

**UNITED STATES DEPARTMENT OF AGRICULTURE
COOPERATIVE STATE RESEARCH, EDUCATION, AND EXTENSION
SERVICE**

OMB Approved 0524-0039

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Project Title: Dev. a fungi. resistance mgmt guide for vegetable growers in the mid-Atlantic states

Key Words: fungicide, fungicide resistance management

PROPOSAL TYPE

**For National Research Initiative
Competitive Grants Program Proposals Only**

- Standard Research Proposal
- Conference
- AREA Award
- Postdoctoral
- New Investigator
- Strengthening:**
- Career Enhancement
- Equipment
- Seed Grant
- Standard Strengthening

**For Higher Education Program
Proposals Only:**

Need Area: _____
 Discipline: _____

This is NE-IPM partnership grant proposal under Regional IPM Publication category. A total of \$20,000 is requested. With the vast number of fungicides available and the potential difficulty in understanding fungicide resistance development, vegetable producers need a simplified reference tool for the management of fungicide resistance in their farm operations. 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 produce approximately 221,000 acres of vegetable crops throughout the region. The objective of this project is to develop a grower reference guide for fungicide resistance management in vegetable crops in the mid-Atlantic region. The anticipated impacts of this project are to i) promote the importance and understanding of FRAC groupings in fungicide resistance management ii) prevent the misuse of specific fungicides with a high-risk potential for fungicide resistance development and iii) provide the tools and knowledge to allow growers to develop fungicide resistance management programs for vegetable disease control in their own farm operations.

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**DEVELOPING A FUNGICIDE RESISTANCE MANAGEMENT GUIDE FOR
VEGETABLE GROWERS IN THE MID-ATLANTIC STATES**

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Project Description:

Problem, background and justification

In the mid-Atlantic region (NJ, MD, VA, DE, PA) of the United States approximately 221, 000 A of fresh-market and processing vegetable crops are grown each year (NASS, 2003-4). 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 important diseases of vegetable crops, such as gummy stem blight and powdery mildew in cucurbits and phytophthora in bell pepper, has been detected in the mid-Atlantic region. Unfortunately, some growers become concerned about managing resistance only after it has developed. They (ie. growers) do not recognize 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 mode-of-actions can make it very difficult for vegetable growers to develop and follow fungicide resistance management programs on their farms.

In 2002, the NAFRAC (North American Fungicide Resistance Action Committee) was established to i) coordinate and identify resources for contact between government, universities, and the public on fungicide resistance management issues, ii) assist in the creation of new working groups in North America for other areas of chemistry, as they are needed and iii) serve as a spokesman for the industry view on fungicide resistance management issues by providing an outlet for comments and position papers from members. Each year the FRAC group publishes a list FRAC codes for most fungicides and fungicide chemistries. FRAC codes group fungicide chemistries according to class, mode-of-action and resistance-risk. To date, there are 43 numbered and 3 lettered FRAC groups for 61 listed chemical groups and 179 common names of fungicides (FRAC code, 2006). Accordingly, fungicides listed within a given FRAC group share a similar mode-of-action, therefore, have i) similar risks for resistance development, ii) similar use patterns on multiple crops and iii) exhibit the potential for cross-resistance development.

Fortunately, most fungal pathogens can be controlled by more than one fungicide chemistry and rotations between fungicides with different modes-of-action can easily be accomplished. However, in many cases, fungicides within a given FRAC code are listed for control of the same pathogen. Unfortunately, this can lead to serious confusion by vegetable producers when it comes to developing a seasonal fungicide application program for specific diseases. For example, Gummy stem blight is an important disease in cucurbit crops in the mid-Atlantic region, as well as, the rest of the US. In the mid-Atlantic region, fungicide chemistries such as azoxystrobin and pyraclostrobin are listed as recommended options for Gummy stem blight control. Unfortunately, both fungicides belong to FRAC code 11, and each has a high-risk for fungicide resistance development.

