# Fungicide Basics and Use in Vegetable Disease Management

Univ. of Florida In-Service Training/The Great CEU Round-Up 2013 February 27, 2013

Nicholas S. Dufault Extension Specialist Row Crops & Vegetables Plant Pathology Department/IFAS University of Florida



# Understanding how and when a disease occurs is critical to determining management.

## In plant pathology there are three principle components that affect the intensity of disease.



## For the host it is important to consider: resistance, age and where the disease occurs.





# Environment is a key in determining the amount of disease that will be present.



**Powdery Mildew: Dry weather** 



## We need to know what stage in the pathogens life cycle we are trying to control.



http://oardc.osu.edu/soyrust/2007edition/11-FungicideBasics.pdf



# An integrated approach is critical to disease control.

Crop Rotation

• Tillage

• Weed mngt.

Assess the risk



This worksheet will lead you through the four-step process of determining your disease risk level in order to castornize a Peanut Ro<sup>TM</sup> for your individual field. Use the reverse side of this worksheet with the assistance of your Bayer CongScience representative to develop a program specifically for your field. For each of the risk index factors, identify which option bent describes the situation in your field and add the index base associated with each choice to obtain your overall disease risk value. This worksheet does not contain all of the notes that accompany each factor included in the 2012 Peanul Ro. To view the

complete 2012 Peanut Rx, visit the University of Georgia peanut web site at www.ugapeanuts.com.

Variety Selection				
facety:	1100V Foints	Load Spot	Winter Maria Prints	Look R
Sevenamer 455 or Fleramer	60	Unknown	Unknown	Unlines
11 V.38	54	30	30	Linkows
47-218	28	30	30	Uniterior
Seongia Dreen	20	29	25	Uniterior
Poside Pancy	25	29	20	Unknow
Seongia-898	20	25	25	Unknow
FielKan 107	20	28	30	Liebnes
Seurgia Director 1	10	30	30	Liebnes
beorgia-E2C *	15	29	10	Uritinos
Deorgia-BIG	10	29	20	Unlines
Plonide-UT	10	29	45	Unknow
Seorgia-ETW	10	29	10	Unknow
Tillguard	10	18	18	Links
latey	10	18	10	Linkson
Deorganic	5	10	10	Unknow
Planting Date				
Prenets are planted:	15MV Points	Losi Spot	White Real	Land I
Prior to May 1	38	0	10	0
Apy 1 - May 10	15	0	5	0
Any 11 - May 21	5	5	0	0
June 1 - June 18	10	10	0	6
Liter June 10	18	10	0	6
Plant Population (Real stand, not	seeding n	atel)		
Hard Stand:	1500	Lost Spot	White Barry	Links
Jees than 3 plants per foot	25	564.	0	5.4
To 4 plants per tool (for varieties with poter will points grader than 26)	10	NOA.	0	5.0
to 4 plants per toot (to varieties with policy will participes that 20	10	NA.	0	5.0
Aore than 4 plants per text	5	504.	5	5.4
N.Plant Insecticide				
	15MV Points	Load Spot	White Maid Funds	1
Sone	10	104.	NA.	5.8
Other than Thimet 20G or Phorate 20G	15	864.	5.4	5.4
Thimet 28G or Phorate 29G	5	56A.	54	5.0
low Pattern				
Peaceds are planted in:	1100V	Load Spot	Wide Build	Land
Single-mass	15	0	5	0
Twin news	8	0	Ð	0
lilase				_
Tillage Type:	110WV	Lost Spot	With State	Look I
(intraminoal	15	10	0	0
and and				
Change Hart Links	_			
Classic Reducides	1997	Load Spot	White Ball	Links
	Putetta	Public	Paints	Parat
TRANS ADDRESS	5	564	5.4	5.4

