

## Chapter 1

### Economic Importance of Soybean Rust

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Soybean rust, a disease that causes serious crop losses in many parts of the world, was first detected in the continental United States in November 2004. Soybean rust is caused by the fungus *Phakopsora pachyrhizi*. Long known to occur in Asia, the fungus spread to Zimbabwe, South Africa; Paraguay; Brazil; Colombia; and now the United States during the last 10 years. Yield losses in other parts of the world due to soybean rust have been reported to range from 10 to 90 percent.

Annual yield losses for North American soybean production are predicted to be at least 10 percent in the upper Midwest, Northeast, and Canada, and 50 percent or greater in the Mississippi Delta and southeastern states. However, losses in hard-hit areas anywhere in North America could exceed 80 percent if effective management tactics are not deployed.

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#### Soybean Rust Disease Symptoms

The first symptoms of soybean rust are small brown or brick-red spots on the upper leaf surface (Figure 1.1). The spots, which are initially less than half the size of a leaf hair, are frequently best seen by holding leaves up to a light source so that they are backlit.

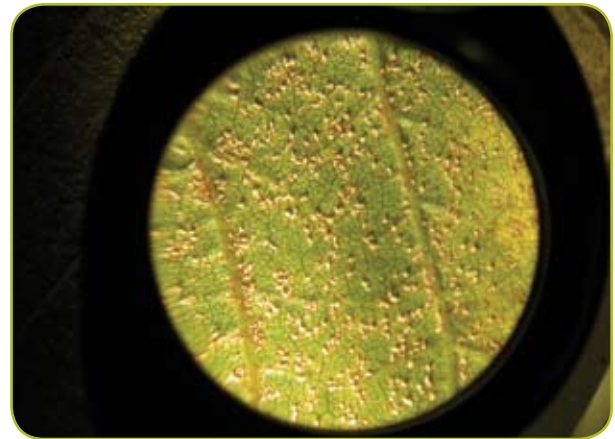
Eventually, pustules will form in the spots, primarily on the

undersides of leaves. Pustules initially have raised centers that eventually break open (circular opening) to reveal masses of urediniospores. Spore masses can readily be seen using a 20x hand lens. As pustules become numerous, leaves turn yellow and drop prematurely. Prematurely defoliated plants have fewer pods, fewer seeds per pod, and poorly filled seeds.

Be aware that in the early stages of infection, soybean rust looks very similar to many other soybean foliar diseases, including brown spot, bacterial blight, bacterial pustule, *Cercospora* leaf blight, downy mildew, and frogeye leaf spot and abiotic factors such as burning herbicide compounds.



*Upper leaf symptoms*



*Pustules (with spores) under 20x hand lens*



*Backlit leaf*



*Top leaf—mid-stage of infection*



*Bottom of leaf with severe infection*



*Top of severely infected leaf*

*Figure 1.1. Soybean rust.*

## Soybean Rust Disease Cycle

Spots and pustules form in leaves when fungal spores, called urediniospores, blow into fields, land on soybean leaves, and infect leaves under favorable conditions. Spots are evident about four days after infection, and pustules can be seen after about 10 days. One pustule can produce urediniospores for about three weeks. Wind disperses these spores, which in turn results in more infections. Rapid increases in disease incidence and severity usually coincide with canopy closure and the beginning of crop flowering.

