An Overview of Apple Disease Models



Sara M. Villani

Assistant Professor-Fruit and Woody Ornamental Pathology Department of Entomology and Plant Pathology

What is a Plant Disease?

- A disorder that interrupts plant physiological function
- Abnormal functioning of an organism: Biotic





Photo courtesy of Emma Lookabaugh, Mike Munster

Rose Rosette Disease (virus)

What is a Plant Disease?

- A disorder that interrupts plant physiological function
- Abnormal functioning of an organism: Abiotic?



Frost Damage







Apple Disease Challenges in the Southeast



Apple Disease Challenges in the Southeast



- Paucity of disease resistant cultivars
 - Breeding efforts focus on consumer preference
 - Usually single-disease resistance

Apple Disease Challenges in the Southeast

- Warm, humid climate
 - Favorable for pathogen infection and disease development
 - Inadequate chilling hours: longer period of susceptibility to blossom infection

Conducive

Environment

Susceptible Host

<u>Biology and</u> <u>availability of</u> <u>pathogen</u>

Apple Disease Challenges in the Southeast

- Maintaining practices of fungicide resistance management and maximum annual applications
 - Commercial apple growers in Hendersonville NC: Up to 24 fungicide applications in 2017!

Multi-site Protectants	Single-site Fungicides	Biologicals
Mancozeb	Group 3: S.I.'s	<i>Bacillus</i> spp.
Captan	Group 11: "Strobys"	A. pullulans
Copper	Group 7: SDHIs	
Sulfur	Group 1: "T-Methyl"	
ziram	U12: Dodine	
Phosphorous Acid		

Apple Disease IPM

Apple Disease IPM: Deterrence



Usually a pre-plant tactic: Minimize abiotic and biotic factors favoring disease

Apple Disease IPM: Host Resistance



Pre-plant tactic: Plant cultivars that are less susceptible to most economically devastating disease in the region

Apple Disease IPM: Host Resistance



Pre-plant tactic: Plant dwarfing rootstocks with resistance to fire blight, *Phytophthora*, and replant disease

Apple Disease IPM: Cultural

Pre + post-plant tactic: Remove overwintering inoculum and deter opportunistic pathogens



Apple Disease IPM: Biological Control

- Biologicals: living organism competitors, bacterial antimicrobials/metabolites, bacteriophage
 (-) Not as efficacious as conventional products, esp. under high disease pressure
 - (-) Performance not consistent
 - (+) Organic production; short REI/PHI
 - (+) Some induce plant defenses

Apple Disease IPM

Chemical Control: Protectant Fungicides

- Prohibit fungal spore germination
 - (-) Application by prediction, phenology, gut feeling
 - (-) Risk of harming non-targets
 - (+) Low risk for resistance development



Chemical Control: Protectant Fungicides

- Fungicide movement in plant = Non-systemic
- Surface active/contact fungicide that is not/should not be absorbed by plant tissue (surfactant/mixing partner)
 - Phytotoxic if absorbed
- Work by direct contact with pathogen on the plant surface: Coverage is critical





Protectant/Non-systemic Fungicide Movement





- Fungicide remains on surface where applied
 - Rain can redistribute (move it to other surface parts)
- Plant tissue (i.e. leaves) emerging after application or tissue missed during application not protected
 - Unless material redistributed

Protectant/Non-systemic Fungicides: Conditions Favoring Phytotoxicity

- Applications under slow drying conditions
 - Early morning or evening/night-time, foggy or misty day, high humidity, cloudy, low wind, high application volume
 - Extends contact period on leaf and fruit surface
- Applications following warm, rainy, windless weather
 - Petal fall 10-14 mm fruit (1st C): Key thinning timings
 - Young, susceptible leaf and fruit tissue without cuticle protection
- Tank mixtures containing surfactants and spreader/stickers that may disrupt waxy cuticle
 - Oils, urea, calcium chloride, LI-700? Regulaid?

Protectant/Non-systemic Fungicides: Conditions Favoring Phytotoxicity



Captan + Surfactant Phytotoxicity



Apple Disease IPM: Chemical Control

• Single-site fungicides

(+) Manage number of phytopathogenic fungi

(+) Minimize harmful effects to non-targets and environment

(+) High level of protective and curative(?) activity

- Curative: Stop/inhibit fungal growth-**fungistatic**
 - DMI (Demethylation inhibitor fungicides)
 - 24-72 hours post-infection application

Single-site/Systemic Fungicide Movement

- Moves through vascular tissue (xylem and/or phloem) to reach parts of plant not directly sprayed with fungicide
- Usually good in "kick-back"/curative mode
- New leaves may be protected depending on movement rate
- Rare in fungicide world
 - Phosphorous acid fungicides and mefanoxam/metalaxyl (good on root diseases)



