Research update 2019
Ripe rot of grape

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A pdf version is available on my blog (grapepathology.blogspot.com)

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Ripe Rot of grape

- Two pathogen complexes
  - *Colletotrichum acutatum*
  - *Colletotrichum gloeosporioides*
- Direct damage
  - Loss of crop up to 30%
- Indirect damage
  - Only 3% contamination can affect taste of wine
- Currently only QoI, captan, mancozeb, and ziram were recommended.

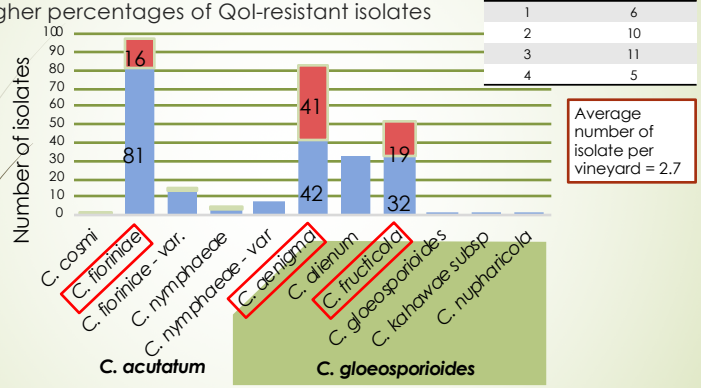
Pathogen ID (Charlotte Oliver)

- Ripe rot was recovered from 32 out of 43 vineyards on 19 cultivars across the state.
- Currently, there are multiple species in Virginia
  - C. *gloeosporioides* complex: *C. aenigma, C. alienum, C. fructicola, C. kahawae subsp., C. nupharicola, C. siamense*
  - C. *acutatum* complex: *C. fioriniae, C. nymphaeae* plus variants of both, *C. cosmi, C. melonis*
- Five main species
  - ***C. aenigma, C. alienum, C. fructicola, C. fioriniae, & C. nymphaeae***

25% of our isolates were resistant to QoI (Abound), and more prevalent species had higher percentages of QoI-resistant isolates

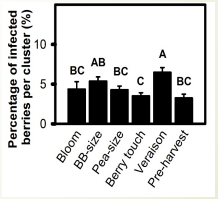
# of species	No. of vineyards
1	6
2	10
3	11
4	5

Average number of isolate per vineyard = 2.7



Ripe rot trials 2015-17

- Locations: Winchester, VA (AREC), Abingdon VA (Southwestern VA)
  - The commercial vineyards have been experiencing chronic ripe rot issues (up to 15% crop loss)
  - @ commercial vineyard, treatments were applied on top of grower's application (Pristine @ bloom, and berry touch, Elevate @ veraison)
- Treatments were applied at bloom, berry touch, and veraison



Newer fungicides tested in ripe rot trials SDHIs

Aprovia (Syngenta)
- SDHI (FRAC = 7)
- A.I. = benzovindiflupyr
- REI = 12 hours
- PHI = 21 days

Miravis (Syngenta)
- SDHI (FRAC = 7)
- A.I. = Pydiflumetofen
- Note: Miravis Prime (7 + 12) became available for grape in 2018

Newer fungicides tested in ripe rot trials DMI and Polyoxin-D

Viathon
- Not available in the US market
- A mixture of Prophyt and tebuconazole (Elite, etc.) (P07 and 3)

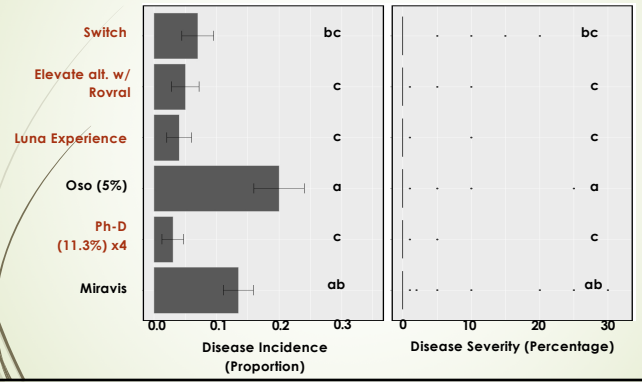
Ph-D (Arysta lifescience)
- FRAC = 19
- A.I. = Polyoxin D zinc salt (11.3%)
- 6.2 oz/A
- REI = 4 hours
- PHI = 0 day

