



## Frogeye Leaf Spot

Frogeye leaf spot of soybean is caused by the fungus *Cercospora sojina*. The disease occurs across the United States and in Ontario, Canada. This publication describes the symptoms of frogeye leaf spot and conditions favorable for the disease. We also point out how frogeye leaf spot differs from several other soybean diseases and disorders and suggest management practices.

### Symptoms and Signs

Frogeye leaf spot initially appears on upper leaf surfaces as small, dark, water-soaked spots (lesions) (Figure 1). Eventually, these lesions enlarge and become round to angular.



**Figure 1.** Frogeye leaf spot symptoms start as small dark lesions.

The centers of frogeye leaf spot lesions progress from gray to brown to light tan, and are surrounded by a narrow reddish purple margin (Figure 2). On some soybean varieties, you may also see a light green halo around the lesion border (Figure 3).



**Figure 2.** Reddish purple margins surround the gray centers on mature frogeye leaf spot lesions. The missing areas on this leaf are from insect feeding.



**Figure 3.** On some soybean varieties, frogeye leaf spot lesions may have light green to yellow halos.

When environmental conditions are favorable, fungal sporulation occurs, which gives the underside of lesions a gray and fuzzy appearance (Figure 4). Lesions can coalesce to create blighted areas on leaves. When frogeye leaf spot is severe, plants can prematurely defoliate.



**Figure 4.** Fuzzy gray sporulation (conidia) of the frogeye leaf spot fungus can sometimes occur in lesions on the undersides of leaves.

In addition to leaf lesions, frogeye leaf spot symptoms can occur on stems and pods late in the season, but these symptoms can be difficult to identify. Stem lesions appear elongated (Figure 5). Pod lesions appear oblong and resemble foliar symptoms (Figure 6). Severely diseased pods can infect and discolor seeds. The fungus that causes frogeye leaf spot may infect seeds, which results in light purple to gray discoloration, but infected seed also may not show any symptoms.



**Figure 5.** The fungus that causes frogeye leaf spot can cause discolored, elongated stem lesions.



**Figure 6.** Frogeye leaf spot lesions on pods.

## Disease Cycle

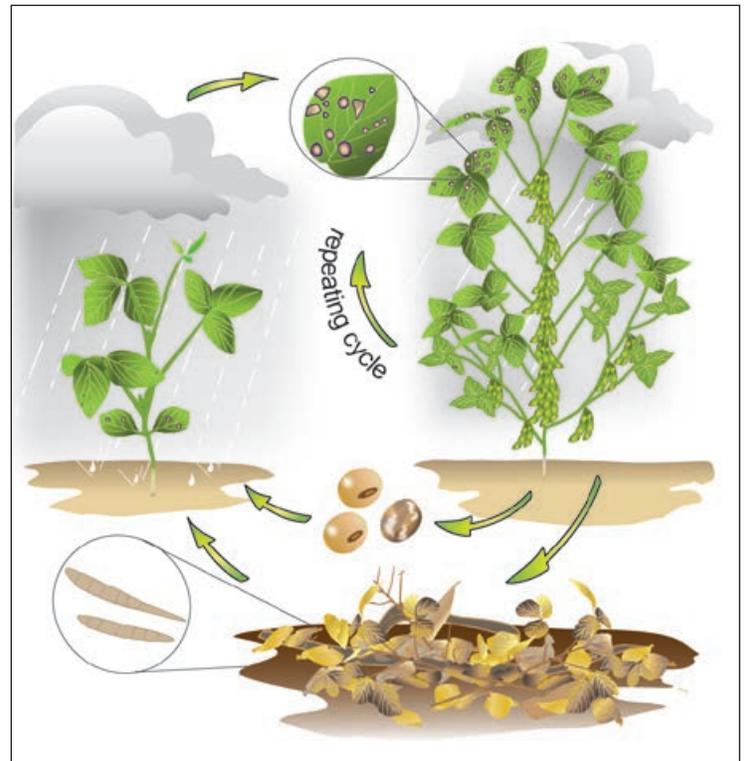
The fungus that causes frogeye leaf spot survives in infested soybean residue for at least two years. Preliminary research suggests that other legumes and some weeds and cover crops may also be hosts of the fungus.

There are reports of the fungus being transmitted by seed, although this has rarely been observed in the field. Wind and splashing water may disperse spores. Spores produced on infected plants can move to new plants in the same field, and wind can also disperse the spores to nearby fields.