	T SHOW	Load Spot	White Made	Link R.
0	86A	25	25	20
1	564	15	29	15
2	864.	10	10	90
3-or more	Pdd.	8.	5	6
Field History				
Previous disease problems in the field?	1100Y	Lost Spot	WEIGHT MORE Projekte	Link H
Ne	164			0
YWE	104	10	18	10
Irrigation				
Does the field receive	1580	Loui Spot	White Model	Link Br
160	504.	0		0
View .	104	- 10		10

Step 2: Calculate Your Severity Points Fills following table to release your severity points for rack of the four major present date

Add your index values for each determining factor below:	15mm	Lost Spot	White Model Promite	Line Rot
Peanut Variety				
Pterting Date				
Plant Population				
At-Plant Insecticide				
Now Pattern				
Tilage				
Character Herbicide				
Crop Plotation				
Pield History				
Integation				

Step 3: Interpret Your Index Values

Risk Index Category					
Rad Calegory:	TRAC Points	Loaf Spot	White Model Preints	Linds The Freinds	
High Risk	+ 115	05-108	55-60	780	
Moderate Kish	70-110	40-00	30-90	180	
Low Risk	(85	10-00	10.25	180	

In a year when taiwate spotted will virus incidence is high statiential or in your region, even fields with a low risk level may experience significant/ocean. Consider the obtaining recommendations to reduce your spotted with risk level. 1: Use leve susceptible versions. 2: - Addrey run planting date. 3: - Consult the complete Freenut Riv ter additional options that may provide limited benefit.

#### Step 4: Develop your Peanut Rx

Correr you have a maintained by any index with the events present diseases, willing the recent conservative bargination programs as your guide for condensaring a per field present/plans upon programs with the available of guide for each conservation of the second of the second disease into appropriate for each relative to each other to extend a disease into appropriate for each relative to each other to extend a disease of the second second s





PEST INFORMATION PLATFORM FOR EXTINSION & EDUCATION



## Spray recommendations are based on all of these components.

#### Watermelon Fungal Spray Program

Nicholas S. Dufault, Extension Vegetable Plant Pathologist – University of Florida Mathews L. Paret, Assistant Professor Plant Pathology – University of Florida, NFREC

#### Program starts 1 week after transplanting, then use a 7-10 day schedule (especially with weekly rainfall)

Spray No.	Fungicide/Product	Notes
1	Chlorothalonil (GSB) Copper fungicide/Actigard (BFB)	Preventative spray Copper used prior to fruit set if BFB is an issue
2	Chlorothalonil (GSB) Copper fungicide/Actigard (BFB)	Preventative spray Copper used prior to fruit set if BFB is an issue
3	Chlorothalonil (GSB)* Copper fungicide/Actigard (BFB)	*If disease is present, use a systemic (i.e. Tebuconazole or Inspire super)
4	Chlorothalonil (GSB)* Copper fungicide (BFB)	*Preventative spray, but should consider a systemic if there is disease pressure.
5	Tebuconazole OR Inspire Super (GSB) Copper fungicide (BFB)	Luna experience can be added to this rotation once it becomes available for GSB and PM, and Torino for PM.
6	Mancozeb (GSB + DM) Presido or Revus (DM or PCAP) Copper fungicide (BFB)	Could spray Cabrio, as well, for Anthracnose control. Remember to watch FRAC and rotate fungicides. Watch for fruit set with copper fungicide spray.
7	Tebuconazole OR Inspire Super (GSB) Quintec or Endura or Procure or Rally (PM)	Luna experience can be added to this rotation once it becomes available for GSB and PM, and Torino for PM.
8	Mancozeb (GSB + DM) Presido or Revus (DM or PCAP)	Managing Gummy Stem Blight Managing DM and Phytophthora.
9	Tebuconazole OR Inspire Super (GSB) Topsin+mancozeb OR Inspire Super (GSB + ANTH) Presidio or Revus (DM or PCAP)	Luna experience can be added to this rotation once it becomes available for GSB and PM, and Torino for PM.

