



Extension FactSheet

Food, Agricultural and Biological Engineering, 590 Woody Hayes Drive, Columbus, Ohio 43210

Spraying Recommendations for Soybean Rust

H. Erdal Ozkan

Professor and Extension Agricultural Engineer
Food, Agricultural and Biological Engineering

Asian soybean rust (*Phakopsora pachyrhizi*) officially arrived in the United States in the fall of 2004. It was first found on soybean leaf samples collected from research plots near Baton Rouge, Louisiana. It has been slowly moving northward. This movement is expected to continue affecting many more areas, including Ohio. Historical and most current soybean yield losses due to rust around the world vary from negligible to complete loss of crop depending on many factors including, severity of the disease outbreak, timing of infection, selection of fungicides and their timely application using **the most effective equipment**. If not detected and treated immediately after its detection, this disease can cause complete defoliation of soybean plant within two weeks.

There are no soybean varieties currently available that have high levels of resistance to soybean rust. Researchers will find such varieties some day, but according to the most optimistic predictions, this may not happen for another five years. This leaves us with only one alternative option—be prepared to do as good a job as possible applying fungicides that are registered for protecting against or controlling this disease. Fungicides manufactured to control soybean rust are effective. However, success will largely depend on proper application done before the disease is detected. So what is the best spray equipment setup to do an effective job?

Before listing a number of *specific* spraying recommendations for soybean rust, I would like to remind applicators of the five major *general* spraying principles that result in satisfactory and economic control of the problem, regardless of whatever it is that we are trying to control: 1) positive identification of the disease; 2) using the right pesticide; 3) selecting the right equipment, and particularly the right type and size of nozzle for the job; 4) applying the pesticide at the right time; and 5) checking the accuracy of equipment periodically to make sure that we are applying the amount recommended on the label.

Spraying the *right amount* of fungicide on each acre of soybean is not enough to achieve effective pest control. How uniformly the fungicide is deposited on the spray target is as important as the amount deposited. Each nozzle produces a unique spray pattern. Some nozzles require precise overlapping of patterns from adjacent nozzles. Setting the proper boom height for a given nozzle spacing is extremely important in achieving proper overlapping. A low boom does not allow proper overlap while a boom set too high causes overdosed areas. Check the nozzle catalog to determine the proper boom height recommended for different nozzle spacings. Other situations that cause improper overlapping and poor uniformity include: clogged nozzles, misaligned nozzles spraying at different directions, and mixing nozzles with different spray angles. These common errors all contribute to uneven distribution of fungicides across the spray swath.

Key to success: Thorough coverage of the soybean canopy

The single most important factor affecting the control of this disease is to get a **thorough coverage** of soybeans with the fungicide, which is much different and more challenging than spraying for weeds and insects. How do we get the most effective coverage on soybean leaves? The answer to this question is much easier when we are dealing with a problem that is visible, and on the top part of the canopy, as is usually the case with weed control. In such situations we will be fairly satisfied if we can achieve a good uniformity of coverage on the horizontal plane. Unfortunately, with soybean rust, we are going to be concerned with both the horizontal as well as vertical distribution of the fungicide on soybean leaves. Soybean rust first shows its symptoms usually in the lower parts of the plant and works itself up towards the top of the plant. So, by the time we notice the problem in the mid- to upper canopy,

it may be too late to spray any fungicide. Complete coverage of the disease could be even more challenging if the symptoms of the disease are found at later stages of plant growth when the plant is close to having the full canopy. Penetrating droplets inside the canopy of a fully grown plant is a much bigger challenge for us.

So, which spray equipment setup is likely to provide the best defense against soybean rust? Unfortunately, in the United States we do not have efficacy data for soybean rust with different equipment yet. However, we do have spray coverage data from several research projects dealing with other soybean diseases such as *Sclerotinia* stem rot that require probably the same type of equipment setup for effective control. Does good coverage correlate with efficacy? Yes, at least most of the time. Findings from some of our research on fungicide applications on vegetables indicate that the control was equally good regardless of the nozzle arrangement used, in spite of the fact that there were differences in coverage on the plant among these nozzle arrangements. But in most cases, there is a very strong correlation between coverage and efficacy.

