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Publications

Soybean Growth and Development (Iowa State)

Crop Injury of Herbicides on Soybeans

Herbicides[ab]	
Preplant incorporated	
Alachlor	VS
Dual II	VS
Frontier	VS
Freedom	VS
Pendimethalin	VS
Sonalan	VS
Trifluralin	VS
Broadstrike + Dual	S
Broadstrike + Treflan	S
Command	VS
Pursuit	VS
Pursuit Plus	VS
Metribuzin	M
Turbo	M
Preemergence	
Alachlor	VS
Command 3	M
Dual II	VS
Freedom	VS
Frontier	VS
Broadstrike + Dual	VS
Cover	S
Lorox	M
Metribuzin	M
Pursuit	VS
Python	VS
Turbo	M
Postemergence	
Acifluorfen	H
Basagran	S
Cobra	H
Galaxy	H
Flexstar	M/H
Reflex	M/H
Resource	M
Stellar	H
Chlorimuron	VS
Concert [d]	M
Pinnacle [d]	M
Pursuit	S
Reliance [e]	VS
Raptor	S
Liberty [f]	VS
Roundup Ultra [g]	VS
Fusilade DX	VS
Fusion	VS
Poast Plus	VS
Quizalofop	VS
Select	VS

[a] These herbicides have been rated for expected weed control, but actual results may vary depending upon rates applied, soil types, weather conditions, and crop management.

[b] Crop injury: H=high; M=moderate; S=slight; VS=very slight; N=none.

[d] Risk of injury on STS soybeans is very slight.

[e] Only apply to STS soybeans or severe injury may occur.

[f] Only apply to Liberty Link soybeans or crop will be killed.

[g] Only apply to Roundup Ready soybeans or crop will be killed.

The above information is from (A3646) *1997 Field Crops Pest Management in Wisconsin; A Guide to managing weeds, insects, and diseases in corn, soybeans, forages and small grains*, and is reprinted with permission from the Cooperative Extension Publications, University of Wisconsin-Extension.

Seed Corn Maggot
Injury

Green Cloverworm
and Damage

Two-Spotted Spider Mite

Bean Leaf Beetle

Wooly Bear Caterpillar

Grasshopper

Soybean Aphid

WInged Soybean
Aphid

Seedcorn Maggot

Description

The maggot is a white, tapered, legless larva that will be found in or near the planted seed. After feeding, the maggot forms a brown capsule-like puparium in which it pupates. Puparia are commonly seen in the soil next to the crop row. The adult is a fly about one-half the size of an adult housefly. They can be found on the soil surface during late spring whenever the ground is disturbed, such as during planting.

Life cycle

This species passes the winter in a brown puparium located in the soil. Adults emerge in late spring about the time soybeans are being planted. Eggs will be laid in any field with an abundance of organic matter. Decaying weeds and crop residue, or application of livestock manure will make a field more attractive to the egg-laying flies. Eggs hatch in approximately four days and the young larva moves about in the soil in search of food. This stage lasts about 12 days at a soil temperature of 70°F. After pupal development (approximately 15 days), adults will appear and start another generation. There are several generations per year.

Damage

The maggot burrows into the germinating seed and even one larva per seed may kill the seed. If the seed germinates, maggots will feed in and on the cotyledons. When these plant parts appear above ground they demonstrate brown feeding scars. Occasionally a shoot will emerge and cotyledons will be absent - such plants are occasionally referred to as "snakeheads".

Anything that delays emergence, such as dry topsoil or cold, wet weather will increase the chance of damage because the plants take longer to emerge and allow more time for egg hatch and feeding injury.

Scouting suggestions

There are no treatments for the crop once damage is present. If an emerging field of soybeans has a spotty stand, seed maggot feeding injury must be considered as one of many possible causes.

Economic thresholds

There is no acceptable method for identifying the fields likely to have economic damage. Because of this uncertainty, it is suggested that an inexpensive seed treatment should be applied to the seed prior to planting.

Green Cloverworm

Description

Although many green, legume-feeding caterpillars can be found in our soybean fields, the green cloverworm is the only species believed to be a potential threat. It can be found in Wisconsin at low levels, but in states like Iowa, Illinois, and Indiana, a few large outbreaks have occurred over the past 20 years. During most years, fortunately, a fungal disease is a key factor in keeping populations at subeconomic levels.

The green cloverworm is light green and has two thin white stripes along each side of the body. They have only four pair of fleshy abdominal prolegs (including anal prolegs). As is true with the other caterpillars. There are three pairs of "true" legs just behind the head. When fully grown they are approximately 1 to 1-1/2 inches long. They are quite active, falling to the ground at the slightest disturbance. When touched, they will wiggle violently. Adults are nondescript, dark brown and black moths that, when at rest, are triangular in shape.

Life cycle

The overwintering stage of the green cloverworm has not been detected in Wisconsin but it probably overwinters as a pupa in the soil. Moths appear in the spring and oviposit on alfalfa and clover. Moths of the next generation continue to deposit eggs on alfalfa and clover but some place eggs on soybeans beginning in June or July. More eggs occur on soybeans as the plants start to form pods. Eggs take about five days to hatch and larvae feed on foliage for three weeks. Three to four generations occur each year.

Damage

Green cloverworms cause defoliation of plants. When populations are heavy, they may attack the soybean pods.

Defoliation that occurs during the pod-set and -filling stages reduces yield to a greater extent than defoliation which occurs during vegetative growth stage.

Scouting suggestions

Detailed scouting is not necessary until leaf feeding is detected. When this occurs vigorously shake several consecutive plants within a row and then examine the soil surface for the presence of the larvae. Do this in several areas of the field and record the number of larvae per foot of row. Also note the growth stage classification for the soybean plants in the field.

Economic threshold

Control is suggested if defoliation occurs during blooming, pod set, or pod fill. This usually requires 12 or more half-grown worms per foot of tow and 15-20% defoliation to justify treatment.

Two Spotted Spider Mite

Description

As the name implies, this pest is a mite and not an insect. Adults are minute (< .02 inch), yellow-green, have eight legs, and feeding stages have dark pigmented spots on either side of their oval bodies. The adult female is globular and slightly larger than the male. The male's body is pointed at the hind end and has longer legs than the female. Eggs and immatures are also yellow-green; there are six - and eight-legged immature stages. When adult mites prepare to diapause (stage of arrested physiological development), individuals are produced that are orange to red in color and slightly larger than non-diapausing mites.

The mites resemble tiny spiders and will spin webbing (hence the name spider mite) and the small round eggs will be found on the leaf surface or within the webbing. Under heavy infestations, plants may be completely covered with webbing. If mites need to move to another area because of a diminishing food supply or other undesirable situations, they will climb to the top of the plant and spin tiny strands of silk that, when caught by breezes, will allow the mite to drift to new host plants. This process is called "ballooning".

Life cycle

The two spotted mite overwinters as fertilized females. This occurs in the loose soil and plant debris at or near the soil surface. After temperatures start to warm in the spring, the overwintering females seek out growing plants and begin to lay eggs. These eggs, and those of subsequent generations are clear to pale in color, oval and less than 0.01 inch in diameter. Eggs hatch into the six-legged immature stage called a larva which, other than the number of legs, looks very similar to the subsequent immature and adult stages. After some feeding and growth, the larva molts its skin and transforms into the slightly larger eight-legged protonymph. An additional molt occurs to the deutonymph stage, also eight-legged. Finally, the immatures molt one last time to the adult reproductive male and female stages.

Damage

Significant damage only occurs during years in which soybean plants undergo severe moisture stress for several days. Damage usually starts at field edges where mites have moved into soybean fields from adjacent grasses and weeds. Dry weather, low humidity, and stressed plants provide optimal conditions for mite reproduction and development.

