

Asian Soybean Rust: Fungicides

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Summary

- Fungicides, chemical substances that kill or inhibit the growth of fungi, have proven very effective at controlling Asian soybean rust (ASR) in major soybean-producing areas of the world.
- Fungicides can be classified by their general function (preventative or curative), mobility in the plant, and mode of action.
- Fungicide mobility ranges from immobile on the leaf surface to translocation within the entire plant. The mode of action refers to how fungicides affect the fungal organism, and is determined by their chemistry.
- To increase fungicide effectiveness, growers should select the fungicide with the highest level of control and apply before disease pressure is too severe.
- Four families of fungicides are available for ASR management – triazoles, strobilurins, chloronitriles, and carboxamides. Triazoles are both curative and preventative, with longer residual properties than most fungicide groups.
- Calculation of true cost of fungicides must include the component of residual activity, which allows determination of cost of fungicide protection per day.

Introduction

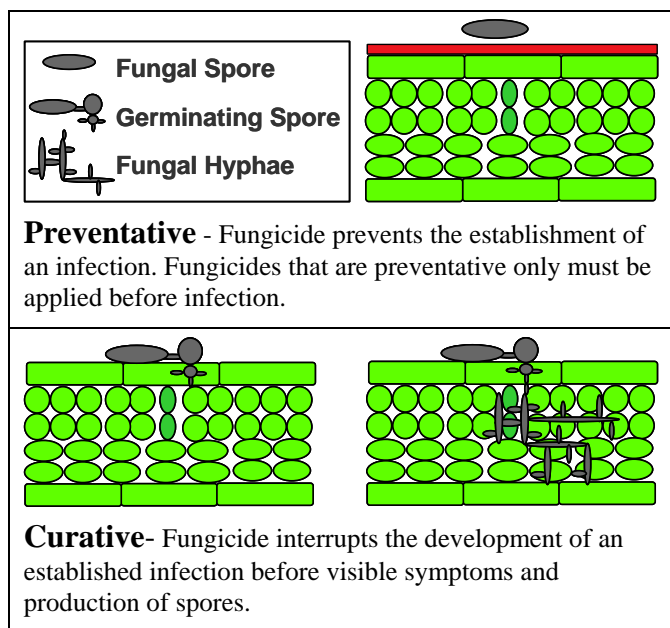
Now that Asian soybean rust (ASR) has entered the southern and southeastern U.S., soybean growers in the U.S. and Canada must be prepared to manage the disease. At this time, the only effective means of management is immediate fungicide application when the disease is detected. A previous Crop Insights (*Asian Soybean Rust*¹) has addressed disease biology and identification, including scouting and sampling procedures. A concurrent article (*Asian Soybean Rust: Fungicide Application Technology*²) provides more information on spraying technology. This article will address fungicide types, selection and use for Asian soybean rust management. Guidelines for use of different fungicide classes in sequential applications are included.

Fungicide Classification

Fungicides are chemical substances that kill or inhibit the growth of fungi. Fungicides can be classified in a number of

ways – by their general function (*preventative* or *curative*), mobility in the plant (*contact*, *fixed protectant*, *penetrant* or *systemic*), and *mode of action* or chemistry.

Figure 1. Classification of fungicides by general function – preventative and curative.



These classes are not discreet -- some active ingredients are both preventative and curative. In addition, some fungicides have two active ingredients, one preventative and one curative. However, neither class of fungicides is effective after development of visible disease symptoms. For that reason, timely application *before* establishment of the disease is important for optimum control and preservation of yield.

Fungicide Mobility

Fungicide mobility ranges from immobile on the leaf surface to translocation within the entire plant, with categories in-between these extremes as well. **Contact** fungicides adhere to the leaf surface but do not go deeper. These products are most susceptible to removal by rain and other weather effects. **Fixed protectants** move from the leaf surface into the waxes or cuticle, which increases their longevity on the leaf. **Penetrants** are able to penetrate beyond the cuticle and into the treated leaf tissue itself, but technically do not translocate. **Systemic** fungicides are absorbed into the leaf tissue, and then translocate from their point of entry to other tissues.