How to achieve the best coverage

There are basically two ways to increase coverage: 1) reduce droplet size; and 2) increase carrier volume (application rate). Large droplets don't provide good coverage and result in waste of chemical. Increasing the application rate may be equally undesirable. It requires frequent refilling of the sprayer tank. This wastes time that may be extremely valuable when there is a short window of opportunity to spray. Ideally, we want to have as many small droplets on the target as possible. However, extremely small droplets have a tendency to drift. Research has shown that there is a rapid decrease in the drift potential of droplets whose diameters are greater than approximately 200 microns. When extremely small droplets are released from the nozzle, they quickly lose the momentum that is needed to push the droplets into the canopy. Also, these extremely small droplets do not last long after they are released from the nozzle. Most of them evaporate within a few seconds.

However, there is a way to utilize most of the droplets that may normally drift—using the air-assist technology. Air flow carries these small droplets into the canopy where they can have a chance to deposit, rather than drift away. In all the spray coverage tests using different sprayers we conducted in Ohio, air-assisted sprayers consistently provided the best coverage on targets placed well inside the canopy. This advantage was even more noticeable when we compared the spray deposits on the underside of plant leaves.

For example, we conducted research on determining which equipment setup would provide the best coverage on a soybean plant to control *Sclerotinia* stem rot (cooperators on this research project: Dr. Anne Dorrance, Plant Pathologist, OSU

Extension; and Dr. Richard Derksen, Agricultural Engineer, USDA-ARS). Because flower petals are the sites of primary colonization of this disease, the application of fungicides must be directed at soybean flower petals, especially in the lower portions of the crop canopy. Once established, infections can spread to leaves, petioles, internodes, and also adjacent plants through contact with diseased plants. Flower petals are very close to the stem of the plant and about at two-thirds of the height of the plant. The challenge to reach the flower petals is similar to the challenge to reach soybean rust spores well hidden in lower parts of the plant canopy.

We compared coverage from four different nozzle/equipment setups: XR8002 conventional flat-fan, TT110015 low-drift flat-fan, D2-23 Disc-core hollow cone, and an air-assisted sprayer fitted with XR110015 flat-fan nozzles. A pair of 1/4-inch map tacks were used as simulated soybean flower buds at two elevations: 20 inches (representing middle elevation), and 12 inches (representing lower elevation) above the ground. Upper elevation on plants was not evaluated because it was assumed that all sprayers could treat this area effectively well and it was assumed that disease incidence would be greater deeper in the canopy. Map tack targets were placed on the soybean stem in the area of flower buds. The plant height ranged from 30 to 34 inches at the time of spraying. The travel speed was 3 mph, and the application rate was 20 gpa. Target map tacks were removed after spraying and washed. The wash solution was then evaluated to determine the amount of deposit on the target. Results from this research are shown in Table 1.

The key conclusions from this research are as follows:

- No significant differences among conventional broadcast sprayers but the low-drift Turbo TeeJet nozzle (TT110015) did produce the highest deposits and the cone nozzle (D2-23) produced the lowest deposits.
- Myers air-assist produced significantly higher deposits at both elevations than all the other sprayers.
- Myers air-assist produced higher deposits in the lower elevation than any of the other sprayers produced in the middle elevation.

All the results mentioned above could be applicable to spraying for soybean rust. So, it is very clear that an air-assisted sprayer is the best equipment option we have if our goal is to achieve the best coverage of soybeans with the fungicide. Unfortunately, a commercial-scale sprayer with the air assistance may add from \$10,000 to \$15,000 to the price tag of the equipment. However, this one-time cost may well outweigh the income lost due to soybean rust in one growing season.