Spider mites feed by penetrating the plant tissue with sharp stylets (specialized structures associated with piercing mouthparts) and removing cell contents. The chloroplasts disappear and the small remaining cellular material coagulates to form an amber mass. Farmers often blame spider mite injury on drought. The water balance of mite-damaged leaves is disturbed, water loss through transpiration is increased, and this will eventually lead to drying out, bronzing, and dropping of leaves. This leaf damage reduces the plant's ability to manufacture plant food through the process of photosynthesis, which in turn reduces the plant's grain filling capability.

The damage first appears as white flecks from feeding by the colonies, which are located on the undersides of leaves. This condition is called "stippling". Eventually this condition will become worse and leaves will appear bronze, and in some varieties necrotic lesions will occur. Under heavy infestations the plants will even shed leaves.

Economic thresholds

Treatment is suggested if several leaves have active colonies and damage prior to the R6.5-7.0 stages. Re-examine the field four-five days after spraying to see if re-treatment will be necessary.

Bean Leaf Beetle

Description

The bean leaf beetle is an insect that feeds primarily on soybeans. Damage is likely to occur in growing seasons that follow mild winters. The adult is ¼ inch long, has various colorations and arrangements of black spots on its wing covers. Pale-yellow is the most common color. Other variations include tan, green and crimson. All adults will have a black triangle behind the thorax (neck region). Some will have no other markings; others will have a series of black dots (usually 2-4) and a black line around the outer edge of the wing covers. Larvae, which are found on roots of soybean, are white and distinctively segmented, with brown heads and a brown hardened area at the posterior end of the body.

Life cycle

Bean leaf beetles overwinter as adults under plant debris in woodlots and fencerows near soybean fields. Adults become active in the spring when temperatures reach 50-55 °F. In Wisconsin, this activity usually begins mid-April, well in advance of soybean planting. These overwintered adults feed on alternate hosts such as clover and alfalfa, and then move to emerging soybeans to feed and lay eggs. Larvae feed on soybean roots and nodules. The first generation of bean leaf beetles takes about 50 days to complete, and adults begin to emerge in late June or early July. These adults also feed on foliage and lay eggs in the soil at the bases of plants. Second generation adult emergence occurs during the latter part of August or early September.

Damage

The overwintering adults attack emerging seedlings and feed on cotyledons and leaves. First generation adults feed only on leaves. Defoliation from the overwintering and first generation adults can reach the economic threshold in Wisconsin. Second generation adults will also feed on leaves but attack pods as the leaves begin to yellow and dry. This pod feeding can cause wrinkled seeds and it creates pathways for invasion of the beans by fungal spores that cause the seed to mold or discolor. Young larvae feed on the root hairs; as larvae mature they will begin to attack the nitrogen fixing nodules. It is not known if feeding damage by the larvae significantly affects yield. Bean leaf beetles also damage soybean plants by transmitting bean pod mottle virus (BPMV). Although bean leaf beetles transmit BPMV all season long, transmission during early vegetative stages of soybean development is regarded as most important to yield loss potential. Thus, critical virus transmission is occurring at a time the bean leaf beetle itself is not regarded as important unless at extremely high levels that kill seedlings. Research data suggests that BPMV is causing yield loss in the 5-10 bu/acre range. Growers who have experienced 10-50% mottled seed at harvest most likely have local sources of BPMV inoculum and their fields are at risk if moderate to high populations of bean leaf beetle are observed in May and June.

Scouting suggestions

Direct observations are the preferred method of monitoring bean leaf beetles during the seedling stage. Bean Leaf Beetle activity can vary according to time of day, as a result, mid morning to midday are preferred. Windy conditions as well as low or high temperature can also affect beetle activity. Slightest disturbances will also cause the beetle to drop to the soil and remain motionless for a considerable length of time. After the soybeans are too large for direct observations, use the drop cloth technique (for wide row soybeans only) or 15 inch diameter insect sweep net. Take a minimum of 20 consecutive sweeps in each of five areas of a field.

Economic thresholds

There are two approaches to manage the bean leaf beetle and/or BPMV. When BPMV is a significant problem it requires different management practices than if the concern is over defoliation only.

Management for Defoliation only

If defoliation is the only concern, economic thresholds can be used to control bean leaf beetles. During the seedling stage, use Table 1 to determine the economic threshold. First generation bean leaf beetles are usually not of economic concern because soybean plants are fast growing and can tolerate up to 40-50% defoliation. Second generation control decision can be made using Table 2. When treatment is justified, consult UW-Extension Bulletin A3646, Pest Management in Wisconsin Filed Crops, for appropriate insecticides and rates. If an insecticide application is necessary for second-generation adult control, care must be used to select an insecticide that has an appropriate pre-harvest interval.

Management to prevent transmission of Bean Pod Mottle Virus

Soybean varieties that are resistant to BPMV have not yet been identified, although anecdotal evidence suggests that varieties differ in their susceptibility. Additionally, growers should avoid early planting if BPMV is expected to be a problem in their area. Early planting often attracts high beetle populations and increases the chance transmitting BPMV.

If virus symptoms (leaf mottling, discolored seed, green stem and/or unexplained yield loss) were high the previous year, then beetles must be managed using a completely different approach. That is, economic thresholds mentioned above are not effective because beetles must be killed prior to significant defoliation. To prevent transmission of BPMV, an insecticide application must be made in the very early stages (VC-V1) of soybean development. A second application may be necessary during the emergence of first generation beetles in late June or early July. Delayed spraying at either crop stage can seriously increase incidence of BPMV.

Table 1. Early-season treatment thresholds for bean leaf beetle defoliation on seedling soybean.
Source: Marlin Rice, Iowa State University

Growth Stage/		Treatment cost/acres (Insecticide + application costs)					
Crop value $/bu.		$6.00	$7.00	$8.00	$9.00	$10.00	$11.00
		#/beetles/plant					
VC/	$5.00	2.4	2.8	3.2	3.6	4.0	4.4
	$6.00	2.0	2.3	2.7	3.0	3.4	3.7
V1/	$5.00	3.7	4.4	5.0	5.6	6.2	6.8
	$6.00	3.1	3.6	4.1	4.7	5.2	5.7
V2/	$5.00	5.9	6.8	7.8	8.8	9.8	10.7
	$6.00	4.9	5.7	6.5	7.3	8.1	8.9

Table 2. Second-generation bean leaf beetle economic thresholds in reproductive stage soybean*
Source: Marlin Rice, Iowa State University

Crop value $/bu.	Treatment cost/acre (insecticide + applications costs)								
	$7	$8	$9	$10	$11	$12	$13	$14	$15
	Beetles/foot of row								
$5.00	5.5	6.3	7.1	7.9	8.7	9.5	10.3	11.0	11.8
$6.00	4.6	5.2	5.9	6.5	7.2	7.8	8.5	9.2	9.9
$7.00	3.9	4.4	5.0	5.6	6.1	6.7	7.3	7.8	8.4
$8.00	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5
	Beetles/sweep								
$5.00	3.5	4.0	4.5	5.0	6.5	7.2	7.7	8.3	8.7
$6.00	2.9	3.3	3.7	4.1	5.4	6.0	6.4	6.9	7.3
$7.00	2.4	2.8	3.1	3.5	3.8	4.2	4.5	4.9	5.2
$8.00	2.2	2.5	2.8	3.2	4.1	4.5	4.8	5.2	5.5

* Economic thresholds are based on a row spacing of 30 inches and a plant population of eight plants per foot of row. For narrow-row soybean (8-inch rows) and a plant population of three plants per foot of row multiply the above economic threshold by 0.70

Wooly Bear Caterpillar

Description

Although an occasional pest in neighboring states the woolybear complex has not reached economically important populations in Wisconsin.