Single-site/ Locally Systemic Fungicide 22 Movement

- Absorbed by plant but do not travel far
 - Move within a treated plant organ (primarily leaf)
- Interfere with fungal growth, have postinfection/curative/kick-back activity
- Movement of most modern fungicides
- Translaminar movement: Spray from one side of leaf moves to other side





Apple Disease Management Options: Biological + Chemical Control

• Single-site fungicides

(+) Manage number of phytopathogenic fungi

(+)Minimize harmful effects to non-targets and environment

(+)High level of protective and curative(?) activity

- Curative: Stop/inhibit fungal growth-**fungistatic**
 - DMI (Demethylation inhibitor fungicides)
 - 24-72 hours post-infection application

(-) Specificity fosters development of resistant populations with repetitive use



ww.shutterstock.com

Fungicide Resistance Management

A Reason for Concern: A (Bad) Trip Down Memory Lane...



Doc Godfrey, 1967 co-founder AgChem Service Corp. Written Paper

Apparent resistance of Venturia inaequalis to dodine in New York apple orchards [1969]

Szkolnik, M. Gilpatrick, J.D.

G f У 🗟 🕂

Fruit growers in certain areas of New York State who have used dodine (n-dodecylguanidine acetate) sprays successfully for as long as 9 years for apple scab control have not obtained satisfactory control of this disease for the last 1 to 3 years. Other fungicides continue to perform satisfactorily. In aerial and ground spray research plots at Sodus, N. Y., decreased control with dodine was observed in 1968. In 1969, control with dodine here was completely unsatisfactory. In this same orchard maneb and captan gave excellent scab control both years. The reason for these dodine failures in controlling scab is attributed to resistance in Venturia inaequalis to dodine acquired over a period of years. This apparent resistance has been observed so far in the Lake Ontario fruit belt counties and in the Geneva area of New York State.

Resistance stable for 30+ years!

2004-2006



Orchard populaiton mean percent relative growth (%) on 0.2 µg/ml dodine

Fun with FRAC

• FRAC: Fungicide Resistance Action Committee:



In general, there will be cross-sensitivity (cross-resistance) between fungicides in same FRAC group

• In other words, pay attention to FRAC # and rotate or resistance!

Strobilurin Fungicides

Standalone Products (single active ingredient)

Strobilurin Fungicides

Premixed Products (stroby + another single-site fungicide)

Resistance Management. To limit the potential for development of resistance, **DO NOT** exceed the maximum limits in the table above.

DO NOT make more than two (2) sequential applications of **Merivon** before alternating to a labeled **non-Group 7** or **non-Group 11** fungicide.

Product Use Maximum Maximum Mining					
Сгор	Target Disease	Rate per Application (fl ozs/A)	Number of Applications per Season	Product Rate per Year (fl ozs/A)	Time from Application to Harvest (PHI) (days)
Pome fruits	Alternaria blotch (Alternaria mali)	4 to 5.5	4	22	0
Crabapple Oriental pear	Apple scab (Venturia inaequalis)				
Pear	Bitter rot (Colletotrichum spp.)				

Development of Fungicide Resistance

Naturally occurring resistant members of population

Mitigating Fungicide Resistance

Great Rate Debate: For single site fungicides (particularly DMIs), use the highest rate

Diseases	Rally 40WSP oz/acre	Use Directions	Restrictions	
powdery mildew (<i>Podosphaer</i> a spp.)	5 - 10 (2 - 4 oz ai)	Begin application at tight cluster and continue through the second cover spray. Additional sprays may be needed on susceptible varieties or under heavy disease pressure. Use high label rate if powdery mildew was present in previous years.	 Preharvest Interval: I not apply within 14 da of harvest. Do not apply more than a total of 5 lb of 	
rust (Gymnosporangium spp.)	5 - 8 (2 - 3.2 oz ai)	Begin applications at pink stage and continue through the second cover spray.	Rally 40WSP (2 lb ai) per acre per season.	
scab - prebloom (<i>Venturia</i> spp.)		Begin applications at green tip or when environmental conditions become favorable for primary scab development. Apply Rally 40WSP in a tank mixture with a protectant fungicide registered for use on apples on a 7- to 10-day schedule.		
scab - bloom		Apply Rally 40WSP in a tank mixture with a protectant fungicide registered for use on apple at the specified rate for improved fruit scab and summer disease control.		

Summing it up: Mitigating Fungicide Resistance

- Practice good application strategies
 - Don't exceed seasonal limits within FRAC groups
 - Ensure sprayer is calibrated
 - Apply prior to infection events (minimize 'kick-back' applications
 - Don't cheat on coverage (e.g. ARM)
 - Adopt cultural practices aimed at inoculum reduction