Proper operation of an air-assisted sprayer is important for taking full advantage of the air assistance. Operating it with improper air flow may even be counter-productive. The amount of air flow should be adjusted depending on the canopy

Table 1. Mean target deposits by treatment and elevation

Sprayer Treatment	Nozzle Pressure (psi)	Middle Elevation Mean Deposit ($\mu\text{g}/\text{cm}^2$)	Lower Elevation Mean Deposit ($\mu\text{g}/\text{cm}^2$)
Myers Air-Assist**	28	725.6	397.0
TT110015 (flat fan; low-drift)	71	283.0	199.0
XR8002 (flat fan)	43	267.3	188.6
D2-23 (hollow cone)	240	232.7	158.0

** The sprayer was equipped with XR110015 flat-fan nozzles

Which nozzle type is the best for applying rust fungicides?

Most nozzles will do the job. The key to success is to select a nozzle type and size that will produce a spray quality that is classified as *Fine to Medium*. The nozzles we use currently produce droplets that vary greatly in size. The range of droplets from a nozzle is also affected by liquid flow rate (size of nozzle orifice), liquid pressure, and physical

density. Also, air directed 30 to 45 degrees forward or backward seems to provide better penetration of droplets into the canopy, and especially a better leaf underside coverage, than when the air flow is straight down. Specific recommendations provided by the manufacturers of air-assisted sprayers should be followed for best results.

Another way to improve coverage on soybean canopy is to use directed spraying to cover the plant with more than one nozzle from different angles (from top and both sides). Directed spraying generally provides better penetration of droplets into the canopy. This technique is used with much success for insect and disease control on row crops, especially vegetables. Most soybeans are solid seeded or planted in narrow rows. Therefore, directed spraying technique may not be practical. However, if beans are planted in 30-inch rows and if there is sufficient open space between the rows at the time of spraying, take advantage of directed spraying. This can be accomplished by using special directed spraying kits with multiple nozzles per row, or drop pipes between soybean rows and attaching a double swivel nozzle to the ends of these pipes. The spray from each nozzle should be directed toward a row of soybeans. An additional nozzle can be placed on the boom directly above the row. Unfortunately, in most cases, the directed spraying with drop pipes will be impractical because the disease may usually occur when the canopy is well established, and there is not enough clearance between the rows for the pipes to go through.

changes to nozzle geometry and operation. To help applicators select nozzles and use them at the most optimum droplet size range for a given situation, ASAE (American Society of Agricultural Engineers) has developed a classification system. According to this system, spray quality from a nozzle can be classified as: Very Fine, Fine, Medium, Coarse, Very Coarse, and Extremely Coarse. Also, a unique color is assigned to each category (this color coding should not be confused with the color coding for flow rates).

ASAE Standard S-572 Spray Quality Categories	
Category	Color
Very Fine (VF)	red
Fine (F)	orange
Medium (M)	yellow
Coarse (C)	blue
Very Coarse (VC)	green
Extremely Coarse (XC)	white

Fine to Medium spray quality (approximately 200–300 micron in size) is recommended by nozzle manufacturers for application of fungicides for soybean rust. To achieve this, choose the right type and size of nozzles and operate them at

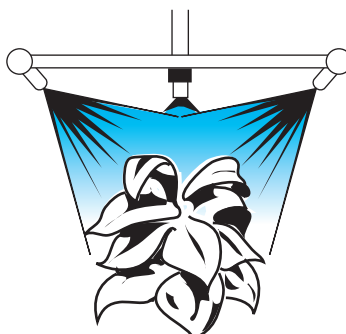
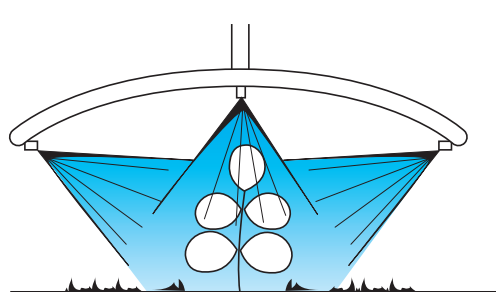


Table 2. Example chart showing spray quality for different size nozzles at different pressures.

