FUNGICIDE RESISTANCE (FR) MANAGEMENT

Soybean Disease Management

Diseases can and do cause economic losses in midsouthern soybean systems. Until the early 2000's, many diseases could only be managed with resistant varieties or with cultural practices that were marginally effective.

A White Paper entitled "Guidelines and Resources for Managing Soybean Diseases" on this website should be used as a supplement to the following information.

Fortunately, there are now preventive and/or curative controls for most major foliar diseases of soybean. Tables 1 and 2, included below, provide a list of fungicides that are available to manage various soybean diseases.

Several important diseases [sudden death syndrome (SDS), stem canker, Phytophthora root rot, charcoal rot, seed and seedling diseases] of soybean have no curative control; i.e., these diseases may be prevented but not cured once present. SDS and stem canker can be managed or avoided by using less-susceptible or resistant varieties. Phytophthora root rot can be managed by using resistant varieties. However, Phytophthora root rot is not as common a disease in Mississippi as commonly thought, since it generally occurs only on clayey soils when excess moisture is an issue.

Seed and seedling diseases [caused by numerous fungi that likely comprise a "complex" that includes, but is not limited to, *Cercospora, Fusarium, Phomopsis, Pythium, Phytophthora*, and *Rhizoctonia solani*] can be effectively prevented by using seed treatments. However, this is not to suggest that they will be eliminated with the use of a properly labeled seed treatment. Keep in mind that a seed treatment remains effective while the seed and developing seedlings are below the soil surface. Once the developing seedling emerges through the soil surface, the seed treatment can no longer effectively prevent seedlings diseases from occurring.

There are no known resistant varieties [only moderately resistant germplasm and some tolerant varieties] or fungicides for charcoal rot management. Additionally, it is likely that the majority of germinating soybean seed are infected with the causal organism *Macrophomina phaseolus*, and infection likely occurs shortly after the cotyledon emerges from the seed. Charcoal rot will manifest itself in infected plants if and when a condition such as drought or poor irrigation management causes stress to plants.

Foliar fungicides can be applied to prevent several prominent soybean diseases. Preventive fungicides [i.e. quinone outside inhibitor (QoI) or strobilurins such as azoxystrobin (Quadris) or pyraclostrobin (Headline)] are most effective when applied prior to or at the earliest appearance of a disease. However, in the past, strobilurin fungicides have been suggested to manage such diseases as frogeye leaf spot [FLS] even when the disease was present. The general view was that a strobilurin fungicide could prevent additional spread of the disease to non-infected plants.

Soybean rust can be managed with preventive and curative [i.e. demethylation inhibitors (DMI) or triazoles such as flutriafol (Topguard) or tetraconazole (Domark)] applications of foliar fungicides timed according to occurrence of rust in sentinel plots. Based on past years' experience, rust may be avoided in the Midsouth by planting early-maturing varieties early so that R6 or full seed stage is reached before about Aug. 1. Additionally, the R3/R4 fungicide application utilized in Midsouth production systems has

likely provided some prevention of soybean rust in areas where the disease has occurred.

Scouting should be used to detect the first occurrence of disease(s) or to accurately determine the reproductive stage recommended for the most effective preventive fungicide application prior to disease presence.

Cost and effectiveness of fungicide products should be evaluated when choosing options for disease management. Resistant varieties should be chosen based on level of pest tolerance and yield, and grown in those areas with a known history of a particular disease.

Fungicide Resistance (FR) and Management

Over the last several years, resistance to fungicides has become a concern in soybean production.

Fungicide-resistant fungal populations generally result from the continuous use of a fungicide or fungicides with the same mode of action (MOA). This overuse of these fungicides results in the selection of traits that allow fungal species to withstand fungicide applications that otherwise would suppress or kill them.

Subsequent generations of the resistant fungi inherit the ability to survive and reproduce following a fungicide application. Thus, FR fungi are the product of intensive selection pressure from the continuous use of a fungicide or fungicides that target a specific physiological or biochemical process.

Knowledge of the MOA categories described by the Fungicide Resistance Action Committee [FRAC] will reduce, if not prevent, the selection for FR fungi, and will aid in managing fungi that are resistant to the fungicides that are currently available.

