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report on
PLANT
DISEASE

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ROOT AND STEM DISEASES OF SOYBEANS

In Illinois, there are 9 common root rot and stem diseases that attack soybeans, causing varying degrees of damage from year to year. Each has characteristic symptoms that should make it possible to identify the trouble readily. All of the symptoms cause affected plants to wilt and turn brown, and usually to die prematurely. All are caused by common soilborne fungi.

PHYTOPHTHORA ROT

Symptoms

Phytophthora root and stem rot, caused by the soilborne fungus *Phytophthora sojae* (synonyms *P. megasperma* f. sp. *glycinea* and *P.m.* var. *sojae*) may attack plants at any stage of growth. The disease, which is favored by cool and rainy weather, may kill the seedlings before emergence; or they may shrivel and die after emergence, leaving gaps in the rows. Older plants may develop dull dark brown lesions extending upward on the stem from the soil line, occasionally to the tenth node. The taproot becomes dark brown, and the entire root system may be rotted. Infected plants usually turn yellow, wilt, and die. The withered leaves commonly remain attached to dead plants for a week or more. *Phytophthora* is found most often in heavy clay soils that are poorly drained and compacted, especially in low areas where surface water has been standing for several days. This disease is also favored by reduced tillage and early planting. Plants are often killed in sections of the rows (Figure 1). Plant losses and yield reductions may approach 100 percent in very susceptible soybean cultivars. The severity of loss depends on cultivar susceptibility, rainfall, drainage, soil type, and tillage.

Figure 1. Soybean field showing sections of rows killed by Phytophthora rot.

Disease Cycle

The *Phytophthora* fungus overseasons primarily as dormant, thick-walled oospores in crop debris or soil. Large numbers of oospores are formed in infected roots and stems of susceptible and tolerant soybean cultivars. Oospores are thought to germinate in the spring in wet soils, forming sporangia which contain numerous motile zoospores. Optimal temperature for oospore germination is 75°F (24°C).

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Zoospores are released into soil water where they swim about and are attracted to soybean roots by normal plant exudates. Optimum temperature for zoospore production is 68°F (20°C) with a minimum of 41°F (5°C). Zoospores adhere to roots, form a cyst, and germinate. Under less ideal conditions, oospores and sporangia in the soil may germinate and infect roots directly (optimum 77°F or 25°C) without forming zoospores.

Leaf infection may result when soil particles containing the *Phytophthora* fungus are deposited on the leaves during wind or rainstorms. If the weather remains cloudy and damp, severe leaf infection occurs and the fungus grows internally toward the petiole and then the stem.

The severity of Phytophthora rot of soybeans may increase if there are high populations of other root-rotting fungi in the soil (e.g. *Pythium* or *Fusarium* spp. and *Rhizoctonia solani*), because damaged roots are more susceptible to infection. Infection of soybean roots by the nematodes also increases the severity of Phytophthora root rot.

There are many races of *Phytophthora sojae*, which greatly complicates the development of resistant cultivars by conventional breeding methods. The races can be distinguished on eight soybean differential cultivars. Resistant cultivars are resistant to only certain races. However, this resistance is high and is effective from planting to plant maturity. Tolerant cultivars are susceptible in the seedling stage but are not susceptible to any race past this growth stage. The level of tolerance may vary from high to low.

Control

1. Grow well adapted, high yielding, resistant or highly tolerant cultivars.

2. Plant in warm soil (65°F [18°C] or more) that is well drained and fertile. Avoid growing susceptible cultivars in low lying areas in poorly drained soil or where Phytophthora rot has appeared in the past. Also avoid deep planting and an excessive seed rate.

3. Where feasible, use tillage or tiling to improve drainage and soil water absorption. Reduced tillage, especially no tillage, often has higher disease levels. Fields with heavy residues tend to warm more slowly in the spring and may have higher soil moisture levels, conditions which favor disease development.

