A3878

Fungicide resistance management in corn, soybean, and wheat in Wisconsin

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FRAC CODE	GROUP NAME	CHEMICAL FAMILY	ACTIVE INGREDIENT	PATHOGEN RESISTANCE?	MANUFACTURER	PRODUCT EXAMPLE	CROP* REGISTERED FOR
1	**MBC's**	thiophanates	thiophanate-methyl	Yes	Cerexagri	***Topsin® M 4.5FL***	Soybean, Wheat
						Topsin® M 70WP	Soybean, Wheat
						Topsin® M WDG	Soybean, Wheat
3	**DMI's**	triazole	cyproconazole	Yes	Syngenta	***Alto 100SL***	Soybean
			fenbuconazole	Yes	Dow AgroSciences	***Indar®***	Wheat
			metconazole	Yes	BASF	***Caramba™***	Soybean, Wheat
			myclobutanil	Yes	Dow AgroSciences	***Laredo EC***	Soybean
			tetraconazole	Yes	Valent	***Domark® 230 ME***	Soybean
			tebuconazole	Yes	Bayer CropScience	***Folicur®***	Wheat
			propiconazole	Yes	Syngenta	***Tilt®***	Corn, Soybean, Wheat
				Yes	Dow AgroSciences	***PropiMax® EC***	Soybean, Wheat
				Yes	Makhteshim Agan.	***Bumper 41.8 EC***	Corn, Soybean, Wheat
			prothioconazole	Yes	Bayer CropScience	***Proline® 480SC***	Wheat
7	**Carboxamides**	pyridine carboxamides	boscalid	Yes	BASF	***Endura®***	Soybean
11	**QoI's**	methoxycarbamate	pyraclostrobin	Yes	BASF	***Headline®***	Corn, Soybean, Wheat
		methoxyacrylate	azoxystrobin	Yes	Syngenta	***Quadris®***	Corn, Soybean, Wheat
M	**M1**	inorganic	copper hydroxide	**No**	DuPont	***Kocide® 3000***	Corn, Soybean, Wheat
			copper sulfate	**No**	Cerexagri	***Cuprofix® MZ Disperss®***	Soybean, Wheat
						Cuprofix Ultra 40	Soybean, Wheat
	M3	dithiocarbamate	mancozeb	**No**	Dow AgroSciences	***Dithane® DF Rainshield™***	Corn, Wheat
						Dithane® F-45 Rainshield™	Corn, Wheat
						Dithane® M45	Corn, Wheat
					DuPont	***Manzate® ProStick™***	Corn, Wheat
						Manzate® Flowable™	Corn, Wheat
					Cerexagri	***Penncozeb™ 75DF***	Corn, Wheat
						Penncozeb™80WP	Corn, Wheat
						Penncozeb™ 4FL	Corn, Wheat
	M5	chloronitriles	chlorothalonil	**No**	Syngenta	***Bravo WeatherStik®***	Soybean
						Bravo® 500	Soybean
					Sipcam Agro USA	***Echo® 720***	Soybean
						Echo® 90DF	Soybean
						Echo® Zn	Soybean
PREMIX FUNGICIDES							
3 3	**DMI** **DMI**	triazole triazole	propiconazole tebuconazole	Yes Yes	Bayer	***Prosaro™ 421 SC***	Wheat
3 11	**DMI** **QoI**	triazole methoxyacrylate	propiconazole azoxystrobin	Yes Yes	Syngenta	***Quilt®***	Corn, Soybean, Wheat
3 11	**DMI** **QoI**	triazole methoxyacrylate	propiconazole azoxystrobin	Yes Yes	Syngenta	***QuiltXcel™***	Corn, Soybean, Wheat
3 11	**DMI** **QoI**	triazole methoxyacrylate	cyproconazole azoxystrobin	Yes Yes	Syngenta	***Quadris Xtra™***	Soybean
3 11	**DMI** **QoI**	triazole methoxycarbamate	metconazole pyraclostrobin	Yes Yes	BASF	***Headline AMP™***	Corn
3 11	**DMI** **QoI**	triazole methoxycarbamate	metconazole pyraclostrobin	Yes Yes	BASF	***Twinline™***	Wheat
3 11	**DMI** **QoI**	triazole oximinoacetate	prothioconazole trifloxystrobin	Yes Yes	Bayer CropScience	***Stratego® YLD***	Corn, Soybean
3 11	**DMI** **QoI**	triazole oximinoacetate	propiconazole trifloxystrobin	Yes Yes	Bayer CropScience	***Stratego®***	Corn, Soybean, Wheat

* MAY BE REGISTERED ON CROPS OTHER THAN CORN, SOYBEAN, OR WHEAT. SEE LABEL FOR INFORMATION.

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FRAC and the FRAC code

The Fungicide Resistance Action Committee (FRAC) is an organization made up of representatives of the agrochemical industry. Their mission: "… is to provide fungicide resistance management guidelines to prolong the effectiveness of 'at risk' fungicides and to limit crop losses should resistance occur." FRAC developed a code, known as the FRAC Code, that can be used to classify fungicides into groups based on their mode of action. Fungicides currently registered in Wisconsin for use on corn, soybean, and wheat fall into five FRAC Codes: 1, 3, 7,11, and M.