Oso (Certis)
- Polyoxin D, but in lower % (5%)

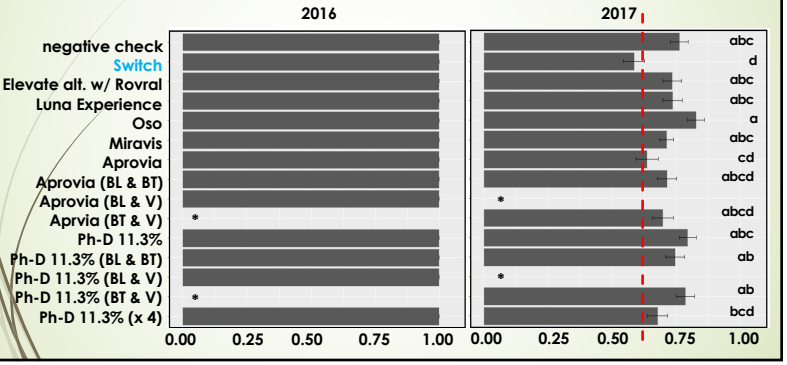
AHS AREC Spray Program

Year	Active ingredient	Commercial products	MOA	Application time
2015	cyprodinil + fludioxonil	Switch® 62.5 WG	9, 12	BL, BT, V
	fenhexamid alt. w/ iprodione	Elevate® 50 WDG & Rovral®	17, 2	BL, BT, V
	fluopyram + tebuconazole	Luna® Experience	7, 3	BL, BT, V
	polyoxin-D	Oso™ 5%SC	19	BL, BT, V
	polyoxin-D	Ph-D®	19	BL, BT, V, LM
	pydiflumetofen	Miravis®	7	BL, BT, V
Added	benzovindiflupyr	Aprovia®	7	BL, BT, V
2016	benzovindiflupyr	Aprovia®	7	BL, BT
& 2017	benzovindiflupyr	Aprovia®	7	BL, V
	benzovindiflupyr	Aprovia®	7	BT, V
	polyoxin-D	Ph-D®	19	BL, BT, V,
	polyoxin-D	Ph-D®	19	BL, BT
	polyoxin-D	Ph-D®	19	BL, V
	polyoxin-D	Ph-D®	19	BT, V

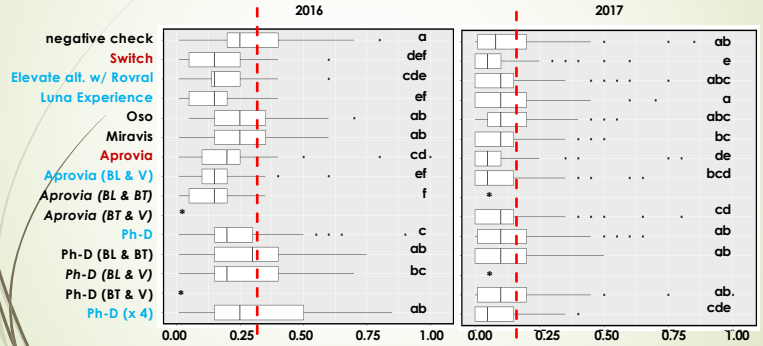
AHS AREC 2015
Ripe rot data from Botrytis trial
(i.e., no negative check + applied with mancozeb)



AHS AREC: Cluster disease incidence (Yes/No per cluster)
Single product trial: negative check = Revus and Vivando



AHS AREC – Cluster disease Severity (% area infected)
Red = significant reduction in both years
Blue = significant reduction in one year