**Figure 7.** A frogeye leaf spot lesion on a unifoliate leaf early in the growing season.

The fungus can infect leaves at any stage of soybean development, but is most common after flowering (Figure 7). Symptoms are most frequently observed from flowering (R1) through beginning maturity (R7). Young, expanding leaves are more susceptible than older, fully expanded leaves (Figure 9). Because of this, frogeye leaf spot symptoms are usually observed in the upper plant canopy.



**Figure 8.** The frogeye leaf spot disease cycle. The fungus that causes frogeye leaf spot survives in crop residue and in infected seeds. Wind and rain spread inoculum (fungal spores) to soybean plants where infection occurs. The disease cycle repeats, and spores spread to new leaves, plants, and fields.



**Figure 9.** New leaves are more susceptible to infection by the fungus that causes frogeye leaf spot than older leaves.

## Conditions that Favor Disease

Frogeye leaf spot is most severe when warm, humid weather with frequent rain persists for extended periods. Several days of overcast weather favor disease development and spread. Overhead irrigation may increase the risk of severe frogeye leaf spot compared to flood or furrow irrigation or dryland production systems.

Fields will have higher risk for frogeye leaf spot if:

- You plant a susceptible soybean variety in a field with a history of frogeye leaf spot
- Your fields have continuous soybean production
- Your fields have short rotations between soybean crops
- You practice conservation tillage

## Yield Losses and Impact

Frogeye leaf spot's effect on yield can vary greatly, depending on disease timing, varietal susceptibility to disease, and weather conditions during soybean reproductive stages.

If the disease begins late in reproductive stages (after growth stage R5.5) or disease severity is low, the yield impact will be minimal.

But if conditions are favorable and there are severe disease outbreaks early or just after flowering, yield losses can be up to 35 percent.

## Diagnosis

Frogeye leaf spot can be difficult to diagnose correctly in the field, because it is easily mistaken for other diseases and disorders (such as herbicide injury). For this reason, we recommend you send symptomatic plants to a diagnostic laboratory to confirm the problem before you implement a disease management program. Obtaining an accurate diagnosis will allow you to determine the best management strategies for your soybean field.

Frogeye leaf spot can be confused with similar diseases and disorders. We describe the most common of these below.

## Diseases and Disorders with Similar Symptoms

### Diseases

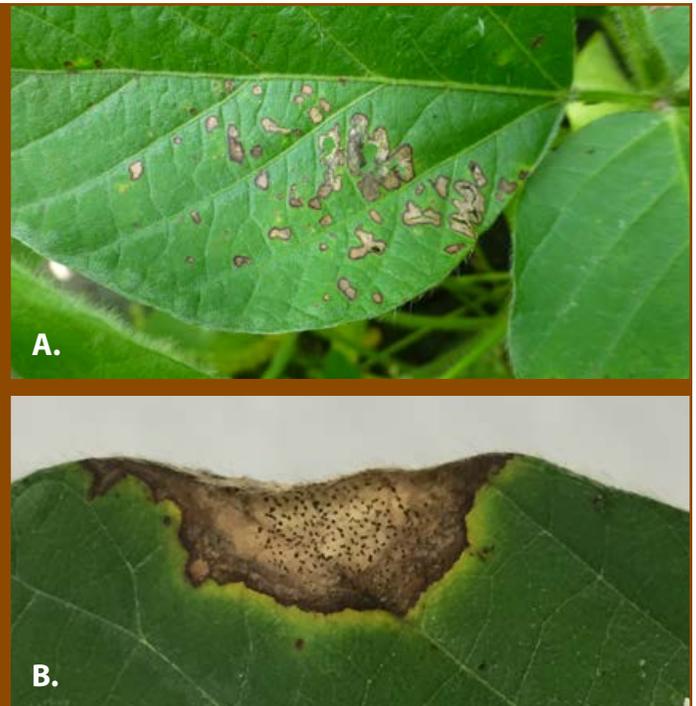
#### Phyllosticta Leaf Spot (*Phyllosticta sojicola*)

Phyllosticta leaf spot lesions, if not formed on the edge of the leaf, appear similar to frogeye leaf spot lesions (Figure 10).

#### How to distinguish Phyllosticta leaf spot from frogeye leaf spot:

Phyllosticta leaf spot lesions can have dark specks (pycnidia) that develop in the center of lesions. Frogeye leaf spots do not contain dark specks but instead may have gray fuzzy growth (mycelium and conidia) in the center of the lesions.

**Figure 10.** (A) Phyllosticta leaf spot lesions (shown here) can look similar to frogeye leaf spot. (B) However, Phyllosticta leaf spot lesions often contain fungal reproductive structures that appear as dark specks.