Selecting and using fungicides with different MOAs should be a primary tool for preventing and/or managing resistance.

Selecting fungicides with different MOAs must be combined with choosing fungicides within those MOA Groups that are effective at managing the targeted fungi in individual fields. In other words, merely selecting fungicides from a different MOA Group will do little to reduce selection pressure if those fungicides are not effective at managing targeted fungi.

The numerical classification system developed by the FRAC (below table) currently appears on fungicide labels. Near the top of the label, a box labeled "Group Fungicides" contains the number or numbers that indicate the MOA of the product's active ingredient(s). Multiple numbers in the box indicate that the fungicide or fungicide premix has more than one MOA.

Examples are the labels for:

Quadris,

GROUP	11	FUNGICIDES

Quilt,

GROUP	3 11	FUNGICIDES

Topsin XTR,

GROUP	1 3	FUNGICIDES

and Priaxor

GROUP	7 11	FUNGICIDES

Important points are:

- Producers, consultants, and professional crop practitioners should select fungicides that are best suited to manage specific resistant fungi, or that can be used in rotation to prevent or delay resistance.
- Knowing and using fungicide MOAs should be an important component of managing the potential development of resistance to fungicides.
- Fungal species present in individual fields should be documented each year so that MOA knowledge and level of control by individual fungicides can be coupled when making fungicide decisions.
- If resistance to a particular fungicide is not documented in a particular field or fields, then its use is a viable option when used in rotation with other fungicide(s) with a different MOA.
- Selecting a different fungicide having the same MOA will not contribute to resistance management.

Any disease management strategy that is adopted to minimize selection pressure for resistance will delay or block the emergence of fungicide resistance. Thus, the MOA strategy should be viewed as just one of several management tools that can be used by producers and advisors to choose fungicides. This tool should be used in conjunction with other resistance management practices to delay the evolution of resistance to fungicides.

Dr. Tom Allen, Extension Plant Pathologist at the Stoneville DREC, provides considerations for soybean fungicide management.

Major points are:

- An R3/R4 strobilurin or strobilurin + triazole fungicide application is made at that time regardless of the presence of disease. The timed application produces the best results when applied to a soybean crop with high yield potential such as continuous soybean that is irrigated.
- Applying products that contain a stand-alone triazole should be saved for when foliar disease is present. They should be relied on for managing against yield loss as a result of FLS or soybean rust infestations.
- Fungicides in the strobilurin class are best suited for when diseases are not present; i.e., used on a preventive basis. The residual effect in this case should be about 21 days.
- Even though triazole fungicides have the ability of being curative and can be applied to manage a present disease, they perform best when applied prior to the onset of visible disease symptoms. Their residual effect generally lasts about 14 days.
- The systemic activity of both strobilurin and triazole fungicides is limited to movement around the area of the leaf where a spray droplet is deposited. Fungicides in both classes should not be considered to move throughout the plant from the point of entry.
- Growing varieties that are susceptible to FLS may increase the likelihood of developing FR FLS biotypes.
- If an FLS-resistant variety is grown, relying on a stand-alone strobilurin fungicide is an acceptable practice.

- If an FLS-susceptible variety is grown and FLS has been detected, applying a labeled triazole fungicide could reduce yield loss.

- With the onset of strobilurin-resistant FLS, triazoles should be considered to manage the disease.

Current FR Information

To help manage and avert fungicide resistance, the United Soybean Board awarded a research and education grant to support activities that will sustain fungicide effectiveness.

Dr. Carl Bradley, the principal investigator on the grant, has teamed up with the Plant Management Network [PMN] to produce the "Soybean Fungicide Resistance Hub", which is a central destination for up-to-date information on soybean fungicide use and management practices that should be considered to ensure the prolonged effectiveness of present and forthcoming fungicide products.

The hub includes a "Featured Webcasts" section with open-access videos on FR management, a "Fungicide Resistance Tracking" section with maps of yearly distribution of FR plant diseases, and a "Fungicide Resistance Resources" section which contains extension information on FR management in soybean.

Table 1. Mechanism of action (MOA) classification for fungicides used for control and/or management of soybean diseases.

