

STATEMENT OF WORK

Fungicide resistance management guidelines for cucurbit downy and powdery mildew control in the Northeastern US.

Over the past decade, a number of new fungicide chemistries for use in vegetable production have been released in the US. Many of these fungicides have specific modes-of-action (MOA) that target pathogen development at a single site (McGrath, 2001). Fungicides with a single-site MOA are often considered at- or high-risk fungicides because the chances for fungal resistance to develop are much higher than fungicides with multiple MOA's (McGrath, 2001). In recent years, fungicide resistance in pathogens causing important diseases of vegetable crops, such as gummy stem blight and powdery mildew in cucurbits and *Phytophthora* blight in bell pepper, has been detected in the Northeast region. Unfortunately, some growers are not aware that resistance can occur and others become concerned about managing it only after it has developed. Growers typically do not understand that the primary goal of resistance management is to delay its development rather than to manage resistant strains (McGrath, 2001). The vast number of fungicide chemistries available and differences in MOA's, combined with the dynamic nature of fungicide resistance, can make it very difficult for vegetable growers to develop and follow fungicide resistance management programs on their farms.

Fortunately, for most fungal pathogens there is more than one fungicide chemistry registered for control and rotations between fungicides with different MOA's can be accomplished. Rotating among fungicides with different MOA's is the primary recommendation for managing resistance. An often unknown and misunderstood fact is that cross-resistance can develop in fungicides in the same FRAC code. Cross-resistance occurs when a fungal population that develops resistance to one fungicide chemistry also becomes resistant to other fungicide chemistries in the same FRAC group, even if only one fungicide chemistry has been applied. In many cases, fungicides within a given FRAC code are listed for control of the same pathogen. This, unfortunately, can lead to serious confusion by vegetable producers who do not understand FRAC codes when developing seasonal fungicide application programs for specific diseases. For example, powdery mildew is an important disease in cucurbit crops in the Northeast region, as well as, the rest of the US. In Northeast region, fungicide chemistries such as trifloxystrobin and pyraclostrobin are listed as recommended options for powdery mildew control. Both fungicides belong to FRAC code 11, and each has a high-risk for fungicide resistance development. Rotating among these fungicides would put strong selection pressure on the pathogen for resistance to this MOA. Importantly, the development of fungicide resistance in the field can be very difficult to detect. Unknowingly, a cucurbit grower without the proper knowledge could be selecting for a resistant fungal population with the overuse of any of these chemistries. With highly mobile pathogens, such as cucurbit powdery mildew, successful management may require regional implementation. Otherwise, growers using an at-risk fungicide exclusively may select resistant strains and thereby thwart efforts of other growers using a resistance management program (McGrath, 2001). Resistance to the FRAC group11 fungicides, as well as others, has

already been detected for important vegetable pathogens in the northeast (McGrath, 2001; Wyenandt et al., 2008).

Because of the vast number of fungicides available and the potential difficulty in understanding FRAC codes and their importance, vegetable producers need a simplified reference tool for the management of fungicide resistance in important diseases in their farm operation. For example, in the mid-Atlantic region, five states (NJ, MD, DE, PA and VA) share the use of a common commercial vegetable production guide which is developed by university personnel from multiply disciplines on an annual basis. Each year over 3,500 copies of the production guide are distributed to growers who plant 221,000 acres of vegetable crops throughout the region on an annual basis. Other areas (ie. other states) in the northeast region produce their own fungicide recommendation guide (ie. New York) or produce a multi-state recommendation guide similar to the mid-Atlantic region (ie. ME, NH, VT, MA, CT and RI). However, among the guides there are differences in the fungicides and management programs recommended for powdery and downy mildew control partly reflecting differences in knowledge of the current status of fungicide resistance. Importantly, the Northeast Vegetable Production Guide for ME, NH, VT, MA, CT and RI is updated every two years. Thus, important changes in control recommendations might not get to vegetable growers before resistance problems develop.

The objective of this regional mini-IPM grant project is to develop and disseminate a single regional fungicide resistance management and control guideline FRAC table for cucurbit powdery and downy mildew for the Northeastern United States.

The anticipated impacts of this project are to i) promote the importance and understanding of FRAC codes in fungicide resistance management in cucurbit powdery and downy mildew control in the Northeast US, ii) prevent the misuse of specific fungicides with a high-risk for resistance development, iii) reduce use of fungicides that are no longer adequately effective because of resistance development, and iv) provide the tools and knowledge to allow growers in the Northeast US to develop disease control programs with an emphasis towards fungicide resistance management for powdery and downy mildew as well as other important diseases.

A fungicide resistance management FRAC table for cucurbit powdery and downy mildew control will be developed for the Northeastern United States. The FRAC table will consist of all currently labeled fungicides for cucurbit powdery and downy mildew along with FRAC and risk management codes and fungicide resistance management guidelines for each particular FRAC group. Fungicide, chemical names, FRAC groups and risk management guidelines will be color-coordinated by group to help distinguish differences based on FRAC code. The guide will also include inherent resistance risks for the particular pathogens listed in each crop section. Like the fungicides listed, the pathogen-risk will be denoted by L, M, or H designations in accordance for the potential of a particular pathogen developing resistance to certain fungicide chemistries. Most importantly, where a pathogen has a high risk for resistance development and a fungicide chemistry has a high potential for resistance to develop to it, the designated x's will be colored red to highlight the fact that particular combination has a very-high risk for

resistance development. The far right-hand column of each table will include fungicide resistance management guidelines for each particular FRAC group with specific instructions on risk assessment and/or application instructions. Each reference guide will be printed on 32 lb paper and laminated so it can be placed in a pesticide shed or weighing area for easy reference. The simple-to-use reference guide will help growers i) learn the importance of FRAC codes, ii) apply the different fungicide chemistries appropriately, iii) reduce the potential for fungicide resistance development in cucurbit powdery and downy mildew and iv) reduce the potential for economic losses due to fungicide resistance development in the Northeast region.