Disease management should be part of an integrated program that uses disease free seed/transplants, proper crop rotation, debris removal and resistant varieties.

Cholorthanonil can burn the watermelon rind and sprays should be stopped 21 days before harvest.

Actigard and copper fungicides are used to manage BFB before it is a disease issue (i.e. high severity or incidence).

As always, fungicide labels should be consulted for rates and application instructions as well as other detailed spray information (PHI, spray limits, etc.).

Pay attention to preharvest intervals (PHI) for late season sprays as they may be as high as 14 days.

Sprays can be reduced to 14 day intervals in the spring under dry condition (i.e. no rainfall).

Consult the Vegetable Production Handbook for Florida for more detailed management information.

Disease Acronyms: GSB=Gummy Stem Blight; BFB=Bacterial Fruit Blotch; PM=Powdery Mildew; DM=Downy Mildew; ANTH=Anthracnose; PCAP=Phytophthora crown and fruit rot.

# How do we know which fungicide to use or recommend in these programs?





# For fungicide recommendations you often hear:

- Rotate the mode of action
- Systemic and contact
- FRAC number

What do these terms mean and how are fungicides active in the plant?



## What is a fungicide?

3 names: chemical name, common name and trade name

Fungicide:chemical/physical agent thatkills/inhibits the growth of fungi

**Classified as follows:** 

- 1. Mode of action
- 2. Breadth of activity
- 3. Mobility within the plant
- 4. Role in protection
- 5. Chemical group
- 6. FRAC Code



### 1. Mode of action

### How the fungicide acts on the target fungus, e.g.

- damage cell membranes
- inactivates critical enzymes/proteins
- interferes with respiration





R. Latin, 2011



## 2. Breadth of activity

### Single-site:

 active against only one point in one metabolic pathway in a fungus, OR against a single enzyme or protein needed by the fungus

### Multi-site:

• affects a number of different metabolic sites within the fungus





**Fig. 2.7.** The respiratory electron transport chain occurs within mitochondria. It generates energy in the form of adenosine triphosphate (ATP) to fuel other cell functions. Two of the four complexes in the chain are targeted by fungicides used for turf disease control. Carboxamide fungicides (boscalid and flutolanil) disrupt electron transport at Complex II. QiI (<u>quinone inside inhibitor</u>) fungicide (cyazofamid) and QoI (<u>quinone outside inhibitor</u>) fungicides (azoxystrobin, fluoxastrobin, pyraclostrobin, and trifloxystrobin) interrupt the chain at Complex III.



#### R. Latin, 2011



Fig. 2.8. Target site of demethylation inhibitors (DMI fungicides).



R. Latin, 2011

## 3. Mobility within the plant



## 3. Mobility within the plant

Systemic: (i) Locally / translaminar

Droplets spread out and are absorbed by plant tissue Leaves produced after the application are not protected

No chemical = no protection



## 3. Mobility within the plant

Systemic: (ii) acropetal

Droplets spread out and are absorbed by leaf tissue. Fungicide moves upwards in the xylem to edge of leaves and new growth

