

Chapter 8

Fungicide Resistance Management in Soybean

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Fungicide Resistance

Development of resistance in fungi to fungicides is a concern for the world-wide agricultural industry. Unfortunately, this phenomenon has occurred in many fungi, especially when fungicides have been used intensively on crops. Producers of several crops in the United States, including potato, sugar beet, sunflower, and others, have dealt with fungicide failure due to the rise of fungicide resistant or insensitive pathogen populations.

How Fungicide Resistance Develops

Fungicide resistance can occur when a *selection pressure* is placed on the fungal pathogen population. Characteristics of both the fungicide and the pathogen play a role in the magnitude of the selection pressure and the risk of resistance occurring. Fungicides that have a single site of action tend to be more at risk for resistance developing compared to those that have multi-site activity. Fungal pathogens that regularly undergo sexual reproduction are more likely to have greater *variability* in the population, which increases the chances of developing a strain that is less sensitive to a fungicide. When diseases have a repeating stage (polycyclic disease), such as soybean rust, the fungal pathogen may also be more likely to develop resistance

to a fungicide partially due to the high number of spores that are produced within a season.

The fungicide user has control over selection pressure, but the variability of the pathogen is out of the applicator's hands. Managing selection pressure is key to reducing the risk of fungicide resistance.

Fungicide Resistance Action Committee (FRAC)

An organization known as the Fungicide Resistance Action Committee (FRAC) was developed to address the issue of fungicide resistance. This is an international group that provides guidelines and recommendations to manage the development of fungicide resistance. This organization developed a code of numbers and letters that can be used to distinguish the different fungicide groups based on their *mode of action*. The mode of action of a fungicide is the means by which it poisons the fungus (*e.g.*, inhibiting metabolic pathways, disrupting cell membranes). This code is known as the FRAC Code and is now included on fungicide labels. A fungus that becomes resistant to a specific fungicide may be resistant to many or all of the fungicides within that fungicide's FRAC Code, a phenomenon referred to as *cross-resistance*. Table 8.1 includes the FRAC codes for the

Table 8.1. Fungicide Groups That Can Be Applied on Soybean in the United States. (Note: Not all are registered for control of soybean rust.)

FRAC Code	Chemical Group	Example	Risk of Fungicide Resistance
1	Methyl Benzimidazole Carbamates (MBC)	Topsin M	High
3	Demethylation inhibitors (DMI; includes triazoles)	Folicur	Medium
11	Quinone outside inhibitors (QoI; includes strobilurins)	Headline	High
M	Chloronitriles; inorganics	Bravo	Low

fungicide groups that currently can be applied to soybean in the United States. More information is available at the FRAC web site: (<http://www.frac.info>).

Fungicide Resistance Management Practices

Different practices are available to minimize the risk that a fungus will become resistant to a fungicide. The best fungicide resistance management program utilizes all available practices to prolong the effectiveness and the life of the fungicides.

Monitoring Programs

One of the first steps in a fungicide resistance management program is the development of baseline levels of sensitivity using laboratory analysis. A baseline is the dosage of the fungicide that is able to effectively control a fungal plant pathogen population that has never been exposed to the fungicide. Another way to look at it is how sensitive the pathogen population is to the fungicide when it is first used. Once the baseline is established, a monitoring program can be implemented to determine if

the pathogen population is becoming less sensitive over time. Generally, monitoring programs consist of collecting populations of the pathogen and testing them for sensitivity to the fungicide in laboratory analysis every season.

Whenever a fungicide is applied to a field, the field should be monitored for how well the fungicide worked and for signs of any failure. Although there are different reasons why a fungicide might fail, it is important to contact the chemical company representative or Extension personnel to determine if fungicide resistance could be a factor.

IPM Practices

Scouting fields and monitoring the development and movement of soybean rust in the United States and applying a fungicide when the disease is present or when there is a high risk for disease is part of an Integrated Pest Management (IPM) program. Applying a fungicide only when it is necessary is important for prolonging

the effective life span of the product. Many of the fungicide products (or similar products with the same mode of action) that can be applied to soybean are also registered on many other crops that are grown in rotation with soybean. Applying a fungicide unnecessarily to a soybean field in the absence of soybean rust could result in undesirable effects on pathogens of rotational crops.

Example: A strobilurin (QoI; FRAC Group 11) fungicide was applied to soybean for reasons other than disease control. This soybean field was planted in ground where sugar beet was part of the rotation, and common lambsquarters and pigweed were prevalent. The common lambsquarters and pigweed in the field were infected with the *Cercospora* leaf spot fungus that also attacks sugar beet. In this scenario, a selection pressure is placed on the *Cercospora* leaf spot fungus in a year that sugar beet is not even grown in the field.

Conserving the fungicide groups that are available is extremely important, because there are few other groups that are effective on certain pathogens. Using IPM practices will help conserve these products for management of soybean rust as well as other disease problems on soybean and other crops.

Fungicide Mixtures and Rotation

Applying mixtures of fungicides with different modes of action can help reduce the selection pressure placed on the pathogen population compared to using only a single product. This helps reduce the risk of fungicide resistance because, should a mutant spore arise that is resistant to one fungicide, the other is there to poison it. This is only effective if both of the fungicides control the target disease, however. For example, tank-mixing of Folicur plus Topsin M would not be a good fungicide resistance management practice for soybean rust, because Topsin M is not effective against soybean rust.

If more than one application of a fungicide during a season is anticipated, then fungicides with different modes of action should be used. For example, a strobilurin (QoI; FRAC Group 11) fungicide could be applied first followed by a triazole (FRAC Group 3) fungicide. Note, that if a fungicide rotation program is used, each fungicide should be applied at timings that suit the individual fungicide's inherent activity on the disease being managed; for example, do not apply a preventative fungicide at a time when soybean rust is already in the field.

Follow Label Recommendations

Following the label is the law and is another important component of fungicide resistance management. Some fungicides may have restrictions on the number of applications that can be made during a season and restrictions on back-to-back applications. Following fungicide label rates is a key component of disease management as well as fungicide resistance management. When sub-lethal doses of a fungicide are applied, the risk of fungal pathogens becoming more tolerant to the fungicide is increased.

- If a fungicide is applied, monitor the crop for signs of disease, which may indicate resistance development.

Summary

Fungicide resistance management is important in the production of soybean and all crops. You will reduce the risk of a fungal pathogen developing resistance to a fungicide by taking the steps listed here:

- Apply a fungicide only when it is necessary.
- Alternate fungicides that have different modes of action.
- Apply mixtures of fungicides with different modes of action.
- Follow the label. Use recommended rates and obey restrictions.