The fungicide resistance management reference guide for cucurbit powdery and downy mildew control will be available to all growers in the Northeast region in early 2009. The goal is to print and distribute approximately 5,000 fungicide resistance management guidelines to cucurbit growers in the Northeast region. Recommendations guides are traditionally handed out at the annual vegetable meeting for each state and at twilight meetings in the spring. The guide will also be distributed to vegetable growers during the 2009 production season. It will be used as a promotional tool for twilight meetings, field days and on-farm tours. During these meetings, collaborators from each state in the region will promote the use of the fungicide resistance management reference guide with the aid of a powerpoint presentation. Each collaborator will help to i) explain the importance of learning and knowing how to use FRAC groups ii) help explain the FRAC tables and resistance management guidelines and iii) answer any related questions related to the resistance management reference guide from vegetable growers. The goal for 2009 is to reach ~20% of the vegetable/cucurbit growers in the northeast region to help them understand the importance of learning and knowing how to use FRAC codes in fungicide resistance management. At each meeting growers will be briefly questioned on i) their prior knowledge of FRAC groups ii) if FRAC groups are used in developing their fungicide programs iii) their use of the reference manual iv) how use of the reference guide has changed their management programs and v) their suggestions for improving the reference guide. Results of all surveys will be compiled at the end of the production season to help determine i) growers prior knowledge of and the importance of knowing FRAC groups ii) how the reference guide has changed disease management programs for fungicide resistance development in the Northeastern US and iii) how to improve the guidelines for future editions. Results of the project surveys will be used to complete a regional report on fungicide resistance management and to improve future versions of the fungicide resistance management guidelines.

LITERATURE CITED:

McGrath, M.T. 2001. Fungicide resistance in cucurbit powdery mildew: experiences and challenges. *Plant Dis.* Vol 85 No 3: 236-245.

Wyenandt, A., Maxwell, N. and D. Ward. 2008. Fungicide programs affect 'practical' resistance development in cucurbit powdery mildew of pumpkin. *HortScience.* Vol. 43(6):1838-1845.

Fungicide Resistance Management Guidelines for Cucurbit Downy and Powdery mildew control in the Northeast United States

Fungicide	Active Ingredient(s)	FRAC Code*	Risk Management**	Management required	Powdery Mildew	Downy Mildew	Fungicide Resistance Management Guidelines***
copper	fixed copper(s)	M1	L		+		FRAC code M fungicides are low risk, protectant fungicides. Use alone, or tank mix with high-risk fungicides and use in rotations with other FRAC codes
Sulfur	sulfur	M2	L	N	+		
Manzate, Maneb, Dithane	EBDC	M3	L	N		+	
Bravo, Echo, Applause	chlorothalonil	M5	L	N	+	+	
Topsin M	thiophanate methyl	1	H	Y	+		Tank mix with FRAC code M fungicides, rotate with other FRAC codes
Nova, Procure	myclobutanil, triflumizole	3	M	Y	++		
Ridomil Gold Copper	mefenoxam + copper	4 + M1	H - L	Y		++	Formulation reduces risk, rotate with other FRAC codes
Ridomil Gold Bravo	mefenoxam + chlorothalonil	4 + M5	H - L	Y		++	
Quadris	azoxystrobin	11	H	Y	+	+	Tank mix with FRAC Code M fungicides and rotate with other FRAC codes
Cabrio	pyraclostrobin	11	H	Y	+	+	
Flint	trifloxystrobin	11	H	Y	+		
Reason	fenamidone	11	H	Y		+	
Pristine	pyraclostrobin + boscalid	11 + 7	H	Y	++	+	
Tanos	fomoxadone + cymoxanil	11 + 27	M	Y		+	
Quintec	quinoxifen	13	H	Y	+++		Tank mix with FRAC code M fungicides and rotate with other FRAC codes
Ranman	cyazofamid	21	M - H	Y		+++	
Gavel	zoxamide + mancozeb	22 + M3	L - M	Y		+	
Curzate	cymoxanil	27	L - M	Y		++	Tank mix with a FRAC Code M fungicide if required, and rotate with other FRAC codes
Previcur Flex	propamocarb HCL	28	L - M	Y		++	
Alliete, Phosphonates	fosetyl AI, phosphorous acids	33	L	Y		+	
Forum, Revus	dimethomorph, mandipropamid	40	L - M	Y		+	

Control Ratings: + = poor ++ = good, +++ = excellent; no + = not labeled

* FRAC code: M = multi-site mode of action (MOA), numbered groups = fungicides with similar MOA

** Risk management: L = low risk, M = moderate risk or H = high risk for fungicide resistance to develop

*** See fungicide label for specific crops, rates and instructions on use

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