4. Apply a seed and/or soil fungicide to fields with known history of disease. For details, see "Condensed Plant Disease Management Guide for Field Crops" chapter in the Illinois Pest Control Handbook. These treatments will control only the seedling blight phase.

PYTHIUM ROOT ROT, DAMPING-OFF, SEED DECAY

Symptoms

Pythium rot is caused by at least five species of the cosmopolitan soilborne fungus *Pythium*. Species of *Pythium* generally cause seedling diseases that may induce seed decay and damping-off (seedlings fail to emerge or they emerge then wilt and collapse), especially in wet seasons with high levels of rainfall before and after planting. Pythium rot is most severe in poorly drained soils. Infected plants have dark areas extending up the stem several inches from the soil line. The diseased areas usually become translucent, soft, and watery. These areas tear away when the plants are pulled from the soil.

If dry weather sets in, the plants appear dry and shredded (Figure 2). Usually, the roots are badly decayed. Infected plants normally occur singly or in small groups scattered throughout a field. *Pythium* usually causes little reduction in yields. Infection by *Pythium* species is often followed by infection by other root- and crown-rotting microorganisms which can mask typical symptoms.

Figure 2. Soybean seedlings wilting and drying in the field from Pythium root rot, caused by Pythium spp. (Courtesy H.J. Walters).

Disease Cycle

Pythium fungi are common inhabitants of the soil that colonize crop residues and attack a wide range of crop plants. The fungi survive in soil and plant residue as dormant, thick-walled oospores and as mycelium in crop residues. When the soil is cool (50° to 59°F, 10° to 15°C) and wet, the oospores commonly germinate and produce a sporangium in which zoospores are formed. After escaping from the sporangium, the zoospores swim about in the soil water and are attracted to seeds or to the roots of seedlings where they encyst and later form a germ tube that penetrates and causes infection. At higher temperatures (77° to 97°F, 25° to 36°C), the oospores may germinate directly and form one or more germ tubes that penetrate the seed coat or the root and stem tissues directly. Seedlings up to 10 days old are more susceptible to damping-off than older plants.

Control

1. **Plant high-quality, crack-free seed capable of at least 85% germination in a warm or standard test and 70% in a cold test.**

2. **Plant in warm soil (above 65°F, 18°C) that is well drained and fertile and well prepared**. Where feasible, turn under weeds or cover crops several weeks before planting.

3. **Apply a seed or soil fungicide**. For details, see the "Condensed Plant Disease Management Guide for Field Crops", chapter in the current Illinois Pest Control Manual. Fungicide seed protectants will often increase emergence, especially when conditions do not favor seedling growth and development. However, seed or soil fungicides will not improve emergence of damaged or low-quality seed.

4. **Do not plant carryover seed or seed that has a high percentage of cracked seed coats.**

5. **Avoid excessive irrigation for the first 10 to 15 days after planting.**

BROWN STEM ROT

Symptoms

Brown stem rot, caused by the fungus *Phialophora gregata* (synonym *Cephalosporium gregatum*), enters plants through the roots and lower stem. Losses are greatest when cool weather occurs during the pod-

filling stage (late July and first half of August) followed by hot, dry weather. Losses of 17 to 25 percent may result from lodging, premature death, or from the production of fewer and smaller seeds.

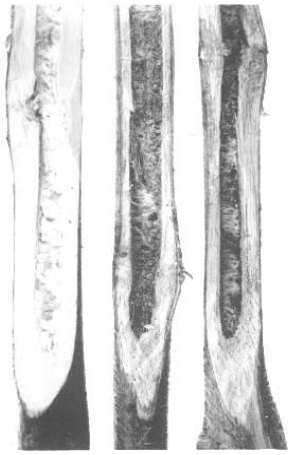

Figure 3a. Brown stem rot.