FRAC Code	MOA*	Chemical group	Active Ingredient	Trade names**	Labeled diseases***
1	Mitosis and cell division	thiophanates	thiophanate-methyl	Topsin	AB, AN, FLS, PSB, PSS
3	Sterol synthesis	triazoles	cyproconazole	Alto	AB, AN, CLB, FLS, PSB, SR
			flutriafol	Topguard	FLS, CLB, SR
			propiconazole	Tilt, etc.	AB, AN, FLS, SR
			prothioconazole	Proline	FLS, SR
			tebuconazole	Folicur, etc.	AN, CLB, FLS, PSB
			tetraconazole	Domark	AN, CLB, FLS, PSS, SR
7	Respiration	carboxamide	penthiopyrad	Vertisan	AN, CLB, FLS, PSB, SR
11	Respiration	methoxy-acrylates	azoxystrobin	Quadris	AB, AN, CLB, FLS, PSB, SR
		methoxy-acrylates	picoxystrobin	Aproach	AB, AN, CLB, FLS, PSB, PSS, SR
		methoxy-carbamates	pyraclostrobin	Headline	AB, AN, CLB, FLS, PSB, SR
		oximino acetates	trifloxystrobin	Gem	AB, AN, CLB, FLS, PSB, SR
		dihydro-dioxazines	fluoxastrobin	Evito, Aftershock	AB, AN, CLB, FLS, PSB, SR
M5		chloronitrile	chlorothalonil	Bravo Ultrex	AN, CLB, FLS, PSB, PSS, SR

*See FRAC (Fungicide Resistance Action Committee) for detailed description of MOAs.
**Examples only. See MP154 (Arkansas Plant Disease Control Products Guide) for a complete list of fungicide products in each Group that can be used to manage soybean diseases.
***AB = aerial blight; AN = anthracnose; CLB = cercospora leaf blight; FLS = frogeye leaf spot; PSB = pod and stem blight; PSS = purple seed stain; SR = soybean rust. This is a general guide. See MP154 and individual labels at CDMS for specific fungi controlled, level of control, time of application, and preharvest interval for the listed fungicides.
Note: See Table 2 in the supplemental White Paper for efficacy ratings of the different fungicides against prominent soybean diseases.

Table 2. Mechanism of action (MOA) classification for fungicide premixes used for management of soybean diseases.			
FRAC Code	**Trade Name**	**Active Ingredients**	**Labeled diseases***
11 + 3	Aproach Prima	picoxystrobin + cyproconazole	AB, AN, CLB, FLS, PSB, SR
11 + 3	Evito-T	fluoxastrobin + tebuconazole	AB, AN, CLB, FLS, PSB, SR
11 + 3	Quadris Top SB	azoxystrobin + difenoconazole	AB, AN, CLB, FLS, PSB, SR
11 + 3	Quadris Xtra	azoxystrobin + cyproconazole	AB, AN, CLB, FLS, PSB, SR
11 + 3	Quilt, Quilt Xcel	azoxystrobin + propiconazole	AB, AN, CLB, FLS, PSB, SR
11 + 3	Stratego	trifloxystrobin + propiconazole	AB, AN, CLB, FLS, PSB, SR
11 + 3	Stratego YLD	trifloxystrobin + prothioconazole	AB, AN, CLB, FLS, PSB, SR
11 + 7	Priaxor	pyraclostrobin + fluxapyroxad	AB, AN, CLB, FLS, PSB, SR
1 + 3	Topsin XTR, Overrule	thiophanate-methyl + tebuconazole	AB, AN, FLS, PSB, PSS, SR
11 + 7 + 3	Priaxor D	pyraclostrobin + fluxapyroxad + tetraconazole	AB, AN, CLB, FLS, PSB, PSS, SR

*AB = aerial blight; AN = Anthracnose; CLB = cercospora leaf blight; FLS = frogeye leaf spot; PSB = Pod and stem blight; PSS = Purple seed stain; SR = soybean rust. This is a general guide. See MP154 and individual labels at CDMS for specific fungi controlled, level of control, time of application, and preharvest interval for the listed fungicides.
Note: See Table 2 in the supplemental White Paper for efficacy ratings of the different fungicide combinations against prominent soybean diseases.

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