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. Importantly, 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 growers using a resistance management program (McGrath, 2001). More so, cross-resistance can develop in fungicides in FRAC code 11. Cross-resistance occurs when a fungal population that develops resistance one fungicide chemistry can develop resistance to other fungicide chemistries in the group, even if, only one fungicide chemistry has been applied. Unfortunately, resistance to the FRAC group 11 fungicides, as well as, others has already been detected for important vegetable pathogens in the northeast (McGrath, 2001).

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 their farm operation. In the mid-Atlantic region, five states (NJ, MD, DE, PA and VA) share the use of a common commercial vegetable productions 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. Although the recommendations guide includes FRAC codes, a simplified version is necessary to help vegetable growers understand FRAC groupings and their importance in fungicide resistance management.

Objectives and anticipated impacts

The objective of this proposal is to seek funding for the printing of the 2008 fungicide resistance management guide for vegetable crops grown in the mid-Atlantic region. The anticipated impacts of this project are to i) promote the importance and understanding of FRAC codes in fungicide resistance management ii) prevent the misuse of specific fungicides with a high-risk for resistance development and iii) provide the tools and knowledge to allow growers to develop vegetable disease control programs with an emphasis towards fungicide resistance management.

In a NE-IPM center partnership grant supported in 2007, 561 Fungicide Resistance Management Guides were distributed to vegetable growers in the mid-Atlantic region and West Virginia and New York representing approximately 42,000 A of vegetable production. This total represents about 20% of the approximately 221,000 A of vegetable production acreage in the mid-Atlantic region. Responses of the pre-survey determined that:

- 66% of the vegetable growers surveyed had heard of FRAC codes
- 82% followed fungicide resistance management guidelines
- 42% however, not sure if they grew vegetables in which fungicide resistance was known

90% said they were willing to use FRAC codes and fungicide resistance management in their farming operation

After listening to the speaker,

62% were more aware and 38% were highly aware of knowing the importance of FRAC codes

73% stated they would use the guide when making decisions about applying fungicides

58% stated the guide would be highly useful in their operation

54% stated the guide was very easy to use, 46% stated it was somewhat easy to use

Asked on how growers would like the FRAC guide produced:

20% wanted it available on-line, 49% wanted in hard copy form and 31% said they would like to see the guide available on-line and in hard copy form.

Approach and procedures

FRAC tables for the 30 crop groups listed in the 2008 Commercial Vegetable Productions Recommendations Guide for the mid-Atlantic region will be developed for a new fungicide resistance management reference guide. Each table will consist of all fungicides recommended for a particular crop (or crop group) in the 2008 recommendations guide along with FRAC and risk management codes, diseases for that particular crop or crop group and fungicide resistance management guidelines for each particular FRAC group. A table for fungicide resistance management guidelines for pumpkin and winter squash crops grown in the mid-Atlantic region, such as the one in Appendix A, has already been constructed. From the 2007 version of the guide listed, (Appendix A) 18 labeled fungicides that include 11 different FRAC codes are listed with risk management codes (L, M, H) for eight common pumpkin and winter squash diseases in the mid-Atlantic region. Fungicide, chemical names, FRAC groups and risk management guidelines will be color-coordinated by group to help distinguish differences based on FRAC code. The new 2008 version of 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 (Appendix B). 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 spiral-bound so it can be placed in a pesticide shed or weighing area for easy reference. Included in each guide will be a space where notes on applications, specific FRAC group use and dates can be recorded for specific crops (Appendices C and D). An example of the table is presented in Appendix C with an example of a production schedule for disease control in a pumpkin crop in Appendix D.

Although growers are required by law to keep a record of applications, little if any emphasis is put in keeping track of specific fungicide chemistry use in terms of resistance management. Without keeping track of such information, growers could unknowingly apply fungicides against label restrictions. A simple-to-use reference guide and method for keeping track of FRAC group use would help growers i) learn the importance of FRAC codes, ii) apply different fungicide chemistries appropriately, iii) reduce the potential for fungicide resistance development and iv) reduce the potential for economic losses due to fungicide resistance development.