Brown stem rot is difficult to recognize before pod set because it has no external symptoms. When the stems of infected plants about mid-season are split longitudinally, however, a characteristic, dark reddish brown discoloration of the vascular elements and pith is evident (Figure 3a), extending upward from the roots or crown. Occasionally during hot, dry weather in late August or early September, wilting occurs followed by a "scorching" (browning and dying) of the leaf tissue between the veins. The leaves blight and dry rapidly. Infected plants often look "frosted" (Figure 3b). The brown stem rot fungus reduces the efficiency of the water-conducting tissues in the stem. However, leaf symptoms may vary and should not be considered in diagnosis without splitting stems.

Disease development is optimum at air temperatures of 59° to 81°F (15° to 27°C). Little or no disease develops at temperatures above 90°F (32°C). Cool weather leads to more internal stem browning.

Disease Cycle

The brown stem rot fungus survives in soybean debris and in soil to a depth of about one foot. The fungus produces spores on all types of soybean residue except pods. Infection occurs through main and lateral roots and the pathogen moves into the lower stem early in the growing season. The fungus spreads slowly upward in the water-conducting vessels. The pathogen may plug vessels partially or completely, interfering with the flow of water and nutrients. The fungus has been reported to be seedborne, surviving as mycelium within the seed coat.

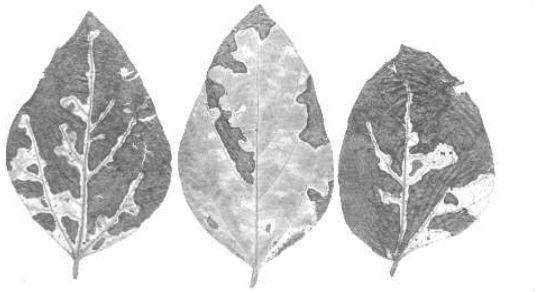

Figure 3b. Brown stem rot.

Control

1. **Grow soybeans in the same field only once in 3 or 4 years**. Rotate with corn, sorghum, small grains, forage grasses, legumes, or other crops.

2. **Plant resistant cultivars in fields where brown rot is a severe problem**. Cultivars that mature early tend to escape severe infection, but generally yield less than later-maturing ones in the absence of the disease.

RHIZOCTONIA ROOT AND STEM ROT

Symptoms

Rhizoctonia root and stem rot is caused by the cosmopolitan, soilborne fungus *Rhizoctonia solani* and is primarily a seedling disease that attacks the basal stem and roots of young plants during May and June causing pre-and postemergence damping-off. The disease is found sometimes in conjunction with Pythium or Phytophthora rot. Rhizoctonia infection typically produces a sunken, reddish brown to dark

brown decay of the outer layer of the main root and stem at the soil line and below (Figure 4). In contrast with Pythium root rot, Rhizoctonia-infected stems remain firm and dry. Phytophthora-infected roots are a dull, dark brown; those infected with *Rhizoctonia* are usually reddish brown. *Rhizoctonia*-diseased plants commonly wilt in more or less circular patches 4 to 10 feet in diameter, distributed irregularly throughout a field. Damping-off of seedlings and stem and root decay can reduce stands and yield losses.

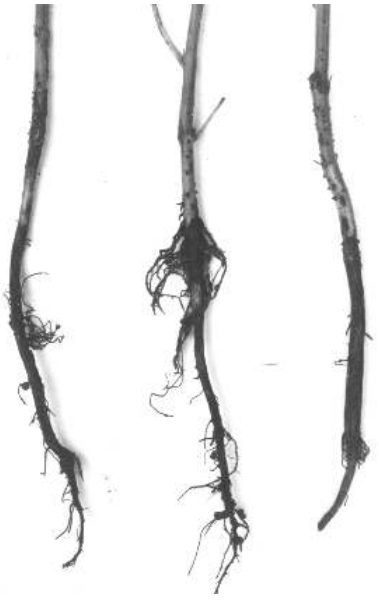

Figure 4. Rhizoctonia root and stem rot.

