

Asian Soybean Rust: Fungicide Application Technology

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Summary

- Asian soybean rust (ASR) is now in the southern and SE U.S. This means that soybean growers in the U.S. and Canada must be prepared to manage the disease.
- The only means of controlling ASR is monitoring for rust movement, scouting fields, and applying fungicides if needed. Apply when 0 to 5% of leaves have one or more lesions.
- Spray coverage needed to control ASR is much greater than that needed to control weeds with glyphosate herbicides. Spray must penetrate the soybean canopy and cover both sides of all leaves, especially in the lower part of the plant.
- Soybeans need to be protected during the critical reproductive period (R1 to R6). In some areas, more than one application may be needed to protect soybean yield.
- Aerial as well as ground applications have proven successful in controlling soybean rust in Brazil. Aircraft can cover large acreages quickly, and are not limited by wet soils.
- Application technologies, both ground and aerial, play an important role in fungicide efficacy for ASR management (see spraying specifications in the sidebar on page 2).
- Growers can choose among scouting-based, reduced scouting and calendar-based fungicide application programs. The choice depends on risk acceptance, scouting requirements, equipment availability, and geography.

Introduction

Asian soybean rust (ASR) is a destructive leaf disease of soybeans now present in most areas of the world where soybeans are grown. ASR has caused extensive damage to soybeans in Brazil over the last several years, and was first found in the southern and southeastern U.S. in the fall of 2004. This means that all soybean growers in the U.S. and Canada must now be prepared to manage the disease. At this time, the only effective means of management is immediate fungicide application when the disease is detected. A previous Crop Insights (*Asian Soybean Rust*¹) has addressed disease biology and identification, including scouting and sampling procedures. Another article (*Asian Soybean Rust: Fungicides*²) provides more information on fungicide types, selection and use. This article will address application technology for Asian soybean rust management.

Fungicide Application

Fungicide application is currently the only means of controlling Asian soybean rust. However, as soybean growers in Brazil have demonstrated, it can be very effective, even when rust pressure is intense. The keys to successful management include monitoring for rust movement into the area, regular scouting, timely application of effective, long-lasting fungicides, good spray coverage, and in some cases, re-application.

Scouting

Soybean fields should be scouted systematically after flowering, as southerly weather systems move northward, or after a report of ASR in your area. Look first in field areas most conducive to disease development including low-lying areas, wet areas, or along tree lines. Check the lower soybean canopy using a 20x or higher hand lens, and know how to differentiate ASR from other soybean diseases.



Figure 1. A hand lens of at least 20x to 30x magnification is a necessary tool in diagnosing ASR symptoms.

In more southern areas of the U.S., scouting of volunteer soybean plants and other susceptible weed and plant hosts are also important. These plants can serve as a reservoir from which the fungus spreads to new plantings. For more information on scouting, see the Crop Insights entitled *Asian Soybean Rust*¹.

Timely Application

Because ASR often spreads very rapidly and aggressively after initial spores are deposited, spraying should begin immediately after detection and identification of the disease. These guidelines are different than those for some other diseases and insects, which require that certain threshold levels are reached before spraying is recommended.

Some fungicides function only to **prevent** fungal infection. Once infection has occurred, preventative fungicides cannot

stop further development of the disease. For this reason, when using a preventative-only fungicide, fields should be sprayed prior to leaf infection. In practice, if rust movement into the area is monitored and fields are regularly scouted, spraying can often be accomplished before 5% rust incidence in the field (i.e., before 5% of leaves have any infection). Such timely applications can largely prevent yield losses due to the disease. Timely application is key to improving the performance of all fungicide products.

Soybean leaves can be infected at any time with ASR. However, research and experience has shown that the most critical time to protect soybean plants with fungicides is from the R1 through R6 growth stages. This is the critical period of soybean pod and seed development that is also sensitive to other stresses such as drought and aphids. Fungicide applications should not be initiated after the R5 growth stage, however. Most fungicide labels prohibit it, and applications at this stage are too late to protect yield.

Spray Coverage

ASR spreads by windborne spores that infect soybean leaves. As rust lesions mature, they give rise to thousands of additional spores. Over time, large spore loads build up within fields and across large geographical areas. Because of these potentially large spore loads and the nature of some fungicides, achieving thorough spray coverage of all soybean leaves is critical to successful control.

ASR infections begin in the lower canopy where humidity is higher and leaves stay wet for longer periods, and move up the plant from there. For this reason, the lower soybean canopy is the primary spray target. Both upper and lower leaf surfaces must be sprayed. Coverage as dense as 400 spray droplets per square inch is considered ideal.