Early Spring 2008	Summer 2008	Fall 2008
Develop master tables for fungicide resistance management guide	Promote use of guide during field days, twi-light meetings, etc	Promote use of guide during field days, twi-light meetings, etc
Develop text for guide introduction, etc.	Demonstrate importance of FRAC groups and guide to vegetable growers	Demonstrate importance of FRAC groups and guide to growers
Make final edit for printing	Grower surveys on their use of guide	Grower surveys on their use of guide
Print fungicide resistance management guide		Compile information collected from grower surveys
Distribute guide – late spring		Make improvements for future guide

Evaluation plans

The fungicide resistance management reference guide will be available to growers in the mid-Atlantic region in the late winter of 2007 and early spring of 2008. The goal of this year is to print and hand out one guide for each Commercial Vegetable Recommendations Guide in the mid-Atlantic. The recommendations guides are traditionally handed out at the annual vegetable meeting for each state and at twi-light meetings in the spring. The guide will also be distributed to vegetable growers in the mid-Atlantic states during the 2008 production season and be used as a promotional tool for twi-light meetings, fields days and on-farm tours. During these meetings, collaborators from each state will promote the use of the fungicide resistance management reference guide. 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 2008 is to reach 80% of the vegetable growers (representing ~ 180,000 A of vegetable production) in the 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 development

their fungicide programs iii) their use of the reference manual iv) how the use of the reference guide has changed their management programs and v) their thoughts on 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 mid-Atlantic region and iii) how to improve the reference manual 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 reference guide. Subsequent copies of the guide (after 2008) will then be sold at-cost (or for a nominal fee) or be available on-line on an annual basis for vegetable growers in the mid-Atlantic region and distributed with the mid-Atlantic commercial vegetable recommendations production guide.

LITERATURE CITED:

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

APPENDIX B

Fungicide Resistance Management Guidelines

Fungicide	Active Ingredient(s)	FRAC CODE	Risk Management		Early blight	Late blight	Rhizoctonia stem canker	Black scurf (Rhizoctonia solani)	White mold	Leak (Pythium)	Pink rot (Phytophthora)	Fungicide Resistance Management Guidelines
			L	H ^R								
Mancozeb	mancozeb	M3	L		X	X						Protectants, low-risk, use alone or tank mix with high-risk FRAC codes, alternate with other FRAC codes
Polyram	metiram	M3	L		X	X						
chlorothalonil	chlorothalonil	M5	L		X	X						High risk, rotate with other FRAC codes
thiophanate-methyl	thiophanate-methyl	1	H					X				Moderate to High risk
iprodione	iprodione	2	M-H					X				
Ridomil Gold Copper	mefenoxam + copper	4 + M1	M					X		X	X	Rotate with other FRAC codes, resistance risk reduced
Ridomil Gold MZ	mefenoxam + mancozeb	4 + M3	M					X		X	X	
Ridomil Gold Bravo	mefenoxam + chlorothalonil	4 + M5	M					X		X	X	
Eurotonil	mefenoxam + chlorothalonil	4 + M5	M					X		X	X	
Ridomil Gold	mefenoxam	4	H ^R							X	X	High-risk, resistance known in Late blight and Pink rot
Ultra Flourish	mefenoxam	4	H ^R							X	X	Low to Moderate risk
Moncut	flutolanil	7	L-M			X	X					Rotate with other FRAC codes
Endura	boscalid	7	M-H	X				X				
Quadris	azoxystrobin	11	H	X		X						High-risk for resistance, tank-mix with a protectant (M) fungicide, Do not apply FRAC code 11 fungicides consecutively. Reduced sensitivity has been reported in Early blight control
Gem	trifloxystrobin	11	H	X								
Headline	pyraclostrobin	11	H	X								
Reason	fenamidone	11	H	X								
Quadris Opti	azoxystrobin + chlorothalonil	11 + M5	M	X								
Tanos	famoxadone + cymoxanil	11 + 27	M-H								X	Apply at planting
Blocker	PCNB	14	L-M			X	X					Always tank mix with a protectant, rotate
Ranman	cyanofamid	21	H							X	X	Rotate with other FRAC codes
Gavel	zoxamide + mancozeb	22 + M3	L-M									Tank mix with protectant, rotate
Curzate	cymoxanil	27	L-M									Tank mix with protectant, rotate
Previcur Flex	propamocarb HCL	28	L-M									Tank mix with protectant, rotate
Omega	fluazinam	29	L						X			Low-risk
Super Tin	triphenyltin hydroxide	30	L-M	X								Tank mix with protectant, rotate
Forum	dimethomorph	40	L-M									Tank mix with protectant, rotate

