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Soybean Rust

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Asian soybean rust is a serious foliage disease that has the potential to cause significant soybean yield losses. Although Asian soybean rust was identified on soybean plants in Hawaii in 1994, the disease was not reported in the continental United States until the fall of 2004. The U.S. Department of Agriculture (USDA) released an official notice of the confirmation of soybean rust on soybean leaf samples collected in Louisiana on November 10, 2004. Over the next few weeks the fungus was detected on plants from a number of additional states, including Missouri. Now that Asian soybean rust has been found in the continental United States, it is critical that anyone involved in soybean production be familiar with the disease and its identification and management.

History

Soybean rust was first reported in the Eastern Hemisphere in the early 1900s. It is now accepted that there are two different fungal species, *Phakopsora pachyrhizi* and *Phakopsora meibomiae*, that cause soybean rust. *Phakopsora meibomiae*, referred to as the New World type, is a much weaker pathogen and is the pathogen that has been found in limited areas in the Western Hemisphere (primarily the Carribean).

Phakopsora pachyrhizi, referred to as the Asian or Australasian soybean rust, is the more aggressive pathogen. It was first reported in Japan in 1902 and was initially limited to tropical and subtropical areas of Asia and Australia. Unfortunately, it is *Phakopsora pachyrhizi* that has been spreading through soybean-producing regions of the world. *Phakopsora pachyrhizi* was reported from Hawaii in 1994, Zimbabwe in 1998 and Paraguay in 2001. In Africa, this aggressive soybean rust has spread to Uganda, Zambia, Rwanda, Nigeria, West Africa, Mozambique, South Africa and Cameroon. In South America, *Phakopsora pachyrhizi* has been found in most of the soybean-producing regions of Brazil as well as Argentina, Bolivia and Colombia.

Figure 1. Soybean rust, especially in early stages, can be difficult to identify. Examine both upper and lower leaf surfaces, starting with leaves in the lower canopy of the plants.

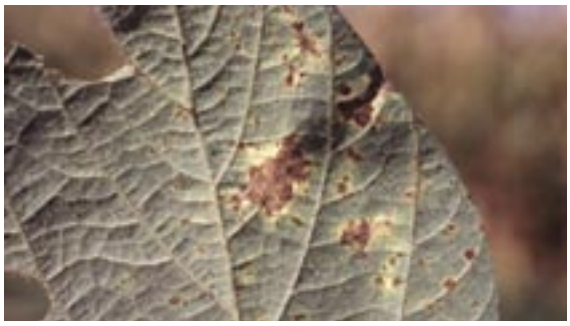
It was also the aggressive, or Asian, soybean rust that was found in Louisiana, other Gulf Coast and southeastern states and Missouri during the fall of 2004.

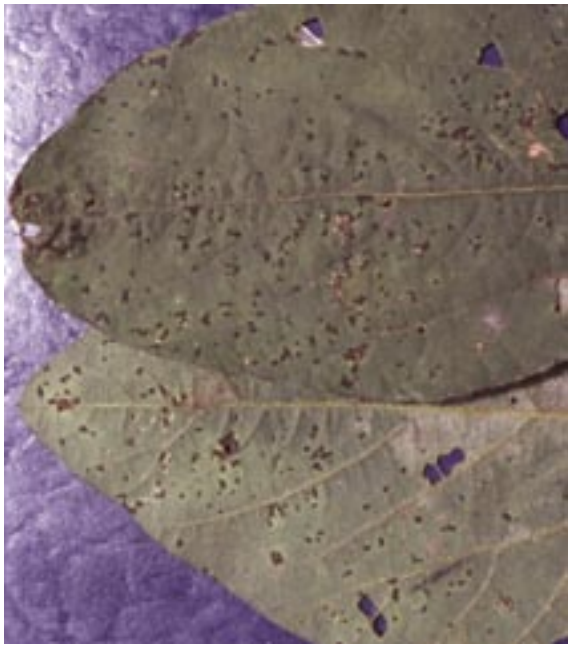
Symptoms

The two types of soybean rust cannot be distinguished by foliar symptoms in the field. The initial confirmation of soybean rust and the determination of which type of soybean rust was present in samples collected in the United States during the fall of 2004 was done by USDA Animal and Plant Health Inspection Service (APHIS) personnel in Beltsville, Md., using molecular techniques.

In countries where soybean rust is established, losses range from 10 percent to 80 percent. The severity of losses varies depends on susceptibility of the soybean variety, time of the growing season in which the rust becomes established in the field and weather conditions during the growing season.

