red crown rot** is the development of small, interveinal chlorotic spots on upper leaves of individual or scattered plants. These spots increase in size and become brown in color. The leaves usually wilt and may drop early. Symptoms also appear on stems.

The fungus that causes **Rhizoctonia root rot** also causes aerial blight. Leaves, petioles and buds may exhibit disease symptoms beginning on the lower or middle parts of the plant and moving upward. Lesions begin reddish brown and then turn brown or black. Leaves may drop prematurely. A brownish web of the fungus may spread across infected leaves, stems and entire plants. Symptoms also appear on roots and stems.

Septoria brown spot causes small, angular to somewhat circular, red to brown spots on the unifoliolate and lower trifoliolate leaves. The individual spots may grow together, forming irregularly shaped brown blotches on the leaves. Leaves quickly turn yellow and drop from the plant. The pathogen is spread by windblown rain.

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The first symptom of **Southern blight** may be a yellowing or wilting of scattered plants in the field. Symptoms also appear on stems.

Soybean mosaic causes a green to yellow mottling or mosaic pattern on leaf tissue as well as puckering and distortion of the leaf shape. On severely infected plants, leaves are curled downward along their margins, and plants are stunted. Symptoms also appear on seeds.

Northern **stem canker** and Southern stem canker are similar yet distinctly different diseases caused by two closely related fungi. Leaf symptoms include interveinal yellowing or browning of leaf tissue. Symptoms also appear on stems.

Foliage symptoms of **sudden death syndrome** begin as scattered yellow blotches in the interveinal leaf tissue. Blotches increase in size and merge to affect larger areas of leaf tissue, but veins typically remain green. The yellow areas may turn 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. Symptoms also occur in stems.

Bean leaf beetles are about $^1/_4$ inch long and yellow, tan, or red in color with various black markings. They are distinguished by a black triangular mark at the front of the wing covers. This beetle feeds on foliage, blooms, small pods and the outer layers of older pods. Adults also transmit viral diseases.

Blister beetles have slender bodies up to $^3/_4$ inch long with a prominent head and slender legs. Markings vary with species. The margined blister beetle has black wing covers with gray margins; other species have black, gray or striped wing covers.

Grasshoppers that feed on soybean range up to $2^1/_2$ inches in length. Color and markings vary with the species. Adults and nymphs feed on foliage and pods, often chewing into and destroying the seeds.

Green cloverworm larvae are up to $1^1/_4$ inches long. The light-green body has two narrow white stripes down each side. The 3+1 arrangement of the abdominal prolegs is distinctive.

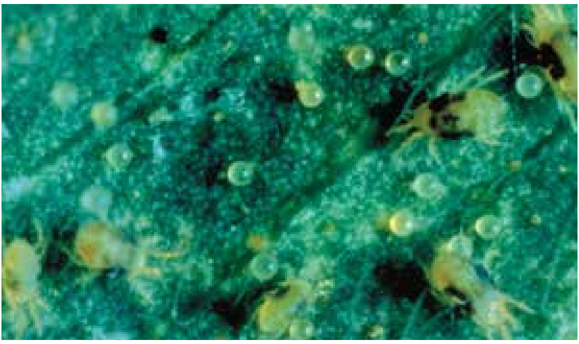
The **Japanese beetle** is about $^1/_2$ inch long and is metallic green with bronze-colored wing covers. It has white tufts of hair visible around the abdomen, just below the wing covers. These beetles skeletonize soybean leaves, stripping away the tissue between the leaf veins. The larvae are white grubs, which apparently do little feeding on soybean roots.

Mexican bean beetles are round, copper-colored insects with 16 black spots on the wing covers. They are about $^5/_{16}$ inch long. The yellow, soft-bodied larvae are up to $^7/_{16}$ inch in length and covered by branched spines. Both adults and larvae feed by stripping away the surface tissue primarily on the underside of leaves. Remaining tissue dies and turns brown to give the foliage a burned, lacy appearance. Beetles may feed on stems and green pods, leaving superficial scars.

Adult **potato leafhoppers** are $^1/_8$ inch long, wedge-shaped and yellowish to pale green in color. Nymphs look similar but are wingless. Leafhoppers are found primarily on the underside of the leaves where they pierce the veins and feed on plant juices. This causes the leaf to turn yellow to red in color from the feeding point outward.