D. Mueller, Iowa State Univ.

Leaves produced after the application MAY be protected

No chemical = rely on fungicide via xylem



#### R. Latin, 2011

Fungicide	Phytomobility classification	Movement throughout the plant	Movement among cells
chlorothalonil	Contact		
mancozeb	Contact		
thiram	Contact		
PCNB	Contact		
chloroneb	Contact		
etridiazole	Contact		
iprodione	Local penetrant	Translaminar	Uncertain
vinclozolin	Local penetrant	Translaminar	Uncertain
trifloxystrobin	Local penetrant	Translaminar	Apoplastic
pyraclostrobin	Local penetrant	Translaminar	Apoplastic
cyazofamid	Local penetrant	Translaminar	Apoplastic
fludioxonil	Local penetrant	Translaminar	Apoplastic
polyoxin D	Local penetrant	Translaminar	Apoplastic
azoxystrobin	Acropetal penetrant	Xylem mobile	Apoplastic
fluoxastrobin	Acropetal penetrant	Xylem mobile	Apoplastic
fenarimol	Acropetal penetrant	Xylem mobile	Apoplastic
metconazole	Acropetal penetrant	Xylem mobile	Apoplastic
myclobutanil	Acropetal penetrant	Xylem mobile	Apoplastic
propiconazole	Acropetal penetrant	Xylem mobile	Apoplastic
tebuconazole	Acropetal penetrant	Xylem mobile	Apoplastic
triadimefon	Acropetal penetrant	Xylem mobile	Apoplastic
triticonazole	Acropetal penetrant	Xylem mobile	Apoplastic
flutolanil	Acropetal penetrant	Xylem mobile	Apoplastic
boscalid	Acropetal penetrant	Xylem mobile	Apoplastic
mefenoxam	Acropetal penetrant	Xylem mobile	Apoplastic
thiophanate-methyl	Acropetal penetrant	Xylem mobile	Apoplastic
propamocarb	Acropetal penetrant	Xylem mobile	Apoplastic
fluopicolide	Acropetal penetrant	Xylem mobile	Apoplastic
fosetyl aluminum	Systemic penetrant	Ambimobile	Symplastic
phosphonic acids	Systemic penetrant	Ambimobile	Symplastic

#### Table 1.3. Phytomobility of active ingredients in turf fungicides

## 4. Role in protection

#### **Preventative:**

- acts as a protective barrier
- prevents spore germination and infection
- contact and systemic fungicides

### Early infection ("curative") activity:

- systemic
- stops pathogen in plant tissues (24-72h after infection)
- most effective when applied before infection



### 4. Role in protection

### **Eradication**:

- stop disease development after symptoms developed
- VERY FEW fungicides

### **Anti-sporulant activity:**

- prevent spores being produced
- disease continues to develop



# A visual depiction of fungicide's role in protection.



Figure 7.1. Schematic representation of fungicide activity in relation to soybean rust development.

http://oardc.osu.edu/soyrust/2007edition/11-FungicideBasics.pdf



## 5. Chemical groups

- A group of chemicals that share a common biochemical mode of action
- May / may not have similar chemical structure
  - Demethylation Inhibitor (DMI) (includes triazoles)
  - Qol (includes strobilurins)
  - Methyl Benzimidazole Carbamates (MBC)
  - Carboxamides
  - Chloronitriles



### **Qol fungicides**

### **Examples:**

- azoxystrobin (Quadris<sup>®</sup>)
- pyraclostrobin (Headline®)
- trifloxystrobin (Stratego YLD<sup>®</sup>)
- fluoxastrobin (Evito<sup>®</sup>)
- **single site activity** quinol outer binding site of cytochrome bc1 complex



### **Qol fungicides**

#### • Mode of action:

- prevent energy production by the fungus by inhibiting mitochondria respiration
- Stop spore germination and early mycelium growth (infection)
- Role in protection: Preventative / early infection activity
- Other information:
  - Residual period up to 21 days
  - mostly locally systemic (translaminar)\*
  - prone to resistance

\*Two strobilurin fungicides currently on the marketplace can move thru the xylem (azoxystrobin (a.i. in Quadris – or one of the a.i.s in Quilt and Quilt Xcel) and fluoxastrobin (Evito).