The most common symptom of soybean rust is a foliar lesion (Figure 1). On the upper leaf surface, initial symptoms may be small, yellow flecks or specks in the leaf tissue. These lesions darken and may range

Disease	Septoria Brown Spot	Bacterial Blight
Pathogen	*Septoria glycines*	*Pseudomonas savastanoi* pv. *glycinea*
• upper leaf surface		
• lower leaf surface		
Symptoms • upper leaf surface	Septoria brown spot develops as small, angular to somewhat circular reddish brown to brown spots. The individual spots can merge, forming irregular shaped, brown blotches on the leaves. In the dead tissue of older lesions, small dark specks (fruiting bodies of the causal pathogen) may be evident.	Bacterial blight begins as small, angular, yellow lesions in the leaf tissue. Lesions usually have a translucent or water-soaked "halo" that may be more readily seen if leaves are held up to the light. Lesions progress in color from yellow to light brown to a dark reddish or blackish brown. Lesions may enlarge or merge, producing large, irregular dead areas in the leaf. With wind and rain these large dead areas drop out or tear away giving the leaf a ragged appearance.
• lower leaf surface	Lesions will be evident as brown spots of varying sizes and shapes on the lower leaf surface.	Lesions on the lower leaf surface resemble those on the upper leaf surface.
• canopy	Septoria brown spot usually begins on the unifoliolate and lower trifoliolate leaves. Under favorable conditions the disease will spread into the upper canopy. Infected leaves may yellow and drop prematurely.	The bacteria that cause bacterial blight are spread by wind-driven rain. Outbreaks typically develop several days after a rainstorm or hailstorm. Symptoms are most evident on growth that is expanding at the time of the rain event.
Weather	Warm, wet weather favors disease development. Symptoms develop over a temperature range of 59-86 degrees F. Spores are spread by wind and splashing rain. The spread of brown spot is restricted by dry weather.	Bacterial blight is favored by cool, rainy weather. Symptoms typically occur several days after a rain with driving winds or a hailstorm. Hot, dry weather checks disease development.
Survival	The brown spot pathogen survives in infested residues left on the soil surface and may be seedborne.	The bacterial blight pathogen survives in infested residues left on the soil surface and may be seedborne.
Distribution in Missouri	Septoria brown spot occurs throughout Missouri. Most years it may occur early in the season and then redevelop close to harvest. Brown spot may be more severe when soybeans are planted into soybean residue or in years when moisture is abundant throughout the season.	Bacterial blight can occur throughout Missouri. It will be most prevalent in seasons with extended periods of wet weather and frequent storms with strong winds or hail.

Bacterial Pustule	Frogeye Leaf Spot
Xanthomonas axonopodia pv. *glycines*	*Cercospora sojina*
	 
Bacterial pustule lesions begin as small, light green lesions. Older lesions may be darker and range from small spots to large areas of dead tissue formed when smaller lesions merge. The water soaking common to bacterial blight is seldom seen with bacterial pustule. Initially the center of the lesion may be slightly raised.	Lesions of frogeye leaf spot are small, circular to somewhat irregular spots that develop on the upper leaf surfaces. Initially the spots are dark and water-soaked in appearance. As the lesions age, the center becomes light brown to light gray in color. Although lesions may merge to kill large areas of leaf tissue, the individual lesions do not increase significantly in size (~0.25 inch in diameter) Older lesions have a light center with a darker red to purple-brown border.
The raised center or "pustule" may be more evident in lesions on the lower leaf surface and might be mistaken for soybean rust pustules. Bacterial pustules do not produce spores; viewed under magnification, they may show cracking or fissures rather than the circular openings characteristic of soybean rust.	Lesions are evident on the lower leaf surface and appear similar to those on the upper leaf surface.
The bacteria that cause bacterial pustule are spread by wind-driven rain. Outbreaks typically develop several days after a rainstorm or hailstorm. Symptoms are most evident on growth that is expanding at the time of the rain event.	Young leaves are more susceptible than older leaves to infection. The disease may be evident throughout the canopy of the plant, if weather conditions remain favorable for disease development.
Bacterial pustule is favored by wet or rainy weather. Disease outbreaks usually occur 5 to 7 days after wind-driven rains. Bacterial pustule is not slowed by high temperatures, as is bacterial blight.	Development of frogeye leaf spot is favored by warm, humid weather. Spores are spread short distances by wind or splashing rain. Dry weather severely limits disease development.
The bacterial pustule pathogen survives in infested residues left on the soil surface and may be seedborne.	The fungus that causes frogeye leaf spot survives in infested soybean residues and infected seed.
Bacterial pustule may occur throughout the state. However, there had been few reports of bacterial pustule occurring anywhere in Missouri over the last 5-10 years — until the 2004 season. The unusually wet conditions of the 2004 season and the number of major hailstorms in the state led to the occurrence of bacterial pustule in many regions of Missouri.	Until about 1998 frogeye leaf spot was found only in the southern parts of Missouri. Since then the distribution of this disease has expanded and it is now found throughout the state.