The **soybean aphid** is a small, lime-green to yellow aphid that has black coloration on cornicles (tailpipes) and antennae tips. Damage is most prevalent on late-planted soybeans. Aphid adults and nymphs usually feed on the stems and underside of soybean leaves, where they suck plant juices and produce a sticky "honeydew."

Up to $1^1/_2$ inches long, the **soybean looper** is light green with white stripes running the length of its body. Black legs and body spots are found on some loopers, and the body is much thicker at the tail end, tapering to the head. The insect has 3 pairs (2+1 pattern) of abdominal prolegs. Looper defoliation typically begins in the middle of the canopy.



Spider mites are very small ($^1/_{64}$ inch) insect relatives. The body is pale yellow to red, with two dark spots sometimes visible.

Spider mites feed on the underside of leaflets, with damage first appearing as yellow flecking on the upper surface. Heavy infestations kill the leaves and result in "scorched" areas in the field.

Adult **soybean thrips** are approximately $^1/_{16}$ inch in length with alternating dark and light transverse bands. The nymphs are yellow.

Symptoms of **soybean thrips** feeding appear on seedlings as leaf puckering and silvering of the upper leaf surface. Thrips feed by rasping the underside of leaves, concentrating their feeding near veins.

The **velvetbean caterpillar** reaches $1\frac{1}{2}$ inches in length with a light-green to black body and yellow-orange head. It has 5 pairs (4+1) of abdominal prolegs, with the first pair not apparent on small larvae. Defoliation starts in the top of the plant canopy.

Most **ALS-inhibitor herbicides** cause veins on the backside of leaves to change to a red or nearly black color if they are not labeled for use in soybeans. ALS inhibitors labeled for soybeans may cause this symptom when applied at excessive rates or to plants under stress.

ALS-inhibitor herbicides labeled for soybean use and applied post-emergence may cause interveinal chlorosis.

ALS-inhibitor herbicides not labeled for soybeans but applied post-emergence as a tank contamination may cause chlorotic leaves and shortened internodes. Damage by spray drift may cause similar symptoms.

Post-emergence application of selective **cell membrane disruptor herbicides** may cause leaf crinkling, speckling or spotting.

Newly expanded leaves may show crinkling but not necrosis from **cell membrane disruptor herbicides** because new leaves did not have the upper surface exposed to spray.

Post-emergence application of a non-selective **cell membrane disruptor herbicide,** such as paraquat, may cause leaf burning and spotting. Only tissue directly contacted by the herbicide will exhibit symptoms.

A soil-applied **cell membrane disruptor herbicide,** such as sulfentrazone, may cause leaf chlorosis. Soybean varieties differ for sensitivity, and symptoms may be greater under stress conditions such as heavy rain and drought.

Post-emergence application of **glufosinate** will cause chlorosis and necrosis.

Post-emergence application of **glufosinate** on soybean varieties selected to tolerate glufosinate may cause injury if excessive rates are used or the plants have been stressed by high temperature or disease.

Post-emergence application of **glyphosate** will cause stunting and leaf yellowing. Leaves may be deformed.

Glyphosate injury of soybean varieties selected to tolerate **glyphosate** appears as yellow or lime-green color on newly expanded leaves. Veins in affected leaves remain green.

Growth regulator herbicides may cause leaf cupping, crinkling or strapping. Leaf tips often yellow.

Post-emergence application of non-mobile, **photo-synthesis-inhibitor herbicides** not labeled for soybeans may cause yellowing and spotting where the herbicides contact the leaf.

Post-emergence application of nonmobile, **photosynthesis-inhibitor herbicides** labeled for soybeans may cause leaf bronzing and spotting.

Injury symptoms from mobile, **photosynthesis-inhibitor herbicides** are usually seen on oldest leaves first. Symptoms first appear on leaflet tips. Leaves turn yellow, then brown, and finally die.

Injury from **pigment-inhibitor herbicides** includes interveinal yellowing of older leaves. Leaves will turn white if injury is severe.

Some **pigment-inhibitor herbicides**, such as norfluazon, may cause white venation.

Quizalofop herbicide injury appears as occasional interveinal chlorosis on leaves exposed during herbicide application.