These larvae are in a rather large insect family that is also referred to as tiger moths because of the colors and color patterns of the adult stage. Larvae are robust and hairy, hence the name wooly bears, and may be white, reddish brown, black, yellow, or black at the head and anal ends and separated by a reddish brown band in the middle of the body. When fully grown they are approximately two inches long.

Life cycle

Depending upon the species, overwintering is either accomplished in the larval or pupal stages. In the spring adults lay eggs in spherical patches on leaves and often cover the egg masses with hairs from their bodies. Young larvae usually feed in clusters on the bottom surface of leaves; as they grow larger they will lose this gregarious habit and feed in more exposed locations. There are two generations per year.

Damage

These caterpillars are leaf feeders that, when present in large enough numbers, are a potential threat to soybean production.

Scouting suggestions

Sample plants in several areas of the field and note the size of larvae, percent defoliation, and stage of soybean development.

Economic threshold

When defoliation reaches 30% before bloom or 20% between bloom and pod fill.

Grasshoppers

Description

Numerous species of yellow to yellow-brown nymphs and adults commonly occur on broader rows of soybeans.

Life cycle

Pest species overwinter in an egg pod located in the soil, near the surface. The species common to soybeans deposit eggs in fencerows or other undisturbed areas near soybean fields. The nymphs will begin to feed in these areas but if the vegetation is consumed or becomes dry, the grasshoppers will move to soybeans. The adult stage is reached in August and the eggs will be laid during September.

Damage

Adults and nymphs will defoliate soybeans. Although damage is normally confined to the border rows, it will become widely scattered over the field as the season progresses.

Scouting suggestions

Damage normally will peak in August. Sample plants in several areas of the field and note the degree of defoliation.

Economic thresholds

Control is suggested of defoliation reaches 30% prior to the bloom stage, or if it reaches 20% between blooming and pod-filling stages.

Soybean Aphid

Description

Soybean aphids are small (approximately $^{1}/16$ inch long) soft-bodied insects, and may be winged or wingless. They are light yellow in color early in the growing season and are concentrated on leaves, petioles and stems at the top of the plant. Winged adults will have a black head and thorax. During August, some of the nymphs produced may be smaller and lighter in color.

Life Cycle

Buckthorn (*Rhamnus* spp.) is the only known overwintering host. As is true of other aphids in the temperate zones, the soybean aphid can only survive the winter in the egg stage. The egg is very winter hardy and can survive prolonged periods of low temperatures. Soybean aphids will hatch in the spring and go through two to three generations of wingless females before a winged generation leaves buckthorn in search of soybean. Numerous generations of winged and wingless females will develop on soybeans before a winged females migrate back to buckthorn in late-summer/early fall to mate and lay eggs.

Damage

Soybean aphids cause damage by sucking plant sap and transmitting viruses during the feeding process. Symptoms of direct feeding damage may include plant stunting, reduced pod and seed counts, puckering and yellowing of leaves. Various plant stresses, including nutrient deficiencies, may intensify these symptoms. Soybean aphids excrete a sugary substance called honeydew while they are feeding. When aphid populations are heavy, the plants will be coated with honeydew and will turn black as a result of sooty mold growing on the honeydew. This can reduce photosynthesis and contribute to yield loss.

Additionally, soybean aphids are capable of transmitting several important viruses that infest soybean, including alfalfa mosaic virus (AMV) and soybean mosaic virus (SMV). These viruses commonly occur together and form a complex. Although plants may be infected early in the season, foliar symptoms caused by viruses usually are most apparent by late vegetative or early reproductive stages. Symptoms are frequently associated with specific fields and not all fields in a region. Symptomatic plants are associated with reduced plant populations, slow developing crop canopies or late planted fields. The incidence of symptomatic plants commonly progresses inward from edges of fields. Symptoms may also be distributed in fields either as single plants or clusters of plants. The pattern of symptomatic plants in the field is dependent on specific viruses present and aphid activity. General symptoms caused by soybean viruses include plant stunting, leaf distortion and mottling, reduce pod numbers and seed discoloration. Infected seed is the most important means for introducing soybean mosaic virus into a field. Seed-borne inoculum, however, is a less significant course of inoculum for alfalfa mosaic virus. Seed transmission is extremely important for soybean mosaic virus because the virus is seldom found in plants other than soybean, thus there is low probability that aphid vectors will acquire this virus outside a soybean field.

Forage legumes are important sources of inoculum for alfalfa mosaic virus. Therefore, soybean aphids will acquire this virus from other legumes and migrate into soybean fields, feeding activity results in virus transmission. Evidence is mounting that soybean viruses are becoming more important in the North Central States. It is not possible to prevent spread of these viruses by using insecticides to control aphids. Research is needed to determine specific symptoms caused by each virus, the extent of yield and seed quality loss caused by each virus and management practices to reduce risks associated with the insect-virus complex.

Scouting Suggestions

Start spot-checking soybeans for soybean aphids in mid-June and continue to estimate aphid numbers at weekly intervals until aphid populations decline. Soybean aphids are usually found on the underside of newly developing leaves. Initially, soybean aphid distribution within a field will be spotty and they will be difficult to find. As the growing season continues, aphid populations will be more randomly distributed throughout the field. The late vegetative to early reproductive stages have typically been the periods for the most rapid population increase, and the time when scouting is most critical. A minimum of two field visits are required to determine if aphid populations are increasing. To calculate a field average, count the number of aphids on 20-30 plants/field.

Soybean aphids have numerous natural enemies. When estimating aphid populations, it would be valuable to estimate beneficial insect populations at the same time. Comparing population trends of natural enemies with that of the soybean aphid can help in determining control needs. For example, if aphid populations are not increasing from one scouting visit to the next and lady beetle populations are rapidly increasing you may decide to delay, if not eliminate, the need for an insecticide application.

Crop Stage:	Economic Threshold:
Emergence to mid-vegetative	Economic benefit from insecticide application is unlikely.
Late-vegetative to R4 (3/4 inch pod)	Treat when the field average is 250 aphids/plant and the populations are actively increasing
Beginning seed (R5)	Thresholds at this crop stage have not been established. However, actively increasing populations greater than 250 aphids/plant may require treatment.
Full Seed (R6) to Maturity (R8)	Economic benefit from insecticide application is very unlikely.

Natural control

Lady beetles, insect pathogens, lacewings, syrphid flies, etc., appears to be helpful in control of soybean aphids. Trends in aphid populations should be considered when determining the need for control.