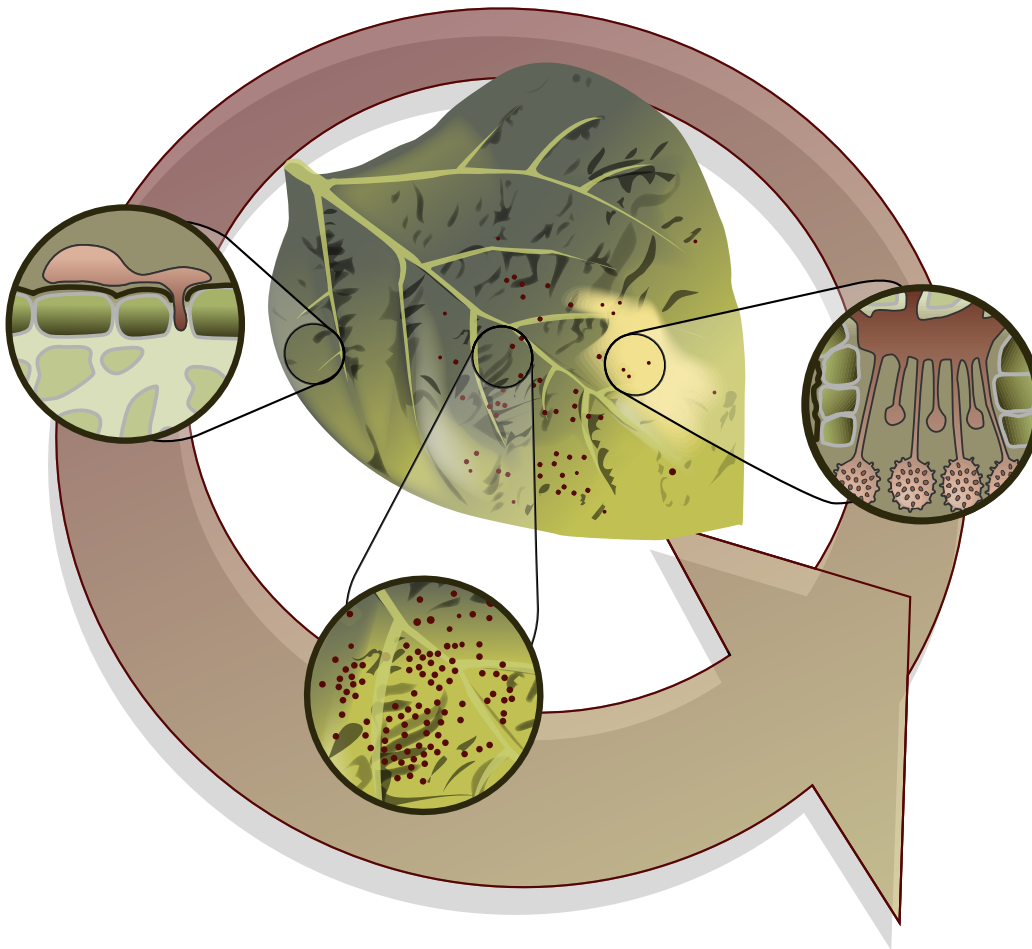
This cycle of infection and development of pustules and urediniospores will continue until the plant is totally defoliated or until weather no longer favors disease development. Defoliation may occur when as little as 30 to 40 percent of the total leaf area

shows symptoms and signs of rust. Premature defoliation can occur four to six weeks after initial infection.

Soybean rust, like most rusts, is capable of progressing rapidly once initial infection takes place. Rusts produce spores that re-infect the host plant population in a field, leading to a very rapid increase in disease under favorable conditions. Soybean rust progresses rapidly when dew periods are long (and frequent) and/or rain events are frequent, and when temperatures are optimum for infection (Table 1.1). **Note: Infections can occur over a broad temperature range (59 to 84°F), but will take a longer time to mature into new pustules at temperature extremes.** The most favorable period for soybean rust is likely to vary for different parts of the country, but risk may be greatest, nationwide, in July.

Rust	Infection Optimum	Time needed for Infection (hrs)	Generation Time (days)
Wheat leaf	59–73°F	6–8	7–10
Corn (common)	61–77°F	6	7
Soybean	68–77°F	6	9–10

Table 1.1. Infection optimum temperatures and generation times for soybean rust as compared to two other common rusts.



*Figure 1.2. The simple disease cycle of soybean rust. At this time, only one spore stage (urediniospore) is known to infect soybeans. It is blown into the crop with prevailing winds.*

Because of the way successive infections develop with rust fungi, they are referred to as “compound interest” diseases. Just as money invested at compound interest increases exponentially, the number of rust pustules in a field increases exponentially. The difference

is that your bank account may earn 3 to 5 percent, or a good mutual fund may earn 12 percent per year; however, once rust becomes established in a field, rust may increase at a 300-percent rate compounded every 9 to 10 days as in the case of soybean rust (Figure 1.3)!