Acetamide, thiophenamine or oxyacetamide herbicides can cause heart-shaped leaflets and cupping because of inhibition of mid-vein growth.

Iron deficiency is limited to high-pH-value (7 or above) soils. Plants are stunted with pale green or yellow to nearly white leaves with green veins, similar to manganese-deficient plants. Symptoms are usually confined to the upper part of the plant.

Although rarely a problem, **magnesium deficiency** may occur on very sandy soils. Deficiency symptoms are pale-green lower leaves, with yellow mottled interveinal tissue, which later show rusty speckling or bronzing.

Manganese deficiency may be found on soils that are very sandy, have high-pH values (7 or above) or are formed from lakebed, glacial outwash, peat or muck parent materials. Symptoms consist of plant stunting and upper leaves with interveinal chlorosis. Chlorotic areas may not be as yellow as with iron deficiency.

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Nitrogen deficiency appears as evenly pale-green or yellow leaves and reduced leaf size. Factors that reduce nodulation or nodule function, including lack of appropriate Rhizobia bacteria, can result in nitrogen deficiency.

Potassium-deficiency symptoms appear primarily on lower leaves as pale-green to yellow leaf margins. Browning and necrosis of leaf margins occur as the severity of the deficiency increases.

Sulfur-deficiency symptoms are similar to those of nitrogen deficiency, but tend to appear on upper leaves. Problems are most likely to occur during cool, wet weather on sandy and/or low-organic-matter soils.

Zinc deficiency may cause yellow and possibly bronze coloration of leaf edges and tips. Leaves may be crinkled, and plants may be stunted. Flower formation or retention may be less than normal. Pods may be abnormal and slow to mature. Zinc deficiency is most likely to occur on high-pH, sandy, high-phosphorus or low-organic-matter soils.

Sunburn damage first appears as small, interveinal, brick-red spots on upper and lower leaf surfaces. Discolor-ation may spread over and along veins, and spots may develop brownish centers.

Wildlife and domestic animals may feed on soybean leaves and stem tips. Leaf petioles often remain attached.

Frost-injury symptoms may range from necrotic spots to overall grayish-black leaf tissue. Plants often appear wilted. Late-season frost may result in seeds remaining green at harvest.

The **corn earworm** grows to $1^3/_4$ inches long with a body color that varies from yellow-green to dark brown to almost black. The head is yellow-orange to brown and the worm has 5 pairs (4+1 pattern) of abdominal prolegs. Often called podworm, this pest feeds on foliage, blooms, pods and terminals. Damage to large pods is characterized by holes eaten through the pod wall at each seed location.

Stinkbug adults have green or brown, shield-shaped bodies up to $^3/_4$ inch long. Immature stinkbugs are multicolored and have the same general body shape as adults, but lack wings.

Stinkbug damage is caused by the mouth parts of adults or nymphs piercing developing pods. Pods may abort. Seeds can be shriveled, flattened or only slightly reduced in size, depending on when the damage occurred.

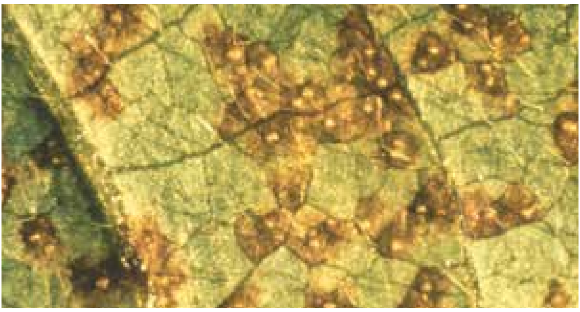
Soybean Rust

Soybean rust is a disease caused by the fungus *Phakopsora pachyrhizi*. The disease causes lesions to appear on the plant that could lead to premature defoliation and decreased yields. Although soybean rust has not been found in the United States, the disease has been discovered in Africa and South America.

The disease originated in the tropical and subtropical regions of Asia and Australia and has caused significant damage to soybean crops in those countries.

This disease could become a significant problem and cause major decreases in yields if it becomes widespread in the United States. Early diagnosis and treatment of the disease are critical.

Symptoms



Early symptoms appear as small lesions on the leaves that become brown to reddish brown and may be confused with bacterial pustule. Under closer examination, tiny bumps within the lesion can be observed. The bumps are spore structures called uredia, which give the leaf a rusty look. Uredia are primarily found on the underside of the leaf, with fewer and smaller uredia forming on the top of the leaf.