Disease Cycle

The *Rhizoctonia* fungus is a very common one which infects most field crops, vegetables, ornamentals, and fruits. The fungus survives in soil and plant residue as small, chestnut brown to black bodies (sclerotia) or as resting mycelium. Many strains of the fungus can colonize essentially any dead plant tissue. During moist soil conditions, sclerotia germinate to form mycelium; or, the resting mycelium grows from all types of plant debris to infect seeds, roots, and stem tissue.

The optimum temperature for disease development is between 77° and 85°F (25° and 29°C); but occasionally, severe losses may occur at 59° to 76°F (15° to 24°C). Rainfall followed by cool and then warm, humid weather is most favorable for disease development. Growth of the *Rhizoctonia* fungus in soil depends on nutrient supply; soil moisture, temperature and pH; and competition from other soil microorganisms.

The severity of Rhizoctonia root and stem rot increases when plants are grown in soils that are deficient in calcium, iron, magnesium, nitrogen, phosphorus, sulfur, or any combination of these elements. There is evidence that some herbicides reduce the number of microbial antagonists in the soil, which favor *Rhizoctonia solani.*

Control

1. **The same as for Pythium Rot**.

2. **Ridge the soil around the base of plants during cultivation**. This practice often stimulates the production of new lateral roots above the rotted basal portion of the taproot. Affected plants commonly recover, at least partially.

3. Apply a recommended seed treatment. See the chapter, "Condensed Plant Disease Management Guide for Field Crops", in the current Illinois Pest Control Handbook for a list of seed protectant materials.

STEM CANKER

Symptoms

Stem canker is caused by the fungus *Diaporthe phaseolorum* var. *caulivora*. It occurs throughout Illinois. Enlarging cankers that are reddish brown to black, slightly sunken, and girdling develop on the lower part of the stem, causing the plants to wilt, wither, and die because the flow of water and nutrients to the foliage is reduced or stopped completely. The lesions usually occur at the fourth or fifth node (joint) or in the region of the second and third trifoliolate leaves (Figure 5). Infected stems are brittle, and the plants break over easily at the center. The symptoms of stem canker usually appear in late July or early August, when the pods are starting to fill out, and persist until the crop matures. The plant withers and dies during the latter half of the growing season. The dead, dried leaves remain attached, instead of dropping off as they normally would at maturity.

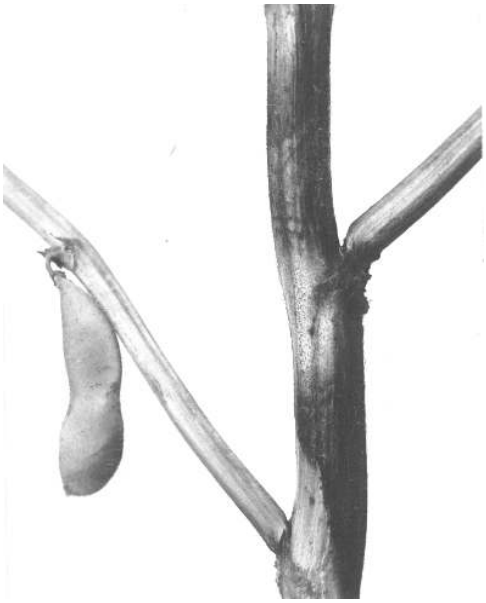

Figure 5. Stem canker..

An often overlooked symptom of stem canker is the appearance of small, reddish brown lesions on one or both cotyledons. Infection may spread into the stem, causing seedlings to wither and die. Seedlings may also die before emergence. Yield losses of 20 to 50 percent have been recorded when infection occurs soon after the pods begin to develop.