Soybean Defoliation Guide

5%

10%

20%

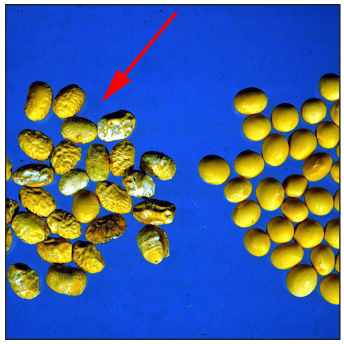
30%

40%

50%

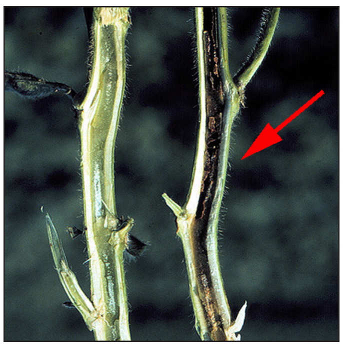
Quick Reference


Pythium Seed Rot

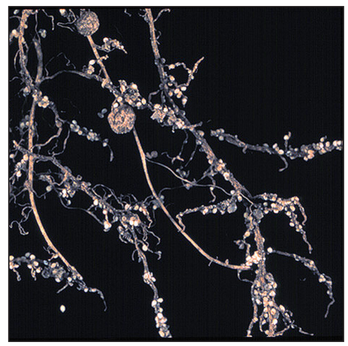

Phomopsis Seed Rot


Phytophthora Stem and Root Rot


Sclerotinia Stem Rot


Brown Stem Rot


Brown Stem Rot *leaves*


Soybean Cyst Nematode


Mottling/Mosaic Leaf Symptoms


Bleeding Hilum


Green Stem


Discolored Pods

Soybean Disease Management

UW Extension

Dr. Craig Grau
Department of Plant Pathology
University of Wisconsin-Madison

Soybeans grown in Wisconsin are subject to attack by several disease-causing organisms. Growers, scouts and crop advisors should learn to identify the major soybean diseases in order to distinguish them from poor plant health due to insects, adverse weather, herbicide injury, and nutrient deficiencies. Solutions to disease problems are generally quite different compared to correcting plant disorders due to insects, weeds, and other agents. Soybean diseases can be prevented or reduced by proper use of resistant or tolerant varieties, correct cultural practices, and fungicides or nematicides.

Resistant or Tolerant Varieties

The use of disease resistant or tolerant varieties is a practical and economical control for soybean diseases in Wisconsin. However, there is not one variety resistant to all diseases. Carefully evaluate the major diseases on your farm and consider disease reactions when selecting soybean varieties you wish to plant. Disease reaction of soybean varieties can differ from year to year because the microorganisms that cause plant disease can change genetically and attack varieties that were formerly resistant. Soybean varieties may also have different reactions when grown under different cultural practices and weather conditions.

Crop Management

The use of crop rotation and clean tillage are very powerful disease control tools. The roles of crop rotation and clean plowdown are more important with soybeans than with corn because disease resistance to many important diseases is not available in soybeans. Many of the important fungal and bacterial diseases of soybeans survive between cropping seasons on and in crop debris. Once this crop residue is thoroughly decayed, these disease-causing organisms die out. Therefore, crop rotation and tillage programs that permit residue decomposition before the next crop is planted will help reduce diseases such as brown stem rot, pod and stem blight, anthracnose, stem canker, Septoria brown spot, Cercospora leaf spot (purple seed stain), bacterial blight, and several other fungal and bacterial leaf diseases.

Production of soybeans with practices which do not allow for soybean debris decomposition may result in severe disease losses. Diseases causing organisms that are normally considered minor can build up and cause severe losses under such conditions. Growers should weigh the benefits of deep-plowing to reduce diseases versus minimum tillage to reduce soil erosion. Factors such as disease severity in past years and the slope of the land should be considered. Crop rotation and an increased number of years between soybean crops should be considered on sloping land where minimum tillage should be used.

Very few of the fungi and bacteria that attack soybeans infect other crop plants. Rotations with corn, small grains, or forages deprive soybean pathogens of a host on which to infect, reproduce, and carryover between soybean crops.

Adequate, balanced soil fertility can be important in reducing disease losses. Less than adequate phosphorous or potash can contribute to losses from Septoria brown spot, several root rots, and pod and stem blight. Healthy, vigorous plants are more tolerant of diseases and better able to produce a near normal yield despite diseases.

Soybean yields for many varieties are greater at narrow row widths (10 inches) compared to wide row widths (30 inches or greater). However, higher yields with narrow rows may not be achieved because leaf and stem diseases can be more severe under a narrow row system. Growers using narrow rows should be more watchful for severe disease development.

Fungicides

Fungicides may be used for control of soybean diseases in two ways.

1. Fungicidal seed treatment for soybeans may be beneficial under the following conditions.

A. If it is desirable to use a minimum planting rate because of high seed cost and/or short seed supplies.

B. If there is an excessive number of cracked seed coats, as may occur under dry harvesting conditions.

C. If germination is below 80% or there are other indications of low seed vigor. Old seed or seed which has been invaded by disease-producing organisms such as Phomopsis (the pod and stem blight fungus) is more likely to respond to seed treatment.

D. If the field is known to be heavily infested with soybean root-invading organisms such as Pythium, Rhizoctonia or Phytophthora.

E. Early planting in cold, wet soils.

2. Foliar fungicides can be used to lower losses due to leaf diseases and pod and stem blight.

Pod and stem blight may reduce yield, but its major effect is through seed infection that results in reduced seed germination rates and reduced seedling vigor. Evaluations in Wisconsin reveal that foliar-applied fungicides reduce seed infection and improve germination. Foliar-applied fungicides for the control of leaf diseases and pod and stem blight have improved yields in Wisconsin tests, but this result has been inconsistent.

Soybean seed producers should consider the use of foliar fungicides to improve seed quality. The following factors should be considered before foliar fungicides are used.

A. Potential risk. The diseases controlled by fungicide sprays are important when warm wet weather prevails during the pod fill stage. If, at bloom, the 30-day outlook is for warm wet weather, these diseases will be prevalent and fungicide sprays will be beneficial. Since two sprays are suggested on the product label, one at early pod development (upper pods 1/2 to 3/4 inches long), and a second spray 14-21 days later, an assessment should be made before the second application. If the weather has been dry since the first application and the forecast is for continued dry weather, the second application should not be made; if wet, the second application should be made. One application when upper pods are 3/4-1 inch long has been effective in Wisconsin trials.

B. Was the field planted to soybeans the previous year? If soybeans have been grown for 2 or more consecutive years, disease severity potential will be higher than if rotation has been used.

C. No-till or minimum tillage will increase the potential of disease.

D. Early-maturing varieties usually suffer greater losses from disease controlled by foliar fungicides than full-season varieties.

E. Benefits of improved seed quality from disease control may be an important consideration for applying fungicides to seed production fields.

F. High yields (40 bu/A or more) should be anticipated if fungicide application is to be economical.

G. A dense canopy of weeds will impede the movement of the fungicide to the soybean pods and foliage.

Soybean Seedling, Root and Stem Health

Soybean health is compromised by several plant pathogenic fungi that infect plants at different growth stages. Although infections may occur early, many of these pathogens do not cause apparent symptoms until later growth stages. Frequently seedling health is ignored because plant populations are acceptable and stem and leaves do not express symptoms during early vegetative growth. Phytophthora sojae, Pythium spp. and Rhizoctonia solani are believed most important, but other plant pathogens are actively invading plants from growth stages VE to V4. Plant health assessment is important during this phase. This information may be used to make adjustments in crop management in subsequent years, and this information may explain symptoms later in the season and less than anticipated yield at harvest. Symptoms caused by pathogens are confounded by symptoms caused by herbicides and other abiotic causes of plant stress. Many pathogens infect plants at VE-V4, cause chronic symptoms or remain latent, but cause symptoms of plant decline during the reproductive growth stages (see summary table on following page).

Pythium Seed Rot

Several species of Pythium are pathogens of soybean. *Pythium spp.* are soil inhabiting fungi that cause seed rot, and pre-emergence and post-emergence seedling death. Pythium is most active when soil moisture is high. Most Pythium species are most active in cool soils, but exceptions are reported. Diseased seedling tissues are initially water-soaked and gradually become brown with time. Diseased seedlings disintegrate and gaps in the rows are the only evidence of a problem.

Controls

Avoid planting in soil conditions that favor disease. 2) treat seed with fungicides and 3) plant seed with good germination and seeding vigor.