## DISEASE PROGRESS CURVE

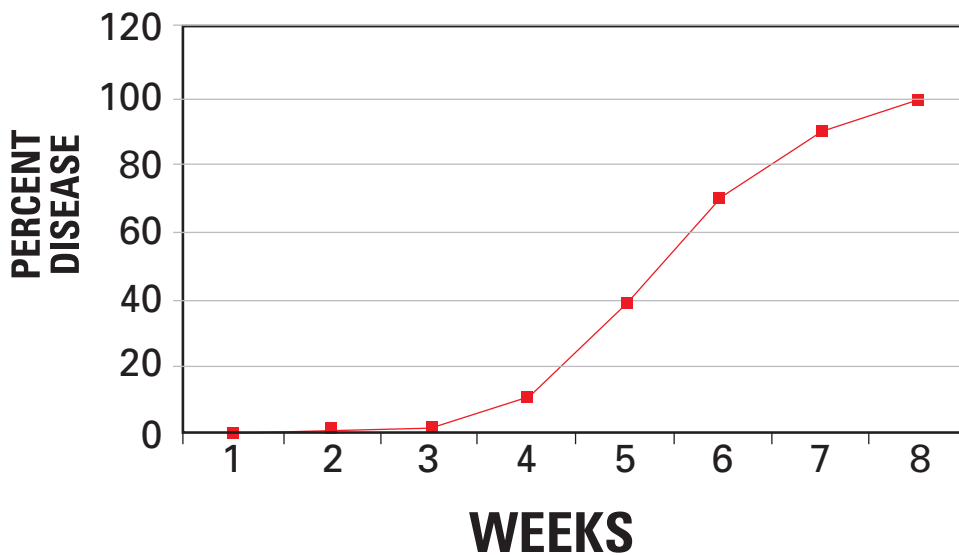


Figure 1.3. A typical rust disease progress curve. Since rusts produce more spores capable of reinfesting the host plant, disease severity starts slowly but increases logarithmically until the food source — leaves — becomes limiting or the environment becomes less favorable for growth and reproduction.

Fungicides provide protection and delay soybean rust epidemics as long as they remain in sufficient concentration in or on the soybean leaf. For fungicides to be optimally effective against soybean rust, they must be applied at the proper time. Experience from Africa, Brazil, and the southern United States indicates that early treatment is critical for optimum fungicide performance with soybean rust.

### Annual Survival and Movement of *Phakopsora pachyrhizi*

The soybean rust fungus is an obligate parasite and cannot survive outside host

tissue except as short-lived urediniospores. As a result, this fungus will only overwinter in southern areas that are free from killing frost (Figure 1.4). In these areas, the fungus continually infects other hosts, i.e., kudzu. In any given year, the onset of an epidemic will depend upon where the soybean rust fungus overwinters, how much overwinters, if weather conditions favor build-up of infection in these areas, and the existence of sufficient tracts of winds and storms to move spores out of overwintering locations and into new regions.