Disease Cycle

The stem-canker fungus overseasons in soybean residue in or on the soil, and in infected seed. For the stem canker fungus, infected seeds may serve as an important source of long range dissemination. The fungus survives as mycelium and as clusters of long necked, black fruiting bodies (perithecia) on infected tissue. The perithecia are capable of remaining viable up to 14 months at temperatures of 4° to 65°F (-15° to 18°C). Perithecia, containing large numbers of microscopic ascospores, are also produced in lesions on infected cotyledons. The wind- and waterborne ascospores provide inoculum for secondary infections. Most infections occur on the lower leaves. The fungus grows from the leaf blade through the petiole to the stem, where a typical canker results. A daily mean temperature of 70°F (21°C) during wet weather is optimum for disease development.

Control

1. **Plant high-quality, certified seed that is disease-free and will germinate more than 80 to 85% in a warm germination test or over 70% in a cold germination test.**

2. **Plant thoroughly cleaned seed** in a warm, fertile, well-prepared seedbed. Treat the seed with a protective fungicide. See the chapter "Condensed Plant Disease Management Guide for Field Crops" in the current Illinois Pest Control Handbook for details.

3. **Bury infected crop residue after harvest**, where soil erosion is not a problem.

4. **Where feasible, rotate soybeans for 1 or 2 years with corn, sorghum, small grains, alfalfa, or forage legumes.**

5. **Make a foliar application of a labeled fungicide. This is suggested for seed-production fields**. For details, see the "Condensed Plant Disease Management Guide for Field Crops" chapter. Spraying increases seed size, quality, and germination. The proper and timely application of a fungicide not only controls stem canker, but also pod and stem blight, Septoria brown spot, anthracnose, Cercospora leaf spot or blight, target spot, and purple seed stain. Yield increases are not unusual in Illinois when August and September are very rainy and the harvest is delayed after full maturity. If these conditions are not present, however, yield increases may be minimal.

6. **Harvest as soon as the crop is mature**. When harvest is delayed under wet conditions, seeds may be infected throughout the plant.

7. **Maintain adequate potash based on a soil test.**

POD AND STEM BLIGHT AND PHOMOPSIS SEED DECAY

Symptoms

Pod and stem blight, caused by *Diaporthe phaseolorum* var. *sojae* (the asexual state is *Phomopsis sojae*), is similar to stem canker but is spread more widely over the entire state of Illinois. Another involved fungus is *Phomopsis longicolla.* The relative presence of the two fungal species varies with location and season. Pod and stem blight occurs primarily on plants nearing maturity. Damage is most severe in wet seasons when harvest is delayed. Seed infection is greater in densely populated fields, due to lodging of plants.

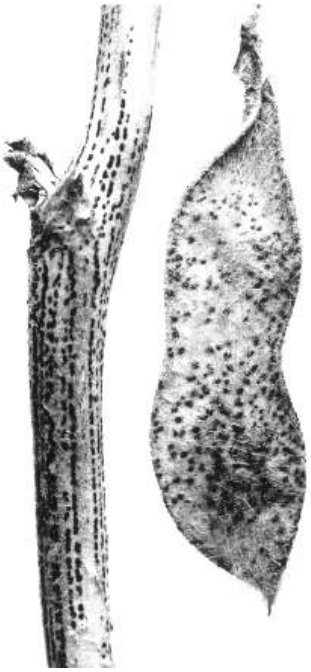

figure 6a. Pod and stem blight.

Numerous, small black "pimples" (pycnidia, the fungus fruiting bodies) appear on the stems and pods. These "pimples" are first detected on petioles of abscised leaves. They are commonly arranged in straight rows along the stem and are scattered on the pods (Figure 6a). The causal fungus may produce seed rot as the plants mature. Infected seeds (Figure 6b) are often discolored, moldy, cracked, shriveled, lightweight, and often fail to germinate when the soil is cool (59° to 68°F, 15° to 20°C) and wet. The infected seeds that do germinate often give rise to infected seedlings, which may serve as a source of inoculum. Pod and stem blight is a prime factor in reducing seed quality in seed-production fields. Infected seeds produce low quality oil and flour.

Figure 6b. Soybean seeds infected with the pod and stem blight fungus, Diaporthe phaseolorum vsr. Sojae (Phomopsis sojae).