Penetrants and truly systemic products both move into the leaf tissue, but their mobility differs from there. Penetrants are locally systemic (“translaminar”) within the leaf where placed, but do not move to, or protect, other leaves. Truly systemic products translocate with plant fluids in the xylem tissue to other plant parts. Since xylem tissue only moves fluids upwards, leaves above the point of application may be protected, but not leaves below.

Table 1. 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.

Mode of Action

The mode of action (MOA) of fungicides refers to how they affect the fungal organism, and is determined by their chemistry. The oldest chemical fungicides were simple sulfur and copper compounds that were general fungal and bacterial inhibitors at multiple biotic sites. Organic fungicides that followed (e.g., mancozeb) were much more effective but were limited by their immobility and non-specific mode of action.

In the 1960s, the first systemic/curative fungicides (e.g., benomyl) were introduced. These fungicides were the first to target a specific, known biological function in fungi such as mitosis. In the 1980s and 1990s, many new fungicide families were introduced with very specific, targeted modes of action. These families, such as the sterol inhibitors (e.g., triazoles) and quinone outside inhibitors (e.g., strobilurins), include the most effective products used today for managing Asian soybean rust.

Fungicides for Managing ASR

Growers should only consider the most effective fungicides to combat the potentially devastating Asian soybean rust disease. Years of experience under intense disease pressure in Brazil have shown that certain fungicides, when applied in a

timely manner with good spray coverage, can effectively manage ASR and protect yields.

Four families of fungicides are available for ASR management – triazoles, strobilurins, chloronitriles, and carboxamides (Table 2). While these families are not all equal in effectiveness or value, they are all presented here as options to include in a fungicide program that protects both soybean yield and fungicide efficacy over time.

Table 2. Properties of fungicides for ASR management*.

	Triazoles	Strobilurins
MOA	Prevent production of sterols critical for cell membrane formation	Stop energy production in the fungus (interfere with production of ATP)
Site	Single site - inhibit one specific enzyme	Single site - inhibit one specific enzyme
Mobility	Xylem systemic	Locally systemic
Function	Curative (affect fungal growth and reduce sporulation)	Preventative (inhibit spore germination and very early infection)
Common Name	Myclobutanil, tebuconazole, propiconazole	Azoxystrobin, pyraclostrobin
Brand Name	Folicur ⁵ , Laredo ⁶ , Tilt ⁷ , Propimax ⁶ , Bumper ⁸	Quadris ⁷ , Headline ⁹

	Chloronitriles	Carboxamides
MOA	Stop energy production in the fungus (interfere with production of ATP)	Stop energy production in the fungus (interfere with production of ATP)
Site	Multi-site inhibitors	Single-site (inhibit enzymes containing sulfur)
Mobility	Contact	Contact
Function	Preventative (inhibit spore germination)	Preventative (inhibit spore germination)
Common Name	chlorothalonil	boscalid
Brand Name	Bravo ⁷ , Echo ¹⁰ , Chloronil	One of two chemicals in Pristine ⁹

* Compiled by Alison Robertson, Extension Plant Pathologist, Iowa State University.

Triazoles

Research on Asian soybean rust in Africa and South America has demonstrated the effectiveness of triazole fungicides in managing this disease. Triazoles are sterol inhibitors – they inhibit the biosynthesis of sterol (especially ergosterol) critical for integrity of fungal cell membranes. This results in destruction of the cell membrane. Triazoles are both curative and preventive, usually with longer residual properties than most other

fungicide chemistries. Triazoles arrest established ASR infections by contacting the fungal hyphae filling cell spaces, destroying new fungal cells and preventing branching.

Within this large group of fungicides, however, there is high variation by active ingredient on activity against ASR and even translocation within the plant (Figures 2 and 3).