Fungicide vs. Glyphosate or Insecticide Application

Although most soybean growers have not sprayed soybeans with fungicides, they have extensive experience with spraying glyphosate herbicides, and recent experience with spraying insecticides for soybean aphids. It is important to understand that the spray coverage needed to control weeds with glyphosate is much less than that needed to control soybean rust with fungicides. In fact, nozzles, spray pressures, spray volumes, and even ground speed may all be different between these two spraying objectives. On the other hand, the spray coverage needed to control soybean aphids is similar to that needed to control ASR (Table 1).

Spray Volume

Ground fungicide applications require a sufficient volume of water for adequate leaf coverage and especially canopy penetration. For this reason, experts suggest a volume of 10 to 20 gallons per acre. Lower volumes are often less effective, but excessive volumes can also be less effective if run-off occurs. Higher volumes also result in less acres covered per day, and timely coverage is essential to control this disease.

Spraying Specifications for ASR Management*

- Target:** All soybean leaves, both leaf surfaces. Lower soybean canopy is critical area.
- Timing:** After ASR is detected in field but before 5% incidence (for first application).
- Reapplication:** If new ASR lesions develop before R6. Check fungicide label for residual activity period.

Ground Specifications

- Volume:** 10 to 20 gallons/acre
- Pressure:** Depends on nozzle – usually 50 psi or higher
- Nozzles:** Twin Flat Fan, Flat Fan
- Droplets:** Medium-fine (less than 220 microns in size)
- Coverage:** 400 droplets per square inch is ideal
- Height:** Boom 12 inches above canopy (see Fig. 2).

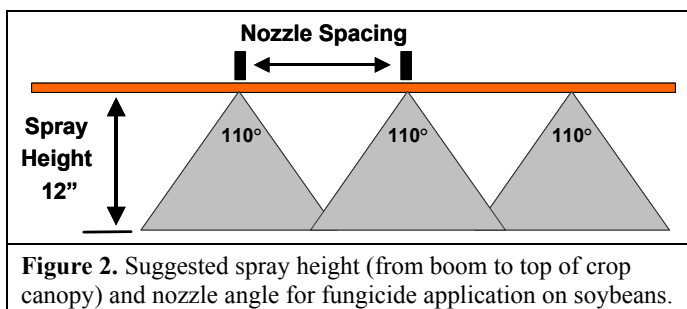
Aerial Specifications

- Volume:** At least 4 gallons/acre
- Height:** 12 feet above canopy
- Other:** Research and experience needed on achieving good leaf coverage with aerial applications.

***Avoid applications under adverse conditions:** temperature above 100 F, relative humidity below 55%, and wind velocity above 5 miles/hour.

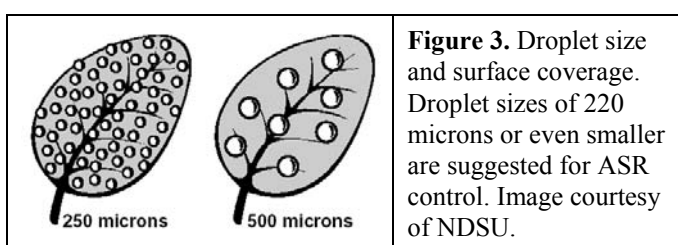
Table 1. Spraying goals and specifications for glyphosate, insecticide and fungicide ground applications on soybeans.

	Glyphosate	Insecticide	Fungicide
Spray Target	Weeds – not soybean plants or leaves per se	All soybean leaves and stems, including bottom surface of leaves	All soybean leaves, especially lower part of plant and bottom surface of leaves
Drift Control	Critical to prevent damage to adjacent crops or plants	Generally important when using pesticides to prevent off-target movement	Generally important when using pesticides to prevent off-target movement
Volume	10 gal/acre	10 to 20 gal/acre	10 to 20 gal/acre
Pressure	20 to 30 psi, depending on nozzle	40 to 50 psi, depending on nozzle	50 psi or higher, depending on nozzle
Nozzle Type	hollow cone or other	Twin flat fan or flat fan	Twin flat fan or flat fan
Restrict Sprayer Speed?	Usually not necessary	May be necessary to help insure uniform coverage	May be necessary to help insure uniform coverage



Nozzles

By controlling the amount and uniformity of spray, nozzles are instrumental in determining the coverage of fungicide applications. The combination of nozzle tip and pressure determines the spray droplet size, which affects both plant coverage and drift potential. Droplet sizes in relation to leaf area are shown in Figure 3.