Nozzle Size	Pressure (psi)										
	15	20	25	30	35	40	50	60	70	80	90
11001	C	M	M	M	M	M	F	F	F	F	F
110015	C	C	M	M	M	M	M	M	F	F	F
11002	C	C	C	M	M	M	M	M	M	M	F
11003	VC	VC	C	C	C	C	M	M	M	M	M
11004	XC	VC	VC	C	C	C	C	C	M	M	M
11005	XC	VC	VC	VC	VC	C	C	C	C	M	M
11006	XC	XC	VC	VC	VC	C	C	C	C	C	M
11008	XC	XC	VC	VC	VC	VC	C	C	C	C	M

the appropriate pressure. Nozzle catalogs have charts, as shown in Table 2, to help you find out at what pressure the nozzle you picked will produce Fine to Medium quality spray. For example, all the sizes of the same flat-fan nozzle (from 0.01 to 0.08 gpm) shown on Table 2 will be suitable for application of rust fungicides because each one has the potential to produce a spray quality of Fine to Medium at specific pressures. The choice of nozzle type and size for rust fungicides will depend on the application rate you choose, and the ability of your sprayer components, especially the pump, to provide the desired spray quality at the travel speed and spray pressure you want to operate the sprayer. Take these two facts into consideration as you select the travel speed when spraying.

Spray coverage is usually improved at slower speeds. Also, it is proven that the higher the travel speed, the higher the drift. Don't let someone else take the benefit of the fungicide that you purchased. As you select the nozzle size, choose Medium spray quality over Fine when drift is a concern.

Nozzles producing a cone pattern may work for soybean rust, but since they produce a higher portion of extremely small (less than 100 micron) droplets than flat-fan nozzles at any given pressure, the flat-fan pattern nozzles are still the best choice as long as the spray quality from these nozzles is categorized as Fine to Medium. In the study for Sclerotinia stem rot mentioned above, the cone nozzle gave the least amount of deposits on targets hidden in both the middle and lower elevation of soybean plants.

A flat-fan nozzle setup with two spray patterns (see pictures below) seems to provide a better coverage of plants with fully developed canopies. Research has shown that hitting the

target from two different angles, with one forward and one backward spray pattern, provides a more effective coverage than spraying with just one spray pattern shooting down. Several nozzle manufacturers have either the nozzles that provide a twin spray pattern from one tip (picture on the left), or special fittings/caps that allow the producers to place two nozzles in the same cap, one pointed forward, and the other one pointed backward. If the two nozzle setup is used, the nozzles should be size 2 (0.2 gpm at 40 psi) or higher to avoid generating a high number of extremely small droplets. Choose size 4 or above when using nozzles as shown on the left below.

Should you combine rust fungicide application with herbicide application?

The answer is **no**. Unfortunately some fungicide labels don't mention anything about this. Some other labels give recommendations that are either not adequate or simply not accurate.

Although some may think that tank mixing fungicides with herbicides and making just one application instead of two to reduce application costs is a good idea, this practice usually leads to poor performance of both chemicals. The reasons for this are:

- The best time to treat weeds may not be the best time to spray for fungicides, or vice versa. Spraying a tank mix that contains both a herbicide and a rust fungicide most likely will result in unsatisfactory control of either rust or weeds, or both. A second application to treat rust or weeds may be necessary. This however may not even be an option for application of rust fungicides because serious damage may have taken place by the time you realized the combined application of fungicides and herbicides did not control rust.
- Fine to Medium spray quality, recommended for rust fungicide applications, presents a high degree of risk for drift. The reason we can still recommend this spray quality when spraying rust fungicides is that drift of these products is not as serious an issue as drift of many herbicides. Fungicides are not likely to create physical damage on plants nearby. That is not the case for many herbicides such as Glyphosate.



Spraying these products with a sprayer set up to produce Fine to Medium spray quality could result in costly damage to nearby vegetation. Don't take this risk.