FRAC Code 1: The methyl benzimidazole carbamate (MBC) fungicide group contains the benzimidazole and thiophanate fungicide families. These fungicides are effective against a broad range of fungi that cause leaf spots, root and crown rots, stem rots, and powdery mildews, but not rusts. MBC fungicides inhibit tubulin production, interfering with normal cell division in sensitive fungi. These fungicides have preventative and early-infection activity. While they have systemic properties, they cannot move down the plant, making canopy penetration and complete plant coverage essential for control.

The MBC fungicide risk of resistance is high. The modification of a single amino acid in a fungus can result in resistance. Resistance to these fungicides was first reported in 1970. Many important fungal plant pathogens have become resistant to these fungicides.

FRAC Code 3: The demethylation inhibitors (DMI) fungicide group contains the triazole fungicides. DMI fungicides are highly effective against powdery mildews, rusts, and many leaf spotting fungi. These fungicides work by inhibiting a specific enzyme that plays a role in sterol production in fungi. Sterols are necessary for the development of functional cell walls. Application of DMIs results in abnormal fungal growth and death. However, triazoles have no effect on spore germination because spores contain enough sterol for the formation of germ tubes. Thus, DMI fungicide must be applied preventively or at early-infection to be effective. DMI fungicides are locally systemic, meaning that they are taken up by the leaves and move within the leaf but not necessarily from one leaf to another. Generally, these fungicides have approximately 14 days of residual activity.

DMI fungicides have a very specific site of action so risk of resistance development is a concern. Resistance management practices include avoiding repeated applications of DMI fungicides alone in the same season against high-risk pathogens such as powdery mildew.

FRAC Code 7: Carboxamide fungicides include boscalid, carboxin, and flutolanil. Boscalid is primarily a foliar fungicide used against the Botrytis, Sclerotinia, and Alternaria pathogens. They work by inhibiting the respiration of target fungi, specifically the complex II fungal respiration. Carboxamide fungicides have locally systemic to systemic properties and movement is translaminar. Resistance has been documented for these fungicides.

FRAC Code 11: The Quinone outside inhibitors (QoI) fungicide group contains three fungicide families, strobilurins, imidazoles, and oxazoles. QoI fungicides are very effective against a broad spectrum of fungi. These fungicides work by inhibiting mitochondrial respiration, effectively stopping energy production of the fungus, and result in death. These fungicides are effective on spore germination and early growth. However, they are not effective against fungi that are growing inside the leaf tissue so they must be applied preventively or at early-infection to be effective. Similar to DMI fungicides, they are locally systemic. These fungicides have approximately 7–21 days of residual activity.

QoI fungicides have a very specific site of action so the risk of resistance development is a high. Currently there are more than 20 plant pathogens with some level of resistance to QoI fungicides.

FRAC Code M: Multi-site activity fungicides include inorganic compounds (M1), dithiocarbamates (M3), and chloronitriles (M5). Multi-site activity fungicides have a broad spectrum of disease control activity. They are considered protective or preventative fungicides as they are applied to the leaf and stem surfaces prior to pathogen appearance. They do not affect fungi once they have infected the plant. Multi-site activity fungicides affect multiple biochemical sites in fungi, killing fungi by overwhelming them with toxins. These fungicides are sensitive to rainfall and sunlight since they are not absorbed into the plant, generally remaining active for 7–14 days.

Multi-site activity fungicides have a low risk of resistance development. Because of this, multi-site activity fungicides are an important part of fungicide resistance management. When multi-site fungicides are combined with either a code 3 or 11 fungicide (if allowed by the fungicide label), they may extend the number of years those higher risk fungicides can be used by reducing the number of applications of those high-risk fungicides.

Text adapted from: Mueller, Daren S., and Carl A. Bradley. 2008. Field Crop Fungicides for the North Central United States. Ames, IA and Urbana-Champaign, IL: Iowa State University and University of Illinois North Central Integrated Pest Management Center.

The Fungicide Resistance Action Committee provides a list of fungicides sorted by modes of action: www.frac.info/frac/index.htm.

Guidelines for fungicide resistance management

- Plant disease resistant hybrids/varieties whenever possible.
- Scout fields on a regular basis noting incidence and severity of diseases. Use this information to develop a field history for future disease management decisions.
- Tank mix high-risk fungicides with fungicides that have different modes of action, are active against the targeted disease(s), and have similar lengths of residual actitivity.
- Do not use reduced rates of fungicides.
- Alternate or tank mix fungicides with different modes of action when multiple applications are required.
- Apply fungicides preventively or early in the disease cycle and when a disease threat is warranted.
- Avoid curative fungicide applications, especially with high-risk fungicides.

Always read and follow the pesticide label

- for maximum number of sprays per season.
- for recommended application rates.
- for application timing for both target disease and plant growth stage.

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