As figure 2 demonstrates, small spray droplets provide better leaf coverage, but if droplets are too small, they may fail to penetrate the canopy or drift off-target. The nozzle actually creates a spectrum of droplet sizes, depending on the nozzle design, opening size and pressure. A medium to fine droplet size spectrum (220 microns or smaller) should give best spray coverage for controlling soybean rust.

Table 2 shows droplet size ranges appropriate for various spraying objectives.

Table 2. Spray droplet size classification and uses.

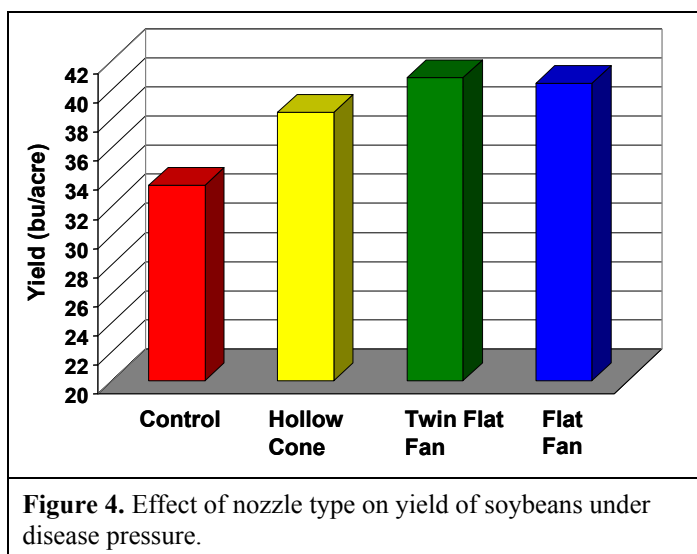
Droplet Classification	Droplet Size (microns)	Recommended Uses
Fine	119 - 216	Insecticides and Fungicides
Medium	217 - 353	
Medium	217 - 353	Herbicides and Postemergence
Coarse	354 - 464	
Very Coarse	> 464	Soil Applications of Herbicides

Nozzle Type: Nozzle manufacturers have created various nozzle tip designs including flood, fan and cone nozzles. Most soybean growers are familiar with these nozzle designs, particularly flat fan and hollow cone nozzles for post-emergence applications to soybeans. Although hollow cone

nozzles can be used for fungicide applications, they create many fine droplets that won't penetrate the canopy.

Extended range flat fan nozzles have been proven very effective in creating the droplet size spectrum needed to penetrate the soybean canopy and achieve good leaf coverage. These are available in "twin" designs which produce two flat-fan patterns, one angled forward and one backward. One twin design has a single nozzle tip with two spray openings; another has a cap that holds two individual tips.

Studies were conducted in Brazil to determine the effect of nozzle type on soybean yield under disease pressure (Figure 4). As the graph indicates, nozzle type did have an effect on final soybean yield. The twin flat fan nozzles did the best job of protecting soybean yield from losses due to disease. In this case, the disease was mildew, but the same principles apply to ASR.



Aerial Application

Aerial applications have proven successful in controlling soybean rust in Brazil. Because they can cover large acreages very quickly, and are not limited by wet soil conditions, aircraft have significant advantages in timeliness over ground sprayers. Aerial applicators in Brazil have used systemic products and developed new application methods, such as applying one gallon/acre with oil suspension.

Aerial applicators in the U.S. may have to experiment with these and other techniques to achieve the spray coverage needed to control ASR. According to Scott Bretthauer, application technology specialist at the University of Illinois, controlling spray droplet size should allow aircraft to achieve soybean rust control with volumes of five gallons per acre, at heights of 10 to 14 feet above the canopy. Flying higher allows for wind effects on spray droplets; flying lower results in air turbulence in the crop canopy that interferes with spray deposition.

Bretthauer suggests that applicators use [the Aerial Spray Nozzle Models](#) developed by the USDA-ARS to set up their aircraft to create the droplet spectrum required for the job.

Research by DuPont and universities on aerial application methods for ASR management is continuing. Those results will be shared with customers as studies are completed.

Fungicides

Fungicides can be classified in a number of ways, but the simplest classification divides them into three categories, contact, penetrant/locally systemic, and systemic. Properties of these fungicide types are shown in Table 3.

Table 3. General properties*of contact, penetrant/locally systemic and systemic fungicides.