- Most systemic herbicides such as Glyphosate don't require higher spray volumes. They may even work better at lower application rates of 5–7 gpa. Unfortunately, such low application rates will not provide as good a spray coverage on the plant as higher application rates will. Recommended rate for rust fungicides is above 15 gpa.

Is aerial application as effective against soybean rust as the ground applications?

No efficacy data is available in the United States to answer this question. However, according to a study conducted by researchers in Brazil, if the aircraft applying rust fungicides is set up with the proper nozzles and operated properly, aerial spraying could be as effective as ground applications for controlling soybean rust. The researchers compared the fungicide coverage on soybean leaves, and yield increases and efficacy levels achieved from ground and aerial applications. Average infection rate associated with all ground and aerial treatments varied from 0.6 to 2.3%. The differences in infection rates were found not to be statistically significant. Coverage on the upper part of the canopy was not significantly different among treatments. However, ground applications provided considerably higher coverage rates than aerial applications at the middle and lower parts of the canopy.

There is no consensus on application rates, but a rate less than 3 gpa is not recommended for aerial applications. Optimum rates vary between 5–7 gpa depending on the density of the soybean canopy.

Summary

Soybean rust is a serious disease. But it can be controlled if the right fungicide is applied with the most effective equipment at the right time. Detecting the disease early and using the most effective control mechanism are keys to controlling this disease. It is best to combat this disease by applying “preventative” fungicides before the disease is detected in the area. If these types of fungicides are applied too early, they may lose their ability to control rust when rust arrives. Therefore, scouting of the field for soybean rust throughout the growing season is extremely important. If the disease has taken a good hold in the field, then your best option is to apply “curative” type fungicides as quickly and properly as possible.

The information presented in this publication is rather general. There is a wealth of information on the internet on

soybean rust and the application equipment to spray rust fungicides. Do a search using key words such as “soybean rust,” “nozzles,” and “spray equipment” to obtain more up-to-date and specific information on this topic. Here are again the key recommendations discussed in this publication:

- Carefully read and follow the specific recommendations given on the fungicide label, and in the nozzle catalogs and sprayer operator's manual.
- Calibrate the sprayer to make sure that the amount recommended on the label is applied.
- Check the sprayer setup to make sure the amount sprayed is distributed evenly across the spray swath.
- Thorough coverage of the plant from top to bottom is the key to success. Choose the appropriate size and type of nozzles and operate them at a pressure that will allow them to produce Fine to Medium spray quality.
- Probability of spray drift is much greater when using fine to medium droplets than coarser droplets used for application of some other types of pesticides such as herbicides. Take all the precautions to reduce spray drift. Not only is drift bad from health and environmental aspects, but it is also a waste of expensive fungicides you purchased for treatment of rust.
- For best results, keep the spray volume (application rate) above 15 gpa for ground and 3 gpa for aerial applications.
- Flat-fan nozzles are better than cone nozzles because they produce a much smaller proportion of extremely small, drift-prone droplets.
- Use twin nozzle/pattern technology. Two nozzles (or spray patterns) angled (one forward, one backward) work better than single nozzles spraying down.
- To improve coverage, if applicable, use directed spraying.
- Air-assisted spraying usually provides the best coverage and droplet penetration into the canopy when beans reach their full or near-full growth stage. Follow the manufacturer's recommendations for proper setup and operation of the air-assist sprayers.
- If possible, slow down when spraying. Spray coverage usually is improved at slower speeds. Also, it is proven that the higher the travel speed, the higher the drift.
- Be safe. Wear protective clothing, rubber gloves, and respirators when calibrating the sprayer, doing the actual spraying, and cleaning the equipment.

This fact sheet, as well as other information on soybean rust, is available at Ohio State University Extension's web site “Ohioline” (<http://ohioline.osu.edu>) by clicking on “Search” and entering “soybean rust” in the search box.

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Keith L. Smith, Associate Vice President for Agricultural Administration and Director, OSU Extension

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