Fungicide resistance management guidelines for potatoes grown in mid-Atlantic region - 2008

FRAC code: M = multi-site MOA, numbered codes = chemistries with similar mode-of-action (MOA) and Resistance-risk

Risk management: L = low risk, M = moderate risk or H = high risk for resistance to develop, H^R = Known resistance reported

High-risk fungicides with similar MOA (ie. same FRAC code number) should not be sprayed consecutively

APPENDIX C

2007 Fungicide Application Schedules										
Crop:	Applications									
	1	2	3	4	5	6	7	8	9	10
Date										
Farm/Block										
FRAC group										
Chemical										
Rate(s)										
Sprayed for:										

Notes:

Crop:	Applications									
	1	2	3	4	5	6	7	8	9	10
Date										
Farm/Block										
FRAC group										
Chemical(s)										
Rate(s)										
Sprayed for:										

Notes:

Crop:	Applications									
	1	2	3	4	5	6	7	8	9	10
Date										
Farm/Block										
FRAC group										
Chemical(s)										
Rate(s)										
Sprayed for:										

Notes:

Crop:	Applications									
	1	2	3	4	5	6	7	8	9	10
Date										
Farm/Block										
FRAC group										
Chemical(s)										
Rate(s)										
Sprayed for:										

Notes:

APPENDIX D

2007 Fungicide Application Schedules

Crop: Pumpkin		Applications									
Date	1	2	3	4	5	6	7	8	9	10	Notes:
	7/15	7/22	7/31	8/7	8/14	8/23	9/1	9/8	9/18		
Farm/Block	RAREC	RAREC	RAREC	RAREC	RAREC	RAREC	RAREC	RAREC	RAREC	RAREC	
FRAC group	M5 + M1	M5	M5+M3	11	4+M5	11+7	M5+3	M5+M1	M5		
Chemical	Bravo+S	Bravo	Bravo+copper	Nova	RidG+Bravo	Pristine	Bravo+Nova	Bravo+S			
Rate(s)	2pt+2lb	3 pt	2pt ea	5 oz	2 lb	15 oz	2 pt + 5 oz	2pt+2 lb	3 pt		
Sprayed for:	PM	PM	PM,ALS	PM	PM,DM	PM,DM	PM	PM,DM	PM		

Crop:		Applications									
Date	1	2	3	4	5	6	7	8	9	10	Notes:
Farm/Block											
FRAC group											
Chemical(s)											
Rate(s)											
Sprayed for:											

Crop:		Applications									
Date	1	2	3	4	5	6	7	8	9	10	Notes:
Farm/Block											
FRAC group											
Chemical(s)											
Rate(s)											
Sprayed for:											

Crop:		Applications									
Date	1	2	3	4	5	6	7	8	9	10	Notes:
Farm/Block											
FRAC group											
Chemical(s)											
Rate(s)											
Sprayed for:											

Cooperation and Institutional Units Involved

Rutgers University is responsible for the total budget and for the coordination of research objectives involved. Rutgers University will participate in the development of resistance management guide and help promote the use of the guide at twi-light meetings, field days and regional meetings. One year budget of \$20,000.

University of Maryland will participate in the development of resistance management guide and help distribute and promote the use of the guide at twi-light meetings, field days and regional meetings.

University of Delaware will participate in the development of resistance management guide and help distribute and promote the use of the guide at twi-light meetings, field days and regional meetings.

Virginia Polytechnic Institute and State University participate in the development of resistance management guide and help distribute and promote the use of the guide at twi-light meetings, field days and regional meetings.