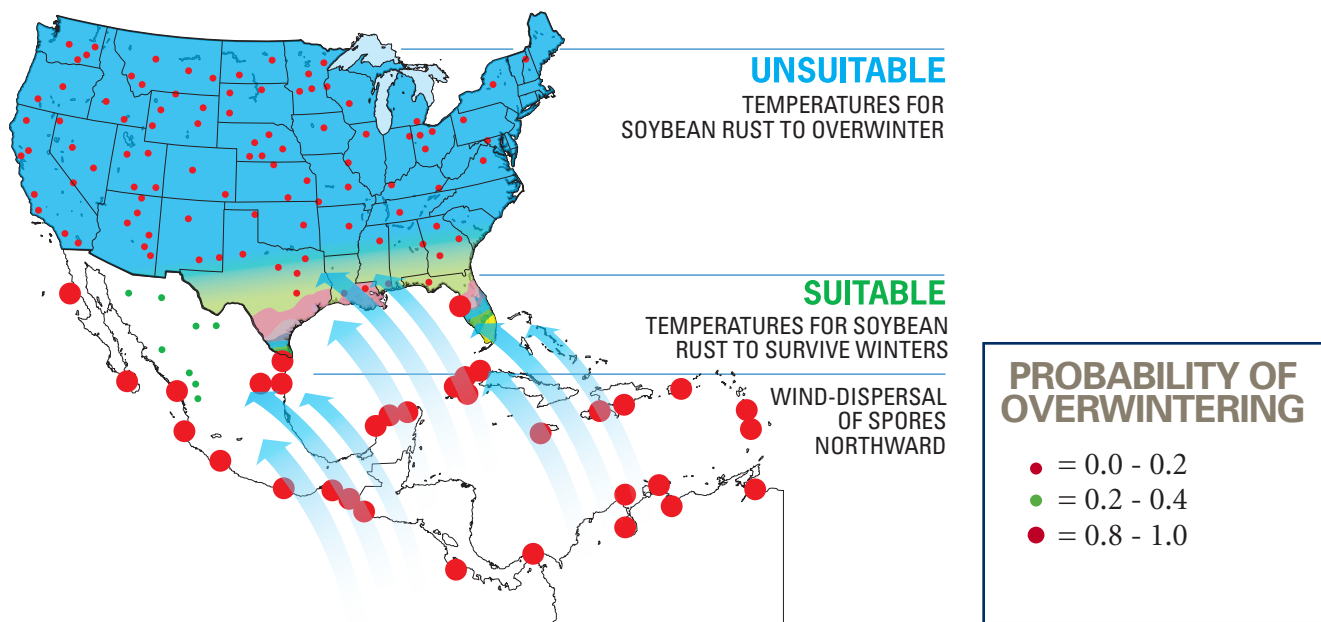


Figure 1.4. Potential sites in North America, the Caribbean, Central America, and South America where soybean rust may overwinter. (Yang et al., 2004.) Used with permission.

### Management Overview

As in other countries where soybean rust occurs, fungicides will be the primary means of managing soybean rust in the United States and Canada until acceptable resistant cultivars are developed. As soybean rust has spread around the world, fungicide use has become commonplace. Although the disease can cause significant losses in yield and quality, producers in other parts of the world have learned to manage soybean rust economically through the use of fungicides. The economic return on those products varies based on age of plant when disease initiates (R1 vs. R5), disease pressure, crop yield potential, and efficacy of available products. Nevertheless, fungicides have produced acceptable control of soybean rust when properly used.

Despite the significant benefits, controlling soybean rust with fungicides comes with a cost. For example, soybean producers in Brazil spent close to \$1 billion on fungicide control of soybean rust during 2003-04. In addition, some Brazilian producers have reported difficulties in deploying appropriate fungicide treatments when needed. Difficulties include fungicide availability, inability to detect initial soybean rust symptoms, inability to spray all of the crop as quickly as needed, application errors, physical barriers to application, and relative high cost of treatment. U.S. soybean producers are likely to encounter similar problems.

Costs of applying fungicide for soybean rust control are estimated to range from \$10 to \$35 per acre per application.

Early detection of soybean rust in a region is key to successful management of the disease. Fungicides must be applied in the early stages of a soybean rust epidemic (*i.e.*, pre-infection to less than 5 percent incidence on leaves in the lower canopy) to be highly effective. Incidence in this case refers to only five out of 100 plants having rust, and there may be only one to two pustules on the leaves. Rust is difficult to detect at these low levels.

Disease control may be severely compromised if applications are made before any infections occur in a field or after soybean rust is firmly established (>10 percent incidence in the mid-canopy). Making applications later in a disease epidemic may be an exercise in futility. Reports from Brazil indicate that when 20 to 30 percent of the soybean leaves in the mid canopy are affected by soybean rust, fungicides are no longer able to protect plants sufficiently from additional infections, or yield reduction is already so great that a fungicide application cannot recover treatment cost. Generally speaking, 10 percent disease incidence in the lower canopy should be considered the maximum action threshold for initial application of fungicides for soybean rust management using a curative strategy. This amount of disease is very small and will require thorough scouting in the field. A note of caution: More disease is often present than can be

detected using traditional field scouting methods. This is because some infections will be in the pre-symptomatic stages when observations are made.

Data from Africa, South America, and now North America indicate that not all fungicides have equal efficacy against soybean rust. Also, some fungicides may be phytotoxic on certain soybean cultivars, under some conditions. Research is in progress on fungicide efficacy under North American conditions, to determine which cultivars may be injured by which products, and which combinations result in measurable yield loss. Thus, the decision as to which fungicide to apply can have a great influence on the outcome.

Because of the differences in efficacy and activity, it is critical for producers to have access to products with multiple modes of action, which provide for effective disease control but also minimize the chance that the fungus will become resistant to a fungicide. Preliminary epidemiological models indicate that soybean rust may not be an economic problem in every production year in every region of the United States and Canada. The soybean rust pathogen may, in fact, behave like the wheat or corn rust pathogens, where the timing of rust movement from overwintering locations to the main production regions varies from year to year. In addition, studies in the United

**Fungicides are critical in a soybean rust disease-management program. However, several important soybean diseases are not effectively controlled with foliar fungicides. These include soybean cyst nematode, Phytophthora root and stem rot, sudden death syndrome, charcoal rot, brown stem rot, and all of the bacterial and viral diseases. Additionally, foliar fungicides are not equally effective against many common foliar diseases, including brown spot, Cercospora leaf blight, frog-eye leaf spot, Sclerotinia white mold, and Rhizoctonia aerial web blight, among others.**

States have shown that spores are sensitive to ultraviolet radiation; thus, rain storms may become the primary mode of transportation. This will make monitoring and forecasting programs all that more important to both limit unnecessary fungicide use and facilitate effective deployment of fungicides when they are needed.