Rhizoctonia Seed Rot and Seedling Blight

Rhizoctonia solani primarily infects seed and seedlings but can continue to cause root rot of older plants (for image see Pythium Seed Rot). Rhizoctonia seedling disease occurs during prolonged periods of warm and wet soil and when conditions are unfavorable for vigorous plant growth. Typically, a reddish-brown decay of the outer tissues appear on the stem base, crown and roots. This may develop into sunken reddish brown cankers which sometimes girdle the stem at the soil line. In relatively dry, windy weather, plants may die if the stems and roots are extensively diseased.

Control

Plant sound, high-quality seed, 2) avoid planting when soil conditions favor infection and 3) treat seed with a fungicide.

Phytopthora Seed Rot and Seedling Blight

Phytopthora megasperma is more noted as a root and stem pathogen of soybean. However, this fungus can cause seed rot and pre-emergence seedling death (for image see Pythium Seed Rot). Symptoms are similar to those caused by Pythium. However, Phytophthora is more aggressive when soils are warm and wet compared to most Pythium species which prefer wet, but cool soil conditions.

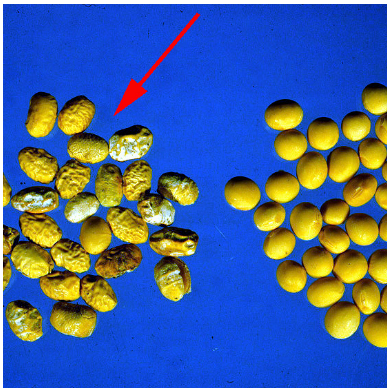
Control

1) Resistant varieties, 2) early planting, and 3) fungicide seed treatment are potential control measures.

SUMMARY SOYBEAN SEEDLING, ROOT AND STEM HEALTH

Disease	Cause	Growth Stage	Symptoms	Control	Comments
Seed rot	*Pythium, Phytophthora, Phomopsis*	V0-VE	Soft decay of seed; missing seedlings in row.	Fungicide treated seed, *Phytophthora* resistant variety.	Favored by cool and wet soils. *Phomopsis* comes with seed.
Seedling Mortality	*Phytophthora, Rhizoctonia*	VE-V4	Chlorotic and wilting leaves followed by necrosis; leaves remain attached to stem.	Fungicide treated seed, *Phytophthora* resistant variety.	*Phytophthora* is most common cause of early seedling mortality in Wisconsin.
Root and lower stem decay	*Rhizoctonia, Fusarium, Phytophthora, Mycolepto-discus*	VE-V6	Reddish-brown lesions on taproot and hypocotyl; usually superficial; *Phytophthora* causes brown lesions on stem above soil-line.	Fungicide treated seed, *Phytophthora* resistant variety; ridging soil around stems by cultivation simulates new roots.	Except for *Phytophthora*, above ground plant parts may not express symptoms.
Premature decline of foliage and stems	*Rhizoctonia, Mycolepto-discus, Fusarium* (sudden death syndrome), *Phialophora* (brown stem rot)	R1-R7	Wilt, chlorosis and eventually necrosis of leaves; inter-veinal tissues progress from yellow to brown, but major veins remain green (SDS & BSR); internal browning of stems (BSR).	Fungicide treated seed; variety selection	Brown stem rot (*Phialophora*) & sudden death syndrome (*Fusarium*) cause unique symptom patterns on leaves; general decline may be due to *Rhizoctonia* or *Myco-lepto-discus*

Phomopsis Seed Rot



Phomopsis sojae is a seed-borne fungal pathogen of soybean. Infection occurs through pod walls and progresses into the seed. Many seed are destroyed in the pod and are never planted. However, many infected seed show no obvious symptoms and are used for seed. Phomopsis can reduce germination and seedling vigor and reduce stands with seedlings of poor vigor result.

Germination tests may identify Phomopsis infection as the cause of low seed germination. Such seed should not be planted. However, in some cases, growers are forced to plant seed with marginal germination.

Control

Treatment of seed with the systemic fungicide carboxin can improve germination of seed if Phomopsis is the cause of germination problems.

Phytophthora Stem and Root Rot

Phytophthora root rot (PRR), caused by the fungus *Phytophthora sojae* is a very destructive soybean disease in Wisconsin. Two major factors are contributing to an increase in the occurrence of this disease: 1) the soybean acreage is increasing and, consequently, soybeans are planted more frequently in specific fields, and 2) many races of Phytophthora exist in Wisconsin soils and there are no soybean varieties resistant to all races. Phytophthora can kill plants at all stages of growth and reduce stands, or infected plants may survive, but are less productive. The incidence and severity of disease depend on soybean variety, soil type, soil drainage, rainfall, and cultural practices. Phytophthora root rot appears most frequently in fields with poor internal drainage, but the disease can occur in normally well-drained fields that are saturated for 7-14 days due to excessive precipitation or irrigation.

Symptoms

Phytophthora sojae can infect soybean seeds causing seed rot, or it can kill seedlings before or after emergence. Symptoms of post-emergence infection are wilting and death of soybean seedlings as they emerge. Stems of older seedlings in the primary leaf stage may become watersoaked and eventually leaves will turn yellow, wilt and die. As plants age, they die more slowly after infection. Plants infected before flowering exhibit a yellowing of leaves, followed by wilt and death. The leaves remain attached after death. A key diagnostic symptom is a brown discoloration that progresses 6-12 inches up the stem from the soil line. Diseased root systems are reduced and the taproot and lower stem are discolored internally.

The root rot phase of PRR is not as readily recognized as the killing stem rot phase. Although less drastic in appearance, the root rot phase can greatly reduce plant productivity. Infected plants in the root rot phase will be a lighter green, and may be stunted and exhibit uneven growth. These symptoms are the result of a diseased root system that is less efficient in supplying the plant with water and nutrients. The nodules formed by beneficial nitrogen-fixing bacterial (Rhizobium) are often destroyed and the plants become yellow, partially due to nitrogen deficiency. The soybean variety, the race(s) of *Phytophthora sojae* present, and environmental conditions will determine whether the killing phase or root rot phase will be most prevalent.

Phytophthora root rot is sometimes misdiagnosed as injury caused by herbicides, especially when the crop is in the seedling stage. Both PRR and herbicide injury can produce stunted plants with yellow or dead leaves. However, the brown discoloration of the stem originating at the soil line is a key symptom of PRR. Herbicide injury very rarely produces this type of stem symptom. Many herbicides will cause affected leaves to be detached from the plant. Also, PRR occurs throughout the growing season, whereas injury from herbicide occurs early in the season.

Races of the Phytophthora

In 1963, fully-resistant varieties became available to control race 1 of *Phytophthora sojae,* the only race (strain) identified in the Midwest at that time. In 1972 in Ohio, a new race of the pathogen was found that infected varieties previously considered resistant. Since 1972, additional races have been identified in many Midwestern states. Twenty races of Phytophthora now have been identified in Wisconsin. There are no soybean varieties in the state that are highly resistant to all races, but many exhibit a moderate degree of resistance which is often described as tolerance. Fortunately, all the races seldom occur in the same field. If only race 1 susceptible varieties are planted in a field, generally race 1 will be predominant. However, if race 1 resistant soybean varieties are grown, other PRR races may become prevalent. Race 3 has been the most prevalent of the new races, but race 4 and similar races are appearing with increasing frequency.