Disease Cycle

The pod and stem blight fungus is seedborne. Most seed infection occurs during or after the yellow pod stage (R^7). Insect injury, such as stinkbug feeding wounds on pods, may increase disease levels. The fungus also overseasons in the residue of soybeans or other host plants (e.g. cowpea, garlic, green bean, lespedeza, lima bean, lupines, okra, onion, peanut, pepper, and tomato) as dormant mycelium. Pycnidia of the Phomopsis state may be found in dead soybean tissue such as Phytophthora - induced lesions, tissues damaged by hail, or plants killed by other diseases. In wet seasons latent infections produce tremendous members of pycnidia simultaneously over entire plants as they mature.

Control - The same as for stem canker.

CHARCOAL ROT

Symptoms

Charcoal rot, summer, or dry weather wilt is caused by the widespread soilborne fungus *Macrophomina phaseolina* (synonyms: *Rhizoctonia batiticola, Sclerotium batiticols*). The disease attacks the roots and basal portion of the plant throughout the season. Charcoal rot is favored by hot, dry weather) especially in combination with fertility deficient soils or other unfavorable growing conditions. Charcoal rot is usually found in plants of low vigor or in a weakened condition after midseason, mostly in the southern two-thirds of Illinois or other parts of the state. In an advanced stage, the leaves on affected plants turn yellow, wilt, wither, but remain attached. After flowering the lower stem and taproot may appear light gray or silvery in color. When the outer "bark" is peeled from the roots and stem base, small black specks can be seen) the microsclerotia (propagating bodies) of the causal fungus. These specks may be so numerous that they give a grayish black color to the tissues; hence, the name "charcoal rot" (Figure 7). When split open, the taproot and base of the stem show black streaks in the woody portion. The causal fungus is a weak parasite of soybeans that attacks and may kill seedlings and young plants when their growth is retarded by hot, dry conditions.

Figure 7. Charcoal rot.

Seedling infestations can mimic those of *Rhizoctonia* producing a reddish superficial lesion on the hypocotyl. Charcoal rot lesions do not cause a shrinking of tissues as does *Rhizoctonia*. Lesions can often be scraped off with a fingernail where charcoal rot is present.

Disease Cycle

The charcoal rot fungus overseasons as jet black, round to oblong or irregular microsclerotia and resting mycelium in dry soils and embedded in plant residues. The sclerotia germinate on the surface of roots. The resulting germ tubes penetrate and cause infection. The fungus is also seedborne. The *Macrophomina* fungus restricts water movement in the plant by mechanical plugging of the water-conducting vessels with mycelium and microsclerotia and by secreting toxins and enzymes that kill host tissues. Disease development and symptom expression are most rapid at temperatures of 82° to 95°F (28° to 35°C).

Control

1. **Plant high-quality, certified seed that is disease-free**. (Same as No. 1 for Stem Canker.)

2. **Plant soybeans at the recommended rate**. Crowding of seedlings makes them more subject to infection.
3. **Fertilize, based on a soil test.**

4. **Rotate soybeans with non-host crops (cereals) for one or two years.**

5. **Where possible, irrigate during extended periods of hot, dry weather.**

6. **Plow down cleanly infected crop residue, where erosion is not a problem**. This places the sclerotia mostly into moist soil where they are more subject to attack by other soil microorganisms.

SCLEROTINIA STEM ROT

Symptoms

Sclerotinia stem rot is caused by the soilborne fungus *Sclerotinia sclerotiorum*. The disease is usually a minor one in Illinois, except for local outbreaks (usually where snap beans, canola, or sunflowers have recently been grown) during prolonged wet periods. The disease is most common in areas of fields where air circulation is poor, e.g. near woods. The first symptoms, often observed on older plants, are the wilting and withering of the upper leaves. A white, cottony growth appears on the branches, pods, and stems of the soybeans, usually near the soil line and originating at stem nodes. Large survival bodies (sclerotia) that are round to irregular and eventually hard and black are formed on and inside the stem; occasionally, in the pods (Figure 8). These sclerotia may be partly covered with the dense cottony fungus growth. Plants die prematurely when the stems are girdled by the fungus. The withered leaves remain attached to the stem for some time. Pod development and pod fill above the girdling stem lesions are greatly reduced. Soybean seedlings may be killed before or after emergence from a watery, soft rot. Seeds may become infected within diseased pods. Infected seeds are discolored, flattened, and smaller than healthy seeds and sometimes replaced by black sclerotia.