Rust-infected leaves eventually turn yellow and fall off the plant. Premature defoliation and a reduction in the number of days to maturity will cause infected plants to have lower seed weight and fewer pods and seeds.

In areas heavily infected with rust, farmers walking through their fields have observed clouds of spores floating in the air. Masses of clear to yellow-brown microscopic urediospores are released from the uredia. They are transported by air currents to other soybean plants and could potentially be transported over long distances.

These are the primary symptoms to look for in your soybean fields. Different varieties may have slightly different reactions to the disease. Over 30 legume species may serve as a host to the rust pathogen, which needs living host cells to reproduce.

Rust Management

The soybean checkoff is funding research to develop varieties resistant to rust and formulate ways to control the disease if it should enter the United States. This guide was developed by the soybean checkoff to help U.S. soybean farmers, extension agents and others properly diagnose and treat this disease.

In some countries where rust occurs, farmers experienced success controlling the disease with multiple applications of fungicides. The picture below shows where rust has infected a row of soybeans that the sprayer missed when fungicide was applied. Moisture is essential for spore germination, so irrigated soybean fields may have more rust. Irrigation should be kept at a minimum when rust is present. In some cases, increasing phosphorus levels has also been found to reduce occurrences of rust.

Rust Contact Information

For more information on soybean rust, see the online version of the *U.S. Soybean Diagnostic Guide* at *www.unitedsoybean.org* or visit the "pest detection" section of the U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service's Plant Protection and Quarantine Web site at *www.aphis.usda.gov/ppq*.

If you think you may have rust in your soybean fields, contact your county extension agent or your local university plant disease diagnostic center. A listing of university diagnostic centers may be found under the "directories and rosters" section of the American Phytopathological Society Web site at *www.apsnet.org*.

Flowers, Pods and Seeds

Soybean plants produce flowers that are nearly always self-pollinated. Flowers and their resulting pods are borne on raceme inflorescences. These inflorescences may occur at all nodes of both stems and branches. Pods contain from one to four seeds.

Soybean yield is directly related to the number of seeds produced and the size of the seeds. Production problems that occur during reproductive development can affect either or both of these yield components. Normal abscission rates for soybeans are 40 percent to 65 percent, but stress may greatly increase the amount of abscission.

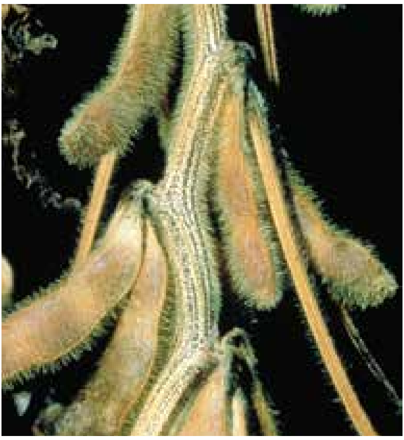
Seed health impacts both grain and seed quality. Grain quality problems may reduce safe storage time and can lead to dockage at the point of sale. Germination percentage and seedling vigor are greatly influenced by seed health. Some diseases within seeds can be passed from generation to generation even if seeds appear healthy.

Plants infected with **anthracnose** exhibit spiny, black fruiting bodies scattered or clustered across diseased tissue, including pods and seeds. Seeds may be discolored, and seed quality is reduced. Symptoms also appear on stems.

The bacterium that causes **bacterial blight** may also infect seeds. Diseased seeds may be covered with a slimy bacterial growth. Symptoms also appear on leaves.

Seeds infected with **soybean mosaic** may exhibit a bleeding hilum or a brown to black mottling of the seed coat. Symptoms also appear on leaves.

The fungus that causes **downy mildew** may infect developing seeds, which decreases seed quality. Symptoms also appear on leaves.



Phomopsis seed decay is caused by the same organisms that cause pod and stem blight. Diseased seeds may be cracked and shriveled. Wet weather during harvest may greatly increase disease incidence. Symptoms of pod and stem blight also appear on stems.

The fungus that causes Cercospora leaf blight also causes **purple seed stain.** Infected seeds exhibit a conspicuous discoloration varying in 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. Symptoms also appear on leaves.

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