Downy Mildew	Soybean Rust	Disease
Peronospora manshurica	*Phakopsora pachyrhizi*	**Pathogen**
		• upper leaf surface
		• lower leaf surface
Initial symptoms of downy mildew are pale green to light yellow spots or blotches on the upper surface of young leaves. The initial lesions may be quite small — appearing as faint yellow flecks across the leaf tissue. Under ideal conditions these areas may enlarge into pale to bright yellow lesions of indefinite size and shape.	Symptoms of soybean rust begin on the lower leaves of the plant as small lesions that may range from light green to yellow to brown flecks on the upper leaf surface. As the disease develops the lesions become more distinct and lesions may merge, killing larger areas of leaf tissue.	**Symptoms** • upper leaf surface
During periods of wet or humid weather, a gray to purple fuzz develops on the lower leaf surface beneath the diseased areas.	On the lower leaf surface the lesions may range from gray to tan or reddish brown in color. When mature the lesions on the lower leaf surface consist of small pustules surrounded by slightly discolored tissue. Each pustule has a circular pore or opening through which the masses of tan spores are released. The pustules and spores may be visible on the lower leaf surface if a 10x or 20x hand lens is used to examine the leaf.	• lower leaf surface
Young leaves are more susceptible than older leaves to infection. The disease may be evident throughout the canopy of the plant, if weather conditions remain favorable for disease development.	Soybean rust tends to start in the lower part of the canopy and can move up through the plant quickly if weather conditions are favorable for disease development.	• canopy
Downy mildew is favored by high humidity and temperatures of 68-72 degrees F. Spores produced on newly infected leaves are primarily wind-spread.	Temperatures in the range of 46-82 degrees F, high relative humidity and prolonged periods of leaf wetness favor the development of soybean rust. Spores are easily spread by wind over both short and long distances.	**Weather**
The downy mildew fungus survives as oospores in infected leaf residues and on seeds.	The soybean rust pathogen does not survive on infested residues left in the field and is not seedborne. Infection is the result of inoculum produced on living host plants or spores blown into a production area.	**Survival**
Although downy mildew can occur anywhere in the state, it is seldom found in more than trace amounts. The 2004 season was atypical in that downy mildew was widespread. In most cases, symptoms occurred in the mid to upper canopy and individual lesions remained small.	Before November 10, 2004, soybean rust had not been reported in the continental United States. The detection of soybean rust in Louisiana was confirmed on November 10, and the disease was subsequently found in the Gulf states of Mississippi, Alabama, and Florida and north to Georgia, South Carolina, Tennessee, Arkansas and Missouri.	**Distribution in Missouri**

Figure 2. Early stage of development of soybean rust: upper and lower leaf surfaces and canopy.

Figure 3. Middle stage of development of soybean rust: upper and lower leaf surfaces and canopy.

Figure 4. Late stage of development of soybean rust: upper and lower leaf surfaces and canopy.

from dark brown or reddish brown to tan or gray-green in color. The lesions tend to be angular to somewhat circular in shape and may be concentrated near leaf veins. Initially the lesions are small, barely larger than a pin point (Figure 2). Mature lesions (Figures 3 and 4) may be somewhat larger, and lesions may merge or run together, killing larger areas of leaf tissue. Symptoms may be more prevalent and more severe on the lower leaf surface. The fungus produces spores in cone-shaped pustules on the lower leaf surface. At first these pustules might appear to be small, raised blisters or callous bumps on the lower leaf surface. But as the rust pustules mature, they begin to produce large numbers of light-colored, powdery spores (urediospores), which emerge through a distinct hole or pore in the cone-shaped pustule. Masses of the light-colored (gray to buff to light tan or brown) spores may lodge in the opening or mound up out of the opening in the pustule (Figure 5). The pustules and emerging spores are difficult to see without magnification. A high-power hand lens or dissecting microscope will greatly aid in the detection of these structures and in identification of soybean rust.

Rust pustules are most common on the under-

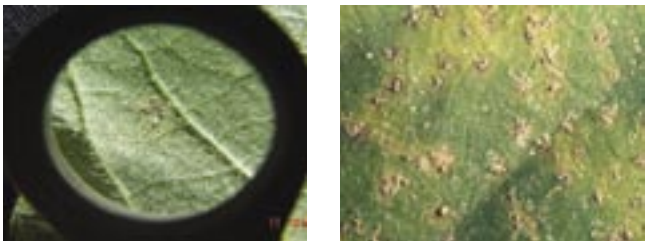


Figure 5. Tan, cone-shaped lesions on leaf surface (viewed under hand lens).