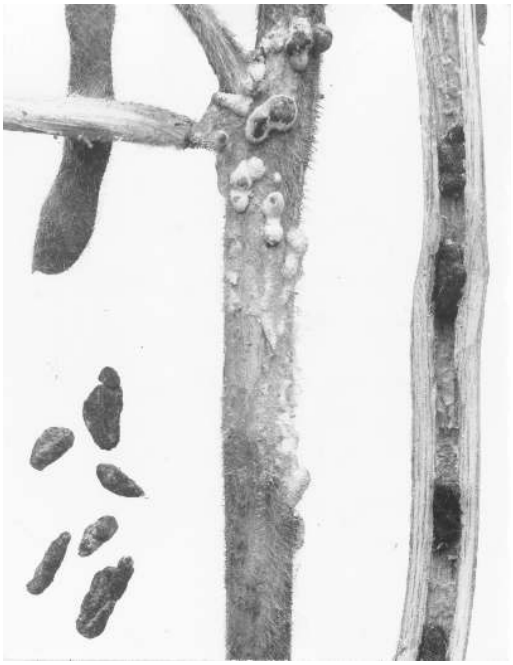

Figure 8. Sclerotinia stem rot. Note sclerotia (lower left); also, those forming on the stem (center) and inside the stem (right).

Disease Cycle

Sclerotia of the *Sclerotinia* fungus can survive in the soil for long periods and are highly resistant to most fungicides. The sclerotia germinate within 2 inches (5 cm) of the soil surface by producing one to many light tan to brown, funnel-shaped structures (apothecia) during prolonged periods of cool (40° to 59°F,

5° to 15°C), wet weather. Large numbers of asci are formed in the apothecia, which literally eject "clouds" of ascospores under proper conditions. The windborne ascospores germinate and infect soybean blossoms, stems, branches, and pods under very damp conditions.

Control

1. **Do not rotate soybeans with garden, snap beans (Phaseolus spp), canola or sunflowers**. Control broadleaf weeds which may serve as hosts.

2. **Thoroughly clean contaminated seed lots to screen out some of the sclerotia**. At a foreign port of entry, even a few sclerotia in a shipment intended for human consumption are grounds for rejection.

3. **Grow soybean cultivars that do not lodge readily.**

4. **Avoid planting soybeans in narrow rows** (less than 30 inches or 76 cm) in fields with a history of Sclerotinia stem rot.

5. **Avoid irrigation at flowering**. High humidity in the canopy at this time increases disease levels.