Contact Fungicides	Penetrant / Locally Systemic Fungicides	Systemic Fungicides
Preventative function	Preventative function	Preventative and curative function
Multi-site biotic inhibitors	Single-site biotic inhibitors	Single-site biotic inhibitors
Less resistance chance	Greater resistance chance	Greater resistance chance
Higher doses	Lower doses	Lower doses
More applications	Moderate applications	Less applications
Low residual	Low to medium residual	Medium to high residual

*These are general properties and exceptions may exist.

Distinctly different properties between fungicide types have important implications for spraying. Contact and penetrant fungicides, by nature, require even better spray coverage than systemics. Contact fungicides, because they do not penetrate the plant tissue, are more easily removed from the leaf by rain and other weather effects. This results in a shorter residual control period and more frequent re-application requirements vs. systemic fungicides. Re-spray interval is an important factor in analyzing the cost benefit of one fungicide vs. another.

Fungicide Selection

The ASR organism completes many reproductive cycles in a single growing season. This property allows it to change rapidly, and increases its chances of overcoming fungicide effectiveness over time. Cases of fungal disease populations becoming less sensitive to fungicides are documented for other diseases. For this reason, growers should be careful to follow best management practices to maximize fungicide performance in order to maintain its effectiveness for ASR control. More information on fungicide types, chemistries and modes of action is available in the Crop Insights, *Asian Soybean Rust: Fungicides*².

Re-application

Many experts predict that in northern U.S. states and Canada, soybean rust management will require, at most, one fungicide application per year. Even in more central Midwest states, one fungicide application may suffice most years. But in years with early spore movement from southern states and weather conducive to rust development, re-application of fungicides will sometimes be needed. In southern and mid-southern states, multiple applications will likely be common.

In areas with intense ASR pressure, growers have found that timely re-application of fungicides is just as important to success as initial application. The keys to timeliness begin with understanding the fungicide's residual activity period as stated on the product label, and then closely monitoring the crop as the period expires. If new lesions are found at this time, another application may be needed. In general, the contact only fungicides such as Bravo⁵ and Echo⁶ give about 7-10 days of protection. Locally systemic, preventative fungicides such as Quadris⁵ and Headline⁷ offer about 14 days of protection. Systemic products such as those in the triazole family (e.g., Folicur⁸) generally give 14 to 21 days of protection, depending on the environment.

Number of Applications

Product labels specify how many fungicide applications are allowed on a single crop per year, so read the label carefully. In addition, for all products receiving a section 18 emergency use registration, a maximum of two total applications using approved section 18 products collectively may be made, according to the EPA. This does not rule out two applications of section 18 products, and an additional application(s) of other registered products, if the label permits. It is unlikely that more than three applications of fungicides will be needed, or economically justified.

Asian Soybean Rust Management Checklist

- Start fungicide applications early (0 to 5% rust incidence).
- Select nozzles, pressures and volumes to achieve deep penetration and full coverage of the soybean canopy.
- Protect soybeans from rust infection during the critical period – the R1 to R6 soybean growth stages.
- Check fungicide label for residual control period (generally 7 to 21 days, depending on fungicide).
- Check fungicide efficacy data for their preventative vs. curative activity.
- Be prepared to make one to three fungicide applications, as needed, to protect soybean yields.
- Assess equipment condition and capacity. How long would it take to cover all soybean acres?

Fungicide Application Programs

Growers can choose among three principle types of programs for managing ASR: scouting-based, reduced scouting and calendar-based fungicide applications. If executed properly and in a timely manner, each of these programs can give very good control of soybean rust and largely protect soybean yield. The choice depends on risk acceptance, scouting requirements, equipment availability, and even geography (Table 4.)

Table 4. Criteria for selecting a fungicide application program.

	Spray Program Based on Disease Presence (Scouting or Reduced Scouting)	Spray Program Preventative or Calendar-Based
Risk Acceptance	High	Low
Scouting Demand	High	Low
Equipment Availability	On Demand	Contract
Geographic Fit	Northern and western U.S., Canada	Southern, south-eastern, eastern U.S.

*Exceptions may exist to the general principles presented in this table.

Characteristics of scouting-based, reduced scouting and calendar-based fungicide application programs are shown in table 5 (on the following page).