Control Strategies

Phytophthora Race Identification

Growers should know which races of *Phytophthora sojae* are present in their soybean fields because the races present will influence the performance of soybean varieties. To determine the races of *Phytophthora* in a field, collect recently killed plants from several areas of the field and submit them to your University of Wisconsin-Extension office. Even if the incidence of disease is minimal, growers should have the race identified to determine the potential problem. Soil sampling is another way to determine the Phytophthora race. Soil samples should be collected from several sites in the field where Phytophthora root rot is observed. Combine the samples into a one quart volume per 20 acres of land. Contact your University of Wisconsin-Extension office if you plan to submit plant or soil samples to the Department of Plant Pathology, University of Wisconsin-Madison (see Summary Table on following page for integrated control strategies).
Cause: The fungus *Phialophora gregata.*

Symptoms

Symptoms are not expressed until after pod development has begun. Internal stem symptoms are first evident at the lower regions of the stem and appear as browning of the vascular system and pith tissues. In time internal stem browning can progress to the top of the stem. Foliar symptoms appear in August to early September depending on the relative maturity of the variety. In fact brown stem rot is often confused with early maturity. Foliar symptoms start as a gradual yellowing followed by wilting, curling and death of leaves. Tissues between leaf veins progress in this manner, but the veins remain green for an extended period of time.

Epidemiology

<Body text 1>The brown stem rot fungus survives in soybean debris and will do so until the debris decays. Thus, crop rotation can be used to prevent damaging levels of the fungus from building up in the soil. Infection occurs through roots and the pathogen travels in the vascular system of the plant. Optimal soil moisture and moderate air temperatures favor the development of brown stem rot. The disease is most damaging under high yield potentials. Yield can be reduced up to 35% by this disease. It is difficult to achieve yields of 45 bu/a or more when this disease is present.

Control

Crop rotation can be used to control brown stem rot, but at least 2 years of a non-host crop are needed between soybean crops. Corn and small grains are excellent non-hosts crop. However, red clover is the only crop commonly grown in Wisconsin that is unsafe to use in rotation with soybeans with regard to brown stem rot.
BSR 201 and BSR 101 are recently released varieties that have resistance to brown stem rot. Both varieties will produce 10-25 bu/a more than susceptible ones when grown on infested land. More resistant varieties should be available in the future and promise better control of this disease in the future. This especially true when shorter rotations are desired.

Brown Stem Rot

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Summary on tactics available for integrated control of Phytophthora root and stem rot (PRSR) of soybean

Tactic	Comments
Host Resistance	1) **Race-specific, 16 genes identified.** Each confers resistance to specific races. 2) **Many races of the pathogen exist.** 3) **Nonrace-specific; also termed field tolerance, tolerance, or rate-reducing resistance.** This form of resistance is more sensitive to environmental factors, less effective in seedling stage. 4) **Relative maturity influences the performance of tolerant cultivars for a specific region.** A cultivar will express more tolerance in the northern extent of its adaptation.
Soil Structure	1) **Tillage influences bulk density:** Spring tillage reduces bulk density and decreases disease. Excessive tillage or tillage under wet soil conditions increases bulk density and disease. Reduced tillage or no-till increases PRSR. 2) **Avoid practices that compact soils.** 3) **Surface and subsurface drainage.**
Plant Nutrition	1) **Soil applied nitrogen enhances PRSR.** 2) **Chloride salts increase PRSR; sources are:** Muriate of potash. Manure. Sewage sludge.
Planting Date	1) **Plant early to avoid warmer soils.** 2) **Pythium problems can be more severe in early plantings**, thus, fungicide seed treatment can be beneficial.
Crop Rotation	1) **Minor effect on reducing PRSR.** 2) **Role of other hosts is not known.**
Chemical	1) **Formulations of metalaxyl (fungicide):** Apron, seed dressing. Ridomil, soil applied fungicide. 2) **Metalaxyl cannot replace host resistance, but should be used to supplement.**

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Sclerotinia Stem Rot

Cause: The fungus *Sclerotinia sclerotiorum.*

Symptoms

Symptoms do not appear until 2 weeks or more after flowering. Leaves become chlorotic, but in most cases wilt and take on a gray-green color. Stems provide the best diagnostic symptoms. Stem lesions begin at nodes and progress in both directions and become bleached in appearance. Fluffy white mycelium (mold) is abundant during moist conditions and black survival structures called sclerotia may form amongst the white mold.

Epidemiology

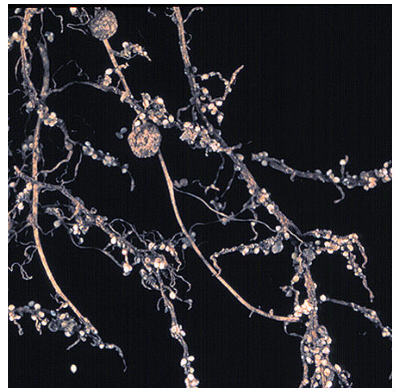
<Body text 1>Sclerotinia has a wide host range consisting of all broadleaf plants. The disease on soybeans is usually more severe when soybeans are planted immediately after another host crop. The pathogen survives many years in the soil. Wet and cool weather conditions favor the disease.

Control

Avoid the following cultural practices if the disease is a threat; 1) plant soybeans using 30 inch wide row spacings or more, 2) avoid planting varieties that excessively lodge, 3) stop irrigation at flowering, and 4) do not grow other susceptible hosts (e.g., snap beans or sunflowers) in rotation with soybeans. Some soybean varieties are less susceptible to Sclerotinia stem rot, the degree that they can be diseased is influenced by weather and the cultural practices listed above.

Soybean Cyst Nematode

Craig R. Grau, Ann E. MacGuidwin, Edward S. Oplinger



Soybean cyst nematode, *Heterodera glycines*, is a small, unsegmented plant-parasitic roundworm that attacks the roots of soybeans. This soilborne pathogen was detected in southeastern Wisconsin in 1980. As of the fall of 2002, soybean cyst nematode has detected in 26 counties in Wisconsin. Currently, severe soybean cyst nematode problems are associated more with sandy soils. However, yield loss due to soybean cyst nematode does occur on silt-clay loam soils. The soybean cyst nematode problem tends to be more chronic on heavier soils, but may cause a significant “yield drag” on the soybean crop.

Field Diagnosis

Field diagnosis of soybean cyst nematode is possible by visual effects (symptoms) of the soybean cyst nematode on plants and the visual detection of the soybean cyst nematode on roots (signs). Symptoms caused by the soybean cyst nematode can be observed shortly after seedlings emerge, but more typically symptoms are expressed in the mid to late vegetative stage. Signs of the soybean cyst nematode begin to appear on roots 6 weeks after emergence. Symptoms may be absent for several years following introduction of the nematode into a field, but are expressed as population density increases with soybean cultivation. The above-ground symptoms, when present, may appear in circular or oblong patterns which vary in size or may be more generalized across much or all of the field. Above-ground symptoms may initially appear near an entrance to a field where farm machinery enters or along a fence line where wind-blown soil tends to accumulate.

Above-ground Symptoms

When above-ground symptoms appear, they are not unique and can be mistaken for damage caused by soil compaction, nutrient deficiencies, drought stress, herbicide injury, or other plant pathogens. Often, soybean injury and yield loss due to soybean cyst nematode have probably gone undetected for several years because of absence of above-ground symptoms or misdiagnosis of these nondescript symptoms. Yield loss can occur in the absence of obvious symptoms before the soybean cyst nematode is detected. This chronic phase may result in significant yield loss for several years because growers or crop advisors are not aware of the soybean cyst nematode. Chronic soybean cyst nematode problems may be recognized by less than anticipated yields with no feasible explanation as to why yields are low.