SUDDEN DEATH SYNDROME

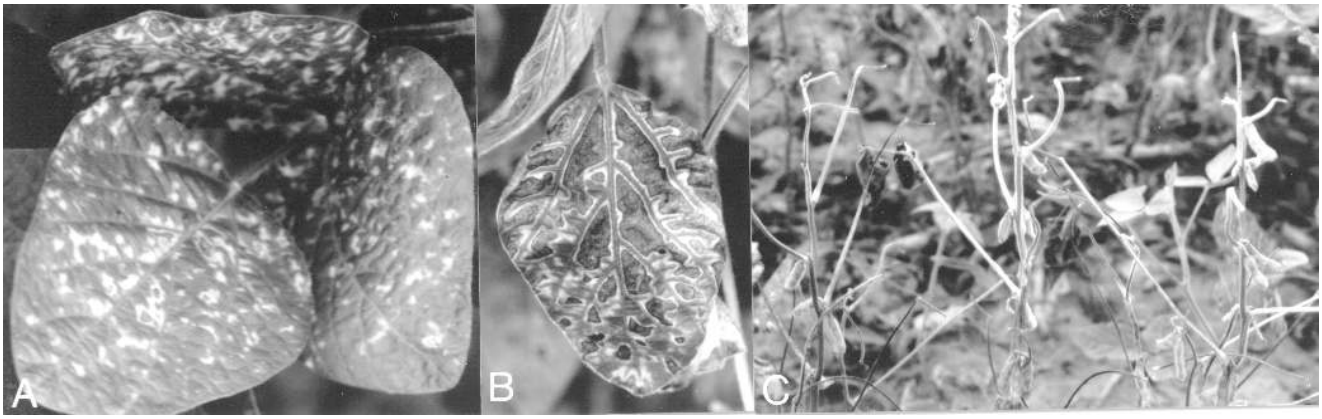

Figure 9. Sudden death syndrome. A, early symptoms showing small yellow blotching; B, late symptoms, note distinctive green vein pattern; C, defoliation (courtesy S.B. Belmar).

Symptoms

Sudden death syndrome (SDS), caused by a strain of the soilborne fungus *Fusarium solani*, generally appears about midsummer in soybeans with high yield potential usually after blooming. The disease can result in minor or severe yield loss, depending on when it develops. SDS is identified by the appearance of small, scattered yellow spots or blotches usually on the upper leaves (Figure 9a). These spots enlarge, merge, and the tissues turn brown between the veins; however, the veinal tissues remain green (Figure 9b). Leaflets may curl upward or drop prematurely, leaving the petioles firmly attached (Figure 9c). Severe foliar symptoms give affected areas in a field a tan to brown cast and may be the first evidence of the disease. Flowers and pods may abort and pods drop or not fill. The first pods to set may have a few beans in them which remain small. Later pods may not fill or may have immature green seed. One characteristic

of SDS is that the interior of the stem (pith region) remains white. There may be a slight gray-brown discoloration of the vascular system just inside the outer "bark" of the stem but the pith remains white. If the pith is discolored, it may indicate the presence of brown stem rot. Root symptoms preclude foliar symptoms and result in deterioration of the topmost, lateral roots, and nitrogen-fixing nodules. Fields in which the disease is present are likely to develop SDS in subsequent years, although there are no accurate methods of assessing possible disease levels.

Disease Cycle

The *Fusarium* fungus overseasons as thick-walled chlamydospores or mycelium in crop debris or in soil. SDS is affected by weather conditions. The disease is more severe during cool, wet growing seasons. It is commonly found in association with soybean cyst nematodes (SCN) and in lower areas of fields. Nematodes are believed to act as a stress factor rather than being directly involved with the disease. However, work in Mississippi has shown that SCN can act to spread the fungus. This research demonstrated that the *Fusarium* fungus was present both on and in the cysts of soybean cyst nematode. Therefore, direct or indirect movement of the nematode could spread the fungus to new areas. The disease tends to be most severe on well managed soybeans with a high yield potential. However, tillage and rotation practices seem to have little impact on this disease.

Control

1. **Grow well-adapted, high-yielding varieties in a warm, well drained, fertile soil. Maintain balanced soil fertility based on a soil test.**

2. **Control other diseases, weeds and insects.**

3. Although SDS is not seed-transmitted, seeds from infected plants are small in size and tend to produce weaker seedlings than those from healthy plants. Therefore, do NOT save seed from SDS-infected areas.

4. Crop rotation, although not consistent in greatly reducing levels of the *Fusarium* fungus, is definitely beneficial in reducing the buildup of other pathogens (especially nematodes) that may weaken the plant.

5. Sanitation (e.g., cleaning tires, combines and other equipment of soil and crop debris), although time consuming, will help to reduce spread of the SDS fungus as well as other soybean pathogens.