### **Qol fungicides**

#### • Mobility



Adapted from: Vincelli, 2002 http://www.apsnet.org/ 1. Surface redistribution

- 2. Penetrate waxy cuticle
- 3. Translaminar activity
- 4. Vapor movement & reabsorption



#### Leaf tip

Leaf base



Fig. 1.8. Movement of acropetal and local penetrant fungicides. Fungicides were applied to the bases of wheat leaves prior to inoculation with the powdery mildew pathogen. (Adapted from Bartlett et al., 2002)



### **Triazole fungicides**

Demethylation Inhibitor (DMI) fungicides

**Examples:** 

- •tebuconazole (TebuStar, Monsoon)
- propiconazole (Tilt<sup>®</sup>, Quilt, Quadris Xtra)
- prothioconazole (Proline<sup>®</sup>)
- metconazole (e.g., Headline <u>Amp</u><sup>®</sup>)
- tetraconazole (Domark<sup>®</sup>)

• single site activity – inhibit C14-demethylase



### **Triazole fungicides**

#### • Mode of action:

- prevent sterol production by the fungus
- sterols = building blocks of membranes
- result in abnormal fungal growth and eventual death
- Role in protection: preventative / early infection activity
   / anti-sporulant
- Other information:
  - Residual period ~ 14 days
  - locally systemic (typically more mobile than QoI fungicides)
  - prone to resistance



### **Triazole fungicides**





### **SDHI fungicides**

### Succinate Dehydrogenase Inhibitor (SDHI) Fungicides

**Mode of action:** SDHI fungicides inhibit fungal respiration (similar to QoI fungicides).

**Mobility in plants:** Locally systemic. Movement is translaminar and upward.



# The classes of fungicide will affect fungal types differently.



UF FLORIDA

R. Latin, 2011

# A example of how to use fungicide classes to control a fungus.

Spore germination or zoospore motility	Penetration	Mycelial growth	Pre- sporulation	Sporulation
			Build	
Chlorothalo	nil			
Strobilurin				
Triazoles				
Premix				

Highly Effective





# A summary comparison of a contact versus penetrant fungicides.

Contact	Penetrant
Must be applied before infection	Applied soon after infection
Prevents spore germination	Ineffective once fungus begins reproduction
No effect after infection	Limited "curative" effect
Low risk for resistance	Higher risk for resistance

Remember common penetrant movement:

- Translaminar
- Acropetal



http://www.ballpublishing.com/growertalks/ViewArticle.aspx?articleid=18447

### 6. FRAC code

- The FRAC code represents the mode of action of the fungicide.
- Alternate numbers to manage fungicide resistance



#### Flowable Fungicide

Broad spectrum fungicide for control of plant diseases

 GROUP
 11
 FUNGICIDES

 Active Ingredient:
 Active Ingredient:
 Active Ingredient:

 Azoxystrobin:
 methyl (E)-2-{2-[6-(2-cyanophenoxy)]
 Pyrimidin-4-yloxy]phenyl}-3-methoxyacrylate\*
 22.9%

 Other
 Ingredients:
 77.1%
 100.0%

 Total:
 100.0%

FRAC Code on the Quadris label



### **Fungicide resistance**

- Resistance risk varies by pathogen and fungicide class
  - DMI (triazole; FRAC 3) Medium Risk slower, more gradual development
  - SDHI (FRAC 7) Medium Risk > 10 mutations
  - QoI (Strobilurin; FRAC 11) High Risk One common mutation (G143A) but others have been detected
    - Some pathogens will not survive the G143A mutation (lower risk)
- Resistance management strategies
  - Good agronomic practices
  - Restriction in spray number
  - Use of a diversity of fungicide modes of action



http://www.frac.info/index.htm

## FRAC # are a simple way to know which fungicide you are using.

#### A list of common fungicides labeled for watermelon disease control

A more extensive list of pesticides can be found in the Vegetable Production Handbook for Florida (2011-2012). As always, it is important to consult the label for detailed information about spray applications and managed pests. This list is designed to encompass many diseases that attack watermelons during the growing season in Florida and is only meant to support the resources like those stated above. Always rotate fungicide products (i.e. different FRAC groups) when implementing a disease spray program.