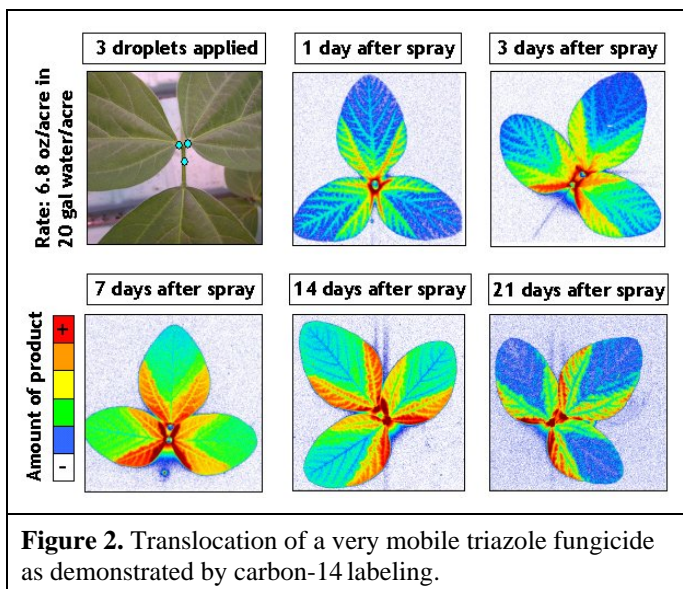


Figure 2. Translocation of a very mobile triazole fungicide as demonstrated by carbon-14 labeling.

In Figure 2, three droplets of a labeled rate of triazole fungicide were applied to a trifoliolate as shown at top left. Leaves were harvested at 1,3,7, 14 and 21 days after application. At 1 day after application (DAA) fungicide covered the entire leaf. At 3 and 7 DAA, fungicide concentration is increasing throughout the leaf. At day 14, fungicide concentration was still near peak. At day 21, the leaf is still protected despite some dissipation of the fungicide.

In another experiment, homogeneous soybean field plants with 5% soybean rust incidence on lower canopy leaves were selected. Labeled rates of several different triazole fungicides were placed on individual plants in a restricted area of a single leaflet as shown (Figure 3). Leaves were marked with a tag and monitored for disease development. As the figure shows, there is significant variation in control of soybean rust among the four treatments, from very good with triazole 1, to poor with triazole 4. (Growers would normally try to achieve better leaf coverage than in this experiment, but some leaves would inevitably receive similar restricted coverage.)

These experiments demonstrate the importance of selecting a product with favorable translocation properties and good efficacy against soybean rust. While there were only a few registered triazole products for soybeans in 2004, a relatively large number of products are awaiting section 18 approval, and many of these will likely be available for use in 2005. Your Pioneer sales professional can help you select a product that is effective against soybean rust and available in your area. Your Pioneer representative will also have access to the latest maps and information indicating soybean rust

movement throughout the growing season, to help you determine if spraying is needed.

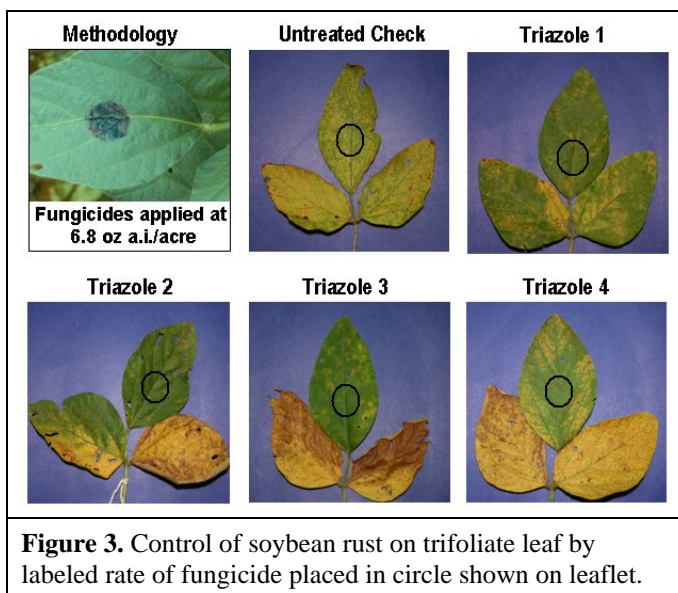


Figure 3. Control of soybean rust on trifoliolate leaf by labeled rate of fungicide placed in circle shown on leaflet.

Fungicide Costs

Calculation of actual fungicide cost must take into account the control period, which varies significantly by fungicide. A fungicide that lasts for only 14 days, for example, will need to be applied more often than one that provides control for 21 days, increasing both the product and application costs by 50% for the shorter residual product. Table 3 is a sample worksheet for determining true cost of control per day based on the control period for each class of fungicides.

Use Guidelines for Fungicide Classes

If multiple fungicide applications are likely, growers should have a pre-determined plan for sequential applications that includes the best-performing products. The spray guidelines shown in Table 4 are based on soybean rust status before each application (adapted from Monte R. Miles, USDA-ARS, 2005 University of Illinois Pesticide Conference).