References

1. Schuh, W. and S. Butzen, 2004. Asian Soybean Rust. Crop Insights Vol.4 no. 20. Pioneer Hi-Bred. Johnston, Iowa. http://www.pioneer.com/usa/agronomy/soybeans/asian_soybean_rust.htm

- Butzen, S., F. Beudot, and B. McInnes, 2005. Asian Soybean Rust: Fungicides. Crop Insights Vol. 5 no. 2. Pioneer Hi-Bred. Johnston, Iowa. http://www.pioneer.com/usa/agronomy/soybeans/soybean_rust/asian_soybean_fungicides.htm
- McInnes, B., A. Marcon, and R. Gueddens. 2003. DuPont Crop Protection Fungicide Training Guide. DuPont Crop Protection. Wilmington, DE.
- McInnes, B., A. Marcon, R. Kczmarczyk, and M. Martin. 2004. DuPont Crop Protection Fungicide Application Technology Training Guide on Soybeans. DuPont Crop Protection. Wilmington, DE.

⁵Bravo, Quadris and Tilt are registered trademarks of Syngenta.

⁶Echo is a registered trademark of Sipcam Agro, Inc.

⁷Headline is a registered trademark of BASF.

⁸Folicur and Stratego are registered trademarks of Bayer.

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Table 5. Characteristics of scouting-based, reduced scouting and calendar-based fungicide application programs.

Scouting-Based Application Program	Reduced-Scouting Application Program	Calendar-Based Application Program
<p>Initial fungicide application based on scouting your fields</p> <p>Scouting done on a regular basis (twice weekly)</p> <p>Scouting done based on occurrence of conducive weather systems</p> <p>Scouting done based on USDA/ARS spore deposition model</p>	<p>Initial fungicide application based on reports of soybean rust in area</p> <p>This information could be obtained from:</p> <ul style="list-style-type: none"> USDA/APHIS web-based rust survey Pioneer Hi-Bred website Radio broadcasts Soybean rust-related websites 	<p>Fungicide application based on soybean growth stage</p> <p>1st application – Flowering (R1)</p> <p>2nd application – 14 - 21 days later based on fungicide residual activity</p> <p>3rd application – 14 - 21 days later based on fungicide residual activity</p>
<p>Typical Spray Schedule</p> <p>1st Spray when rust is detected in your field or close vicinity - triazole*</p> <p>2nd Spray – Start scouting 14 - 21 days after first application depending on fungicide residual activity</p> <p>If there are new infections, apply triazole or triazole/strobilurin** mix.</p>	<p>Typical Spray Schedule</p> <p>1st Spray when rust is in vicinity – triazole (14 - 21 days efficacy)</p> <p>2nd Spray 14 - 21 days later – triazole or triazole/strobilurin mix</p>	<p>Typical Spray Schedule</p> <p>1st Spray at R1: Preventive fungicide strobilurin* (14 day efficacy) or chlorothalonil* (7 day efficacy x 2)</p> <p>2nd Spray (14 days later): Systemic fungicide – triazole (14 - 21 days efficacy)</p> <p>3rd Spray (14 - 21 days later): Fungicide mixture – triazole/strobilurin</p>
<p>Advantages</p> <p>Fungicide is only applied if disease is present – might reduce fungicide applications to one or none</p> <ul style="list-style-type: none"> – most economical strategy – saves on both fungicide and application costs – may be only profitable program for very low-yielding environments 	<p>Advantages</p> <p>First fungicide application only when necessary</p> <p>Might reduce schedule to 2 applications – one less than calendar-based schedule</p> <p>Reduced scouting effort compared to scouting-based program</p>	<p>Advantages</p> <p>May protect crop from flowering through seed fill (R1 - R6)</p> <p>May prevent yield loss due to ARS, and potential increase in yield and seed quality due to control of late season diseases</p> <p>Timeliness of application not as critical</p> <ul style="list-style-type: none"> – less risk that weather or fungicide/equipment availability may interfere
<p>Disadvantages</p> <p>Intensive scouting required</p> <p>Disease might be missed in field</p> <p>Timeliness of application more critical</p> <ul style="list-style-type: none"> – weather may interfere with spraying – equipment might not be available 	<p>Disadvantages</p> <p>Definition of rust distance to initiate fungicide application currently unknown</p> <p>Disease might be missed in field</p> <p>Reduced time for equipment staging</p> <p>Access to internet required</p>	<p>Disadvantages</p> <p>Fungicide application when no disease is present</p> <p>Most expensive treatment option</p> <p>May be profitable only in high-yield environments</p>

* Triazoles (e.g., Folicur) are systemic fungicides that are both curative and preventive; most have medium-high residual properties. Strobilurins (e.g., Quadris and Headline) are locally systemic fungicides that function to prevent fungal infection. Chlorothalonils (e.g. Bravo and Echo) are contact-only preventative fungicides with generally low residual activity. For more information on fungicides, see the Crop Insights entitled *Asian Soybean Rust: Fungicides*².