The first obvious symptom of soybean cyst nematode injury to soybeans is the appearance of stunted, yellowed, less vigorous plants. Plants growing in heavily infested soils may remain stunted throughout the growing season. Additionally, rows of soybeans grown in infested fields are often slow to close with foliage. Slow canopy closure frequently results in weeds breaking through the crop canopy later in the growing season. Yellowing due to soybean cyst nematode damage will occur early in highly infested fields, but can occur later in the season, usually in July and August, in moderately infested fields. Symptoms can range from severe to nonexistent. The intensity of the symptoms is influenced by the age and vigor of the soybean plants, the nematode population density in the soil, soil fertility and soil moisture levels, and other environmental conditions. Soybean cyst nematode damage is usually more severe in light, sandy soils, but will occur in all types of soil.

Below-ground Symptoms and Signs

Most below-ground symptoms of soybean cyst nematode injury are not unique. Roots infected with the nematode are dwarfed or stunted. Soybean cyst nematode also decreases the number of nitrogen-fixing nodules on the roots, which leads to light green to yellow foliage. Furthermore, infection of roots by soybean cyst nematode may make the roots more susceptible to infection by other soil-borne plant pathogens. It is often difficult to recognize roots as being stunted and having fewer nodules unless some infected soybean roots are also available for side-by-side comparison.

The only unique sign of soybean cyst nematode infection is the presence of adult female nematodes and cysts on the soybean roots. Female and cysts appear as tiny, lemon-shaped objects which are initially white but turn yellow, then tan to brown as they mature. Females and cysts can be seen on infected roots with the unaided eye, although observation with a magnifying glass is usually much easier. The females and cysts are about the size of a period at the end of a sentence and are much smaller than nitrogen-fixing nodules. Roots should be carefully dug, not pulled, from the soil to observe the nematodes on the roots, otherwise many of the females and cysts may become dislodged. Observation of the nematodes on the roots of infected soybean plants is the ONLY accurate way to diagnose soybean cyst nematode infestations in the field. In most years, such diagnoses can be performed beginning four to six weeks after planting and continuing through September in Wisconsin.

Analysis of Soil

Above-ground symptoms for identification of soybean cyst nematode infestations cannot usually be relied upon. If soybean yields in a particular field have decreased for no apparent reason or if soybean cyst nematode has been confirmed on nearby land, more thorough examination of plants for below-ground symptoms and a soil analysis are needed. Plant symptoms are important, but a laboratory analysis of soil compliments or verifies the accuracy of field diagnoses. A laboratory analysis defines the population density of soybean cyst nematode and can be taken on as an extra step to determine the race or races of soybean cyst nematode in a specific field. The soil from soybean fields should be sampled to determine:

1. The presence of soybean cyst nematode
2. The population density of soybean cyst nematode
3. The race of soybean cyst nematode in specific fields

Soil should be collected in a systematic pattern within a 15 to 20 acre area. Fields can be sampled anytime of the year, but spring samples may be more predictive of the level of risk due to soybean cyst nematode. A small trowel may be used to collect soil, but a 1-inch soil probe is preferred to collect soil at 15 to 20 sites within a 15 to 20 acre block of land. The soil should be collected at a depth of 6 to 8 inches within the rows if possible, and placed in a container. The soil should then be mixed thoroughly and placed in bags that retain moisture to prevent the drying of the soil. The soil samples do not need to be refrigerated, but should be kept cool by not placing the samples in direct sunlight or near other sources of heat. The samples should be submitted quickly to a laboratory that analyzes soil for soybean cyst nematode. Send samples to the:

Plant Disease Diagnostics Clinic
1630 Linden Drive
University of Wisconsin - Madison
Madison, WI 53706-1598

The following information is important when submitting samples:

1. Cropping history of the area sampled
2. Soybean variety most recently planted
3. Acreage that the sample represents
4. Soil pH, organic matter, and nutrient levels

Life Cycle

The soybean cyst nematode life cycle has three major stages: egg, juvenile, and adult. The life cycle can be completed in 24 to 30 days under optimum conditions in the summer, and three to four generations per growing season are possible in the Midwest. Worm-shaped soybean cyst nematode juveniles hatch from eggs in the soil when adequate temperature and moisture levels occur in the spring. These juveniles are the only life stage of the nematode capable of penetrating and infecting soybean roots. Juveniles move through the root until they establish a specialized feeding site in the vascular tissue. As the nematodes feed, they change from worm-like to a lemon shape. Eventually female nematodes break through the root tissue and are exposed on the surface of the root.

After fertilization, the males die and the females remain attached to the roots and continue to feed. The swollen females begin to produce eggs, initially in a mass or egg sac outside the body and later within the body cavity of the female. The entire body cavity of the adult female eventually becomes filled with eggs, and the female dies. It is the egg-filled body of the dead female that is referred to as the cyst. Cysts will eventually dislodge from the roots and become free in the soil. The walls of the cyst become very tough and provide excellent protection for the 200 to 400 eggs contained within. Soybean cyst nematode eggs survive within the cyst until conditions become proper for hatching. Although many of the eggs may hatch within the first year, many will also survive within the cysts for many years.

Management

For all practical purposes, soybean cyst nematode can never be eliminated from soil once it is present. However, strategies are available that curb reproduction and pathogenic effects of the soybean cyst nematode.

1. Sanitation

Knowledge of how the soybean cyst nematode is spread is important to growers concerned about this destructive pest. The soybean cyst nematode can move through the soil only a few inches per year on its own power. However, it can be spread great distances by anything that moves even small amounts of soil. Spread can occur by soil moved by farm machinery, vehicles and tools, wind, water, seed-sized clumps of soil, animals, and farm workers. There is even evidence that cysts of soybean cyst nematode can be spread by birds, especially migratory water fowl. Known infested fields should be tilled last if possible. Finally, equipment should be thoroughly cleaned with high pressure water, or steam, if available, after working in infested fields. In reality, despite these precautions, it is most likely that all fields are infested with soybean cyst nematode once obvious symptoms are observed on a farm.

2. Maintenance of Plant Health

Plants that have adequate moisture and soil fertility are better able to withstand infection by soybean cyst nematode. However, maintaining proper soil fertility and pH levels in land infested with soybean cyst nematode should not be considered a primary control strategy, but rather a means to supplement crop rotation and resistant varieties. Plant stress caused by other pathogens renders plants more susceptible to the yield suppressing effect of the nematode.

3. Crop Rotation

Planting nonhost crops can be very effective in preventing or delaying the spread of soybean cyst nematode to noninfested land. Soybean cyst nematode is an obligate parasite and is unable to develop and reproduce in the absence of host roots. Nematode densities decline during any year that nonhost crops are grown. Alfalfa, corn, and oats are common nonhost crops grown in Wisconsin, and soybean cyst nematode densities decline similarly when infested soils are planted with these three crops. Snap beans, dry edible beans, and lima beans will support reproduction of soybean cyst nematode and present a risk to soybeans, and are commonly planted in Wisconsin. Newly acquired land should be sampled for the soybean cyst nematode.

4. Host Resistance

Resistant soybean varieties are an effective strategy to enhance a soybean yield while managing the presence of soybean cyst nematode. A direct benefit is higher yields from resistant compared to nonresistant varieties, but an indirect benefit is that a resistant variety can suppress soybean cyst nematode reproduction. By planting resistant soybeans in infested soil, reproduction of the nematode is suppressed and population densities may decline in time. In the past, there were few resistant varieties available for Wisconsin, but in recent years many public and private varieties have been released. Virtually all soybean cyst nematode resistant soybean varieties available in Wisconsin were bred for resistance using one of two soybean breeding lines, 'Peking' or 'PI88788'.