Product Name	Active Ingredient	Group (FRAC)	Туре	Target Pest
Bravo, Echo, etc	chlorothalonil	м	с	GSB, DM, PM
Dithane, Penncozeb, etc.	mancozeb	м	С	GSB, DM
Champ, Kocide, etc.	copper hydroxide	м	с	BFB
Topsin M	thiophanate-methyl	1	S	ANTH
Folicur, Tebuzole, etc.	tebuconazole	3	s	GSB, PM
Procure	triflumizole	3	S	PM
Rally	myclobutanil	3	S	PM
Endura	boscalid	7	S	PM
Pristine	boscalid + pyraclostrobin	7+11	S	GSB, DM, PM
Inspire Super	cyprodinil + difenoconazole	9+3	s	GSB, PM
Switch	cyprodinil + fludioxonil	9+12	S + C	GSB, PM
Cabrio	pyraclostrobin	11	S	ANTH
Quintec	quinoxyfen	13	С	PM
Ranman	cyazofamid	21	S	DM
Previcur Flex	propamocarb	28	S	DM
Revus	mandipropamid	40	S	DM
Presidio	fluopicolide	43	s	DM
	FUTURE PRODU	UCTS		
Luna Experience (Bayer)	Tebuconazole + Fluopyram	3 + 7	s	GSB, PM
Torino (Gowan Co.)	Cyflufenamid	U6		PM

GSB: Gummy Stem Blight; DM: Downy Mildew; PM: Powdery Mildew; ANTH: Anthracnose; BFB: Bacterial Fruit Blotch. C: contact spray S: "systemic" spray

# In general, fungicides either stay where you apply them or move up!



A fungicide deposit close to the crown will protect the oldest leaf sheath from infection, but will not provide protection to new leaves.



R. Latin, 2011

# Key spray factors for disease control with fungicides are:

- Application rates vary from 15 to 100 GPA
  - Range of rates specified on label
  - Higher rates often better coverage
- Spray intervals vary from 7 to 21 days
  - Fungicides breakdown
  - Environment
- Surface coverage (spray nozzle type and droplet size)



# Spray intervals are based on fungicide residual or plant growth.



https://www.pioneer.com/home/site/us/agronomy/library/template.CONTENT/guid. 6604153B-DB01-CE9E-6A9D-B916EE2573BB



### Complete coverage (100%) is impossible.

- How much do we need to cover?
  - Late blight: yield increases at 28% coverage
  - Foliar disease can be tolerated
    - Corn: upper 1/3 canopy coverage
    - Legumes: upper 1/3 or so canopy coverage
- Ornamentals and turf more extensive coverage.



# Droplet sizes from 200 to 300 microns are best for fungicide applications.

DROPLET SIZE					
Category	Symbol	Color code	Approximate VMD (0.5) (microns)*		
Verv fine	VF	red	<150		
Fine	F	orange	150-250		
Medium	М	yellow	250-350		
Coarse	С	blue	350-450		
Very coarse	VC	green	450-550		
Extremely coarse	XC	white	>550		
*VMD (volume mean diameter) = droplet size where half of the volume has droplets greater than the volume mean diameter, and half the volume has droplets smaller than the volume mean diameter.					
Table 1. Droplet size categories.					

Drift is a worry (avoid herbicide mixing)



### **Common nozzles used for fungicides**



Hollow Cone or Whirling Disc

**Air Induction Flat Fan** 



## Canopy density important in determining coverage from a nozzle.





T. Mueller (soybeans), 2006

## Fungicide coverage might be less important when using a penetrant.



# Spray coverage is important, but it is important to consider the goal.

• If it is a preventative (contact) spray than coverage is critical.

 If it is a responsive (penetrant) spray then coverage maybe less critical.



http://oardc.osu.edu/soyrust/2007edition/11-FungicideBasics.pdf



### The basics of a "good" spray program

Prevention is key!

- Be sure to rotate chemistries
  - FRAC number
  - Labels for details



Fungicides will manage diseases, but will not eliminate them.



## Questions?

#### Thank you to Dr. Daren Mueller