Photos: *Left* - J.T. Yorinori, Embrapa, Brazil
***Right* - R. Frederick, USDA, ARS, Ft. Detrick, Md.**

side of leaves but may also develop on petioles, pods and stems. Infected leaflets may show a yellow mosaic pattern. Leaves may yellow and drop prematurely. Losses are due to a reduction in photosynthetic area of the plants and resulting reduction in pod and seed numbers and in seed weight.

Soybean rust is usually found first on the lower leaves of plants, especially at or near flowering. As the soybean plants mature, lesions may be found in the middle and upper canopy. When conditions are favorable for disease development, yellowing of the foliage may be evident and defoliation and premature death

of plants may occur. Under ideal conditions the disease can develop on much younger plants.

For Further Information

See the following USDA Web sites for photographs, news and information about soybean rust:

http://www.aphis.usda.gov/lpa/issues/sbr/sbr.html

http://www.aphis.usda.gov/ppq/ep/soybean_rust/

Development

The development of soybean rust is favored by prolonged periods of leaf wetness (6–12 hours) and temperatures of 46 to 82 degrees F. Extended periods of cool, wet weather during the growing season would favor soybean rust epidemics. Rust pustules appear on the leaf surface 9 to 10 days after infection, and spores are usually evident soon after. Each lesion can produce vast numbers of spores and spore production may continue for weeks. Spores are easily spread by the wind. Soybean plants are susceptible to soybean rust at any stage of development, but symptoms are most common during and after flowering.

Rust pathogens are considered to be obligate parasites in that they survive on living plant material. Although the soybean rust fungus may not be able to overwinter in central or northern soybean-production areas of the United States, it may be able to survive the winter months on hosts such as kudzu in the southern United States. Soybean rust spores could then be carried north on wind currents and by storms. This scenario of reintroduction of rust pathogens from the southern United States to the central and northern regions of the country each growing season is well documented in wheat for stem rust, leaf rust and stripe rust and in corn for common rust and southern rust.

The soybean rust fungus has several characteristics that make it a serious threat to soybean production. As with most rust fungi, the soybean rust produces large numbers of spores on infected plants. These spores are readily spread by wind currents and storms. This combination of high spore production and successful long-distance spore spread allows soybean rust to buildup rapidly and makes it a difficult pathogen to control. Soybean varieties grown in the United States have little or no resistance to soybean rust. In addition, the soybean rust pathogen *Phakopsora pachyrhizi* has many other cultivated and uncultivated or wild hosts. At least 31 species in 17 genera of legumes can be hosts of this fungus. Among the other hosts of *Phakopsora pachyrhizi* in the United States are kudzu, yellow sweet clover, medic, vetch, lupine, green and kidney bean, lima or butter bean and cowpea or black-eyed pea.

Management

In the long term, resistant varieties may be the more practical, economical means of managing soybean rust. However, commercial soybean varieties currently grown in the United States have little or no resistance to soybean rust. Both public and private soybean breeders are working to identify sources of resistance and to incorporate resistance into soybean varieties suitable for U.S. production.

For the immediate future, the use of foliar fungicides may be one of the main tools for managing soybean rust. Currently only a limited number of foliar fungicides are labeled for use on soybeans in the United States. Section 18 special exemption registrations have been requested for additional fungicides and more are likely to be requested. Check with University Extension personnel or the Missouri Department of Agriculture for current information on fungicides labeled for use against soybean rust.

Early detection followed by prompt application of fungicides in a manner that ensures good coverage of the plant canopy will be necessary for successful management of soybean rust. The number of fungicide applications required will vary depending on how early in the season rust spores reach Missouri and on weather conditions during that growing season. There are still many questions concerning the effective use of fungicides to manage soybean rust.

Answers to questions about how various agronomic practices such as row spacing, date of planting, and irrigation techniques affect the development of soybean rust are also unclear. Practices that minimize conditions favorable for rust development and optimize crop vigor need to better defined.

It is difficult to predict the impact soybean rust on Missouri producers. Soybean rust has the potential to reduce yields significantly, to increase production costs and to reduce profits. However, the severity of the disease in Missouri could vary greatly from season to season. Weather conditions that promote introduction of rust inoculum from the southern states and weather conditions that favor development of the disease during the growing season will determine how severe soybean rust is each year.

For information on submitting samples for soybean rust identification to the Plant Diagnostic Clinic at the University of Missouri, see the lab's Web site at http://www.agebb.missouri.edu/pdc/.

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