Although, use of resistant varieties is the most effective management strategy for soybean cyst nematode, RESISTANT VARIETIES SHOULD NEVER BE PLANTED YEAR AFTER YEAR. If resistant varieties are planted several years in a row, eventually a population (or race) of soybean cyst nematode may develop which is capable of reproducing on the resistant varieties. Growers are encouraged to alternate use of soybean varieties with the two different sources of soybean cyst nematode resistance. Furthermore, it is recommended that a susceptible soybean variety be grown once after both types of resistance have been used to offset the effect of growing the resistant soybean varieties. The following is a recommended six-year rotation scheme using both types of soybean resistance in conjunction with susceptible soybean varieties and nonhost crops for integrated management of soybean cyst nematode. It should be noted that soybeans should never be grown in monocultures. Even an alternating corn-soybean rotation can be vulnerable to plant pathogens. Growers should consult county Extension personnel and seed company representatives for information on suitable resistant soybean varieties and their source of soybean cyst nematode resistance or to further discuss other aspects of effective crop rotation schemes.

1st year - Nonhost crop
2nd year - 'PI88788' Resistant soybean
3rd year - Nonhost crop
4th year - 'Peking' Resistant soybean
5th year - Nonhost crop
6th year - Tolerant (high-yielding), Susceptible soybean

5. Nematicides

There are several nematicides which are labeled for use against soybean cyst nematode, but often do not give season long control. The performance of the nematicide will depend on soil conditions, temperatures, and rainfall. A yield benefit is not guaranteed, and nematicides are expensive. Consequently, growers are advised to consider economic, environmental, and personal health factors before utilizing nematicides for management of soybean cyst nematode.

Soybean Virus Diseases

Within the past five to ten years, soybean growers and researchers in Wisconsin have become increasingly aware of the importance of viral pathogens in soybean production. Several viral pathogens including alfalfa mosaic virus (AMV), bean pod mottle virus (BPMV), soybean mosaic virus (SMV), tobacco streak virus (TSV) and tobacco ringspot spot virus (TRSV) have been recovered from soybeans in the state. Of these viruses, BPMV, SMV and AMV in particular appear to have the greatest potential for serious impact on soybean production, with BPMV reported to have caused 10 to 40% yield reductions in some areas.

Symptoms

Symptoms of infection by viral pathogens can vary greatly depending upon the virus or viruses involved, the specific soybean cultivar that is infected and environmental conditions. Interactions between several viruses, when they occur in the same plant, can influence symptom development as well.

Abnormal leaf color and development are typical symptoms associated with viruses. A classic leaf symptom associated with AMV, BPMV, SMV and TSV infections is mosaic or mottling, a randomly blotchy discoloration of leaf tissue. A crinkling of leaf tissue, and elongation and narrowing of leaves is oftentimes associated with mosaic symptoms. Vein clearing (a yellowing of veins) is another, often transitory symptom of viral infections. Green stem, the abnormal retention of green leaves and petioles at plant maturity, is a leaf symptom often associated with BPMV and SMV.

Viral infections can also lead to abnormalities in flowering, pod formation and seed production. Plants infected with TSV and TRSV may produce excessive numbers of flower buds from a given point on a soybean stem (a phenomenon called bud proliferation), and pods produced on infected plants can be malformed and distorted. Infections by TRSV, as well as BPMV and SMV, can cause pod discolorations. Seeds produced by plants infected with BPMV, SMV and TSV are also often discolored. Common seed symptoms include mottling of the seed coat (typically around the hilum) that looks like bleeding ink, or even discolorations of the internal seed tissue. Discolored, virus-infected seed often has a poor germination rate.

Because different viruses can often cause very similar symptoms, a laboratory analysis is typically required to determine which specific virus or viruses may be causing problems. Contact your county Extension agent for details on the soybean virus testing that is available in your area.

Finally, symptoms due to viral infections, particularly foliar symptoms, are very similar to symptoms caused by herbicide injury. In order to distinguish between symptoms caused by viruses, and those caused by herbicides, look at the pattern of symptom development. Virus-infected plants typically occur in irregularly-sized patches, and symptoms, once they develop will persist for the entire growing season. Symptoms due to herbicide injury are typically more uniform. They typically follow the row direction and may be more prevalent where overlap of spray could have occurred. Plants exposed to herbicides typically grow out of their abnormal growth and eventually produce foliage that looks normal.

Epidemiology

Soybean viruses can be introduced into soybean fields in a variety of ways. SMV is brought into fields in infected seed. Seed infection rates of 1-5% have been reported for this virus. TSV has also been reported to be transmitted at high frequency in seed. BPMV can be seed-transmitted, although the frequency with which this virus is carried in seed (< 1%) is less than that for SMV or TSV, and this means of transmission is considered relatively unimportant epidemiologically. For BPMV, the primary means of introduction of the virus into a soybean field is via bean leaf beetles. If winter temperatures are mild, substantial numbers of adults that are carriers of BPMV can overwinter and these adults can transmit the virus to soybeans during feeding. Later generation bean leaf beetles can acquire the virus from legume hosts (either infected soybeans or infected legume weeds) and thereafter move the virus as they continue to feed. The primary source of inoculum for AMV is infected forage legumes such as alfalfa. This virus is moved from forages to soybeans by aphids. Forage legumes can also serve as a reservoir for TSV (although forages are a less important source of this virus than contaminated seed) and this virus is subsequently moved into soybean fields by thrips.

Once introduced into a field, soybean viruses can spread rapidly. SMV and AMV are moved from plant to plant by aphids, which pick up these viruses as they feed on infected plants, then drop off the viruses as they feed on noninfected plants. Similarly, BPMV is moved from plant to plant as bean leaf beetles feed. As noted above, TSV can be moved from plant to plant by thrips.

Management

Because management strategies vary from virus to virus, the first step in managing soybean virus diseases is to determine the viruses your soybeans are likely to encounter. Plan a virus management strategy that is tailored to potential viruses in your area. Oftentimes information on virus problems from previous years provides the best insight on potential problems in the current growing season.

Be sure to select high quality seed. Inspect seed prior to purchase for discolorations that are typical of viral infections and do not purchase seed that appears infected. Use of high quality seed is particularly important in preventing introduction of SMV and TSV into fields.

Select varieties that are potentially resistant to viral pathogens. Current soybean varieties have not been bred specifically for virus resistance. However, if you have grown varieties in the past under conditions favorable for viral problems to develop and you have not observed viral symptoms, these varieties may have some resistance and should be considered for future use.

Modify seed planting dates and rates. Delay planting soybeans when BPMV is of concern to avoid overwintering adult bean leaf beetles that may be carrying this virus. If AMV or SMV are of concern, plant as early as possible. Early planting allows plants to grow substantially before they are likely to encounter aphids carrying these viruses. Infections that occur in later growth stages of a soybean plant tend to lead to less severe symptoms and yield losses than infections that occur early in growth. Also, soybean stands that are uniform, relatively dense and relatively non-stressed tend to be less attractive to insects (particularly aphids) that carry viruses.

Use of insecticide may help reduce the incidence and severity of BPMV. Threshold values for the bean leaf beetle have not been determined in the context of BPMV transmission. However, if BPMV has historically been a problem, insecticide sprays applied in the early stages of plant development (VC-V2) may help kill overwintering adult bean leaf beetles than might lead to early infections by the virus. A second insecticide application may also be necessary in late June or early July as first generation bean leaf beetles emerge. At this time, synthetic pyrethroid insecticides appear to provide the most consistent control for bean leaf beetles. Note that currently, insecticide treatments have not been demonstrated to be effective for control for vectors of other common soybean viruses (e.g., aphids).