### Importance of Applying Fungicides Correctly

Fungicides must be applied correctly to achieve effective, economical control of soybean rust. Because soybean rust tends to develop initially in the lower and mid canopy, thorough coverage of foliage, including penetration of spray into the canopy, is essential for achieving successful control of rust. Fungicides are best applied at higher gallons per acre, higher pressures, and with different nozzle tips than herbicides. Research is under way to improve fungicide spray technology for best management of soybean rust. Results from these studies may also help with future delivery of insecticides to soybean.

The most important thing to remember about soybean rust control with fungicides is coverage. Control is directly related to how thoroughly the fungicide spray covers leaf tissue. Better coverage results when the spray is delivered as

fine to medium droplets (about 200 to 300  $\mu\text{m}$ ). This is why higher spray pressures, nozzles with smaller orifices, and higher spray volumes per acre are used with fungicides than is customary for herbicides.

Despite the considerable need to improve existing fungicide spray technology, current spray technology (aerial and ground) has performed adequately for soybean rust control in other countries. Similarly, North American soybean producers have access to the appropriate spray technology to achieve excellent results against soybean rust using foliar fungicides. One question that is still to be answered, however, is if North American soybean producers have the capacity to spray fields as quickly as may be needed during a soybean rust epidemic. This could be a special challenge in areas of the country that have historically relied on custom applicators to apply pesticides.

### Recent Fungicide Special Labeling Activities

The normal route of pesticide registration in the United States is through Section 3 of the Federal Insecticide, Fungicide, and Rodenticide Act of 1947 (FIFRA). This Act has been amended several times (most extensively in 1972), but it remains the foundation for pesticide regulation. Registration of all pesticides is handled by the

**Although fungicides are an important soybean rust management tool, it should be noted that only a few fungicides currently have a federal label for use on soybean in the United States and Canada. Registrations and recommendations will change over time as more products move through the registration process and obtain full Section 3 labels, as compared to Section 18 Emergency Use labels, and as we become more familiar with the level of control provided by each of these products. The comments presented here are intended to provide general information about currently registered fungicides. It is always the applicator's responsibility to read and follow all label instructions. In today's modern agriculture, regulations and recommendations can change rapidly; therefore, check with your local agricultural supply dealer, or the pesticide manufacturer, for updated label information prior to making applications.**

U.S. Environmental Protection Agency (EPA). Section 3 of FIFRA provides the normal pesticide registration process. However, the EPA acknowledges that there are needs for exceptions to the general process. As such, sections are provided in the law that allow for rapid response to critical issues, thus giving states a legal avenue to address special local needs (Section 24c exemptions) or emergency/crisis situations (Section 18 exemption). Thus, producers may have access to products that are not specifically labeled for a given crop or pest, but have been shown to effectively control the pest in question. For clarifications on these rules, contact your state or provincial Department of Agriculture.

In response to the recognition that soybean rust could become a serious problem in North America and that there was an inadequate supply of labeled, efficacious fungicides, a Section 18 template was developed in the winter of 2003 to facilitate submission of Section 18 applications to EPA from each soybean-producing state. Several products were proposed, based on the best available information, from among products that had been evaluated against soybean rust in other countries. Over the coming years, the preferred products will likely change as more data are generated in the United States. Each state must request a Section 18 from

EPA for a product to be legally available for use by growers in that state.

In Canada, a similar need for efficacious fungicides resulted in an Emergency Use Submission to the Pest Management Regulatory Agency (PMRA) in 2004. More products will be submitted to PMRA in the future. As well, a full Canadian registration of these products will be pursued for soybean rust control.

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### Purpose of Publication

Foliar applications of fungicides to the soybean canopy will be the standard disease-management practice to limit yield losses due to soybean rust for the foreseeable future. This bulletin reviews the factors involved in making fungicide spray decisions and basic fungicide information, including mode of action, application, and use strategies. Specific recommendations for each state, province, or region are likely to vary depending on whether sources of rust inoculum are within the region, state, or province; how conducive the weather is for soybean rust; the growth stage of soybean when rust becomes a threat; yield potential of the crop; and price of soybeans. For these reasons, be sure to consult local soybean rust management guidelines and information when making decisions on best management practices for soybean rust control.