References

- Schuh, W. and S. Butzen, 2004. Asian Soybean Rust. Crop Insights Vol.4 no. 20. Pioneer Hi-Bred. Johnston, IA. http://www.pioneer.com/usa/agronomy/soybeans/asian_soybean_rust.htm
- Butzen, S., A. Marcon, B. McInnes, and W. Schuh. 2005. Asian Soybean Rust: Fungicide Application Technology. Crop Insights Vol. 5 no. 1. Pioneer Hi-Bred. Johnston, IA. http://www.pioneer.com/usa/agronomy/soybeans/soybean_rust/asian_soybean_fung_app.htm

3. McInnes, B., A. Marcon, and R. Gueddens. 2003. DuPont Crop Protection Fungicide Training Guide DuPont Crop Protection. Wilmington, DE.

4. 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.

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Table 3. Sample worksheet of total daily cost* of fungicides.

Fungicide Family	Control Period		Daily Cost/Acre
Chlorothalonil	<i>7 days</i>		
Product cost	\$6		
Application cost	\$4		
Total cost	\$10		\$1.43
Strobilurin	<i>14 days</i>		
Product cost	\$12		
Application cost	\$4		
Total cost	\$16		\$1.14
Short-residual Triazole	<i>14 days</i>		
Product cost	\$10		
Application cost	\$4		
Total cost	\$14		\$1.00
Long-residual Triazole	<i>21 days</i>		
Product cost	\$10		
Treatment cost	\$4		
Total cost	\$14		\$0.67

*These costs and control periods are approximate only. See your local supplier for actual costs, and product label for re-spray interval.

Table 4. Guidelines for Use of the Different Fungicide Classes in the Management of Soybean Rust*

Program type (based on soybean rust status before first application)	First Application
<p>Preventative Fungicide Program: No soybean rust present but is predicted or expected</p>	<p>A. Chlorothalonil Use in late vegetative or early flowering, before any soybean rust is expected in the field; will not prevent disease if the spores have already infected the plant.</p>
	<p>B. Strobilurin Use before any soybean rust is expected in the field</p>
	<p>C. Triazole Can be used before and after initial infection or sign of disease</p>
	<p>D. Strobilurin-Triazole mixture Can be used before and after initial infection or sign of disease</p>
<p>Curative Fungicide Program: Soybean rust is present and lesions are sporulating in the lower canopy, less than 10% incidence</p>	<p>A. Triazole Can be used before and after initial infection or sign of disease</p>
	<p>B. Strobilurin-Triazole mixture Can be used before and after initial infection or sign of disease</p>
<p>Late Curative Fungicide Program Soybean rust is present and lesions are sporulating in the mid-canopy, incidence is greater than 10%.</p>	<p>Once the disease is in mid-canopy or greater than 10% incidence, yield losses will occur. The decision to apply fungicide will need to take into account the expected yield in the field and the economics of the crop.</p>
<p>Second Application Use triazole or strobilurin-triazole mixture if disease is present, less than 10% incidence, and limited to lower canopy. However, if chlorothalonil was used in the first application, and rust is still not present in the field, use a strobilurin.</p>	
<p>Third Application Use triazole or strobilurin-triazole mixture if disease is present, less than 10% incidence, and limited to lower canopy. Some products may not allow a third application – check product label. A maximum of two total applications using section 18 products <u>collectively</u> is allowed.</p>	
<p>Other Guidelines: Scouting and monitoring of fields with information on regional spread of the disease are critical for management of soybean rust. Read and follow all instructions on the label of each of the products. Chlorothalonil products should only be used protectively. Strobilurin products should only be used in preventative programs. Strobilurin-triazole mixtures can be used in curative programs. For Section 18 registrations, triazoles can be used twice per season. If a third application is needed, a different triazole can be used. Pre-harvest intervals (PHI) differ by fungicide; most range from 14 to 21 days. Three applications may not be economically viable. Incidence, as used in this table, is the number of plants in 100 that have any sign of the disease, e.g., 1% incidence = 1 plant in 100 with a lesion.</p>	

*Adapted from Monte R. Miles, USDA-ARS. 2005 University of Illinois Pesticide Conference.