**Target Spot (*Corynespora cassicola*)**

The secondary lesions of target spot can appear similar to frogeye leaf spot. Secondary lesions range in size from 1/16 to 1/8 inch and do not have a defined set of concentric rings within the lesion itself (Figure 11). Target spot lesions form on pods, petioles, and stems like frogeye leaf spot. You may need a laboratory diagnosis to distinguish between these diseases.

**How to distinguish target spot from frogeye leaf spot:**

In soybean varieties susceptible to target spot, secondary target spot lesions can form in the upper canopy, but rarely have the purple margin around the lesion that is commonly observed with frogeye leaf spot.

**Figure 11.** Secondary target spot lesions can appear similar to frogeye leaf spot.

**Other Conditions****Protoporphyrinogen Oxidase (PPO) Herbicide Injury**

PPO herbicide injury on soybean plants results in a contact burn that produces circular to irregular spots with the same brown to reddish brown margins as frogeye leaf spot lesions (Figure 12).

Postemergence PPO herbicide injury will appear shortly after application, and will be confined to the specific zone of growth on the plant that was present at the time of application. Typically, this zone will be lower in the canopy later in the season as most postemergence PPO herbicides are applied before pod set, so leaves that emerge after PPO herbicide application will be unaffected.

**How to distinguish PPO injury from frogeye leaf spot:**

PPO herbicide injury will appear on lower leaves (older growth in the canopy). Frogeye leaf spot lesions typically appear in the upper soybean canopy (newer growth). Frogeye leaf spot will begin in small pockets in the field whereas herbicide injury will occur over the entire field with many "spots" appearing at once.

**Figure 12.** PPO herbicide injury is confined to the area of the plant where herbicides were applied.



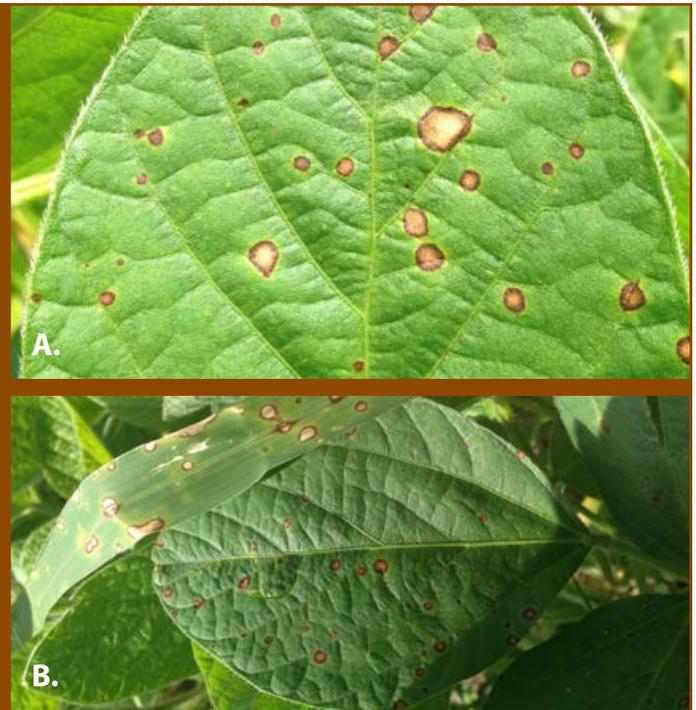
## Paraquat Herbicide Injury

Paraquat injury appears as brown spots on leaves that can have dark halos (Figure 13). Paraquat injury from drift often appears in a gradient from the field edge and is associated with a specific zone of the plant canopy exposed to the drift. The herbicide does not affect unexposed new growth.

### How to distinguish paraquat injury from frogeye leaf spot:

Paraquat injury will affect other plant species (including weeds exposed to the drift), not just soybean. Herbicide injury typically will follow a regular pattern that corresponds with the herbicide application. Check application records to determine if herbicide injury could be the cause of the disorder.

**Figure 13.** Paraquat herbicide injury (A) appears similar to frogeye leaf spot. However, paraquat injury symptoms will be found on all plant species in the affected area (B), not just soybean.



**Table 1. Symptoms of diseases and disorders that are similar to frogeye leaf spot.**

Disease or Condition	Timing of Symptom	Plant and Field Symptom Distribution	Key to Differentiate
frogeye leaf spot	After flowering.	Mid- to upper plant canopy. Patchy to uniform distribution across the field.	Gray fuzzy fungal growth may be present in lesion (conidia and mycelia).
Phyllosticta leaf spot	After flowering.	Mid- to upper plant canopy. Patchy to uniform distribution across the field.	Black fungal “specks” (pycnidia) form in lesion.
paraquat herbicide injury	Drift pattern associated with field margins treated with paraquat.	New growth not affected. Gradient from field edge. All plant species affected in drift area.	New growth is healthy.
PPO herbicide injury	Associated with postemergence herbicide applications that contain PPO herbicide (often during vegetative stages).	New growth is not affected. Symptom distribution matches PPO herbicide application.	New growth is healthy; injury occurs lower in canopy. Large area uniformly affected.
target spot	After canopy closes, post-flowering.	Lower to mid-canopy. Patchy to uniform distribution across the field.	No fungal growth on the undersides of lesions. Most mature lesions have bright yellow halos.

## Management

### Resistant Varieties

There are soybean varieties with frogeye leaf spot resistance. However, varieties marketed as resistant may not be completely resistant to the disease (known as partial resistance). To date, the resistance gene known as *Rcs3* has been effective against all races of this fungus known to occur in North America (resulting in a high level of resistance).

Information about specific resistance genes in a variety may not be readily available, so you should consult seed dealers to help locate varieties with the *Rcs3* gene. Also, planting high-quality, certified seed will reduce the risk of introducing infected seed into a field.

### Crop Rotation and Tillage

Because the fungus that causes frogeye leaf spot survives on residue, you should follow practices that encourage residue to decompose. This will reduce the amount of the fungus available to infect the next soybean crop.

Rotations to a nonhost crop such as corn, small grains, or grain sorghum will help reduce residue; however, long rotations may be necessary if the disease has been severe in a particular field. Tillage will help break up residue and reduce the amount of fungus for the subsequent crop.

### Foliar Fungicides

Well-timed foliar fungicide applications can effectively control frogeye leaf spot. Researchers have reported that foliar fungicides applied during the pod development stages (R3-R4) are the most effective for managing frogeye leaf spot and protecting against yield reductions.

Foliar fungicide efficacy guides are updated annually by the NCERA-137 soybean disease working group. For a current fungicide list, see *Diseases of Soybean: Fungicide Efficacy for Control of Foliar Soybean Diseases* (Purdue Extension publication BP-161-W), available from the Education Store, [www.edustore.purdue.edu](http://www.edustore.purdue.edu).

Scout your fields and note other risk factors to determine if you need to apply a foliar fungicide. Factors that can affect risk of frogeye leaf spot are:

- **Variety susceptibility** — frogeye leaf spot is more likely to develop to economically damaging levels on susceptible varieties.

- **Cropping history** — fields in short rotations or continuous soybean production will be at higher risk for developing frogeye leaf spot. These fields may be more likely to benefit from a fungicide.
- **Environmental conditions** — warm, humid weather with frequent moisture and heavy dews favor disease development. Irrigated fields (especially with overhead irrigation) will be at a greater risk for disease development.

While these factors can help you decide whether to apply foliar fungicides to manage frogeye leaf spot, the decision to apply depends on the farmer. There is not a set threshold for foliar diseases of soybean (including frogeye leaf spot), but you should consider growth stage, disease level, and variety susceptibility.

Yield response from fungicides applied to varieties with the *Rcs3* gene is much lower than applications to susceptible varieties in trials with severe frogeye leaf spot pressure.

## Fungicide Resistance Management

The genetic diversity of the frogeye leaf spot fungus is a key reason why fungicide-resistant isolates can be selected. Resistance to quinone-oxidoreductase-inhibiting (QoI/strobilurin) fungicides has been reported in the frogeye leaf spot pathogen in North America.

It is important to use fungicide products **that contain active ingredients from different fungicide classes for resistance management purposes.**

Never rely on only one class of fungicide to manage frogeye leaf spot, and always consider the risk factors listed above before you apply a fungicide in order to minimize the risk of further fungicide resistance developing.

If you decide to apply a foliar fungicide, scout fields two weeks after the application to determine if the fungicide is adequately managing disease. Although many factors influence fungicide efficacy (such as low-volume spraying, nozzle choice, carrier-water quality, etc.), inadequate control *may* indicate that the fungus is resistant to the fungicide you used. Also remember that no fungicide will ever provide 100 percent control on a susceptible variety.

If you believe fungicide resistance may be an issue in your field, contact your local extension specialist.

## Find Out More

To learn more about fungicide resistance, visit Plant Management Network's Soybean Fungicide Resistance Hub ([www.plantmanagementnetwork.org](http://www.plantmanagementnetwork.org)).

Other publications in the *Soybean Disease Management* series are available on the Crop Protection Network website ([cropprotectionnetwork.org](http://cropprotectionnetwork.org)).

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