AHS field trial summary

- Switch and Aprovia provided consistent reduction of disease severity
  - But the % disease reduction was not sufficient AND effect on disease incidence was very small.
- Ph-D was not promising by itself, but it worked well in 2015, when it was applied with mancozeb
- Meteor (Iprodione) has suppressive effect that probably contributed to the reduction of ripe rot

Field Trials

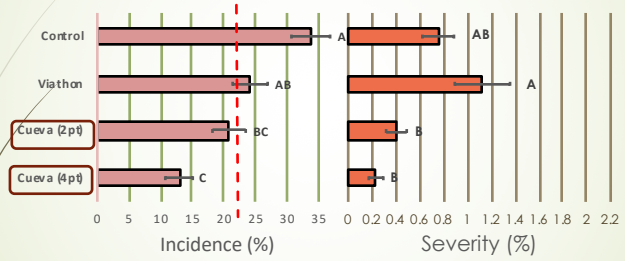
1. AHS Jr. AREC at Winchester, VA
2. Commercial vineyard in southwestern VA
   - **Treatments were applied in addition to regular fungicide applications**
   - Disease assessments were conducted less than a week before harvest
- A generalized linear mixed model (GLIMMIX, SAS 9.4) was used for ANOVA, assuming the binomial and normal distribution for incidence and severity, respectively. Fisher's LSD was used for the mean separation

Southwestern VA spray program

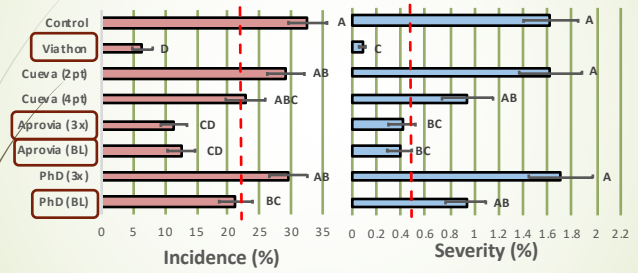
2015		2016 & 2017	
Treatment (rate/A, 100 gal)	Timing	Treatment (rate/A, 100 gal)	Timing
Control		Control	
Viathon (2pt)	BL, BT, V, LM	Viathon (2pt)	BL, BT, V
Cueva (2 pt)	BL, BT, V, LM	Cueva (2 pt)	BL, BT, V
Cueva (4 pt)	BL, BT, V, LM	Cueva (4 pt)	BL, BT, V
		Aprovia (9 fl oz)	BL, BT, V
		Aprovia (9 fl oz)	BL
		PhD (6.2 oz)	BL, BT, V
		PhD (6.2 oz)	BL

Viathon is a mixture of Prophyt and tebuconazole (Elite)

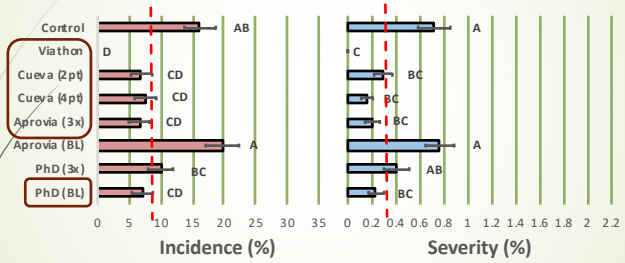
Southwestern VA, 2015



Southwestern VA, 2016

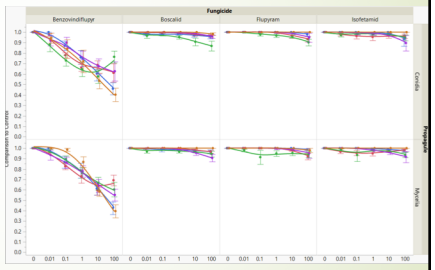


Southwestern VA, 2017



Single mode of action is probably not enough to stop ripe rot…

- Fungicide resistance (esp. QoI)
- SDHI is very weak
  - We conducted a plate assay to screen Aprovia, Endura, Kenja, and Luna
    - ***None of them completely stopped the growth of ripe rot pathogens***
- Multiple species
  - On average, we found 2.7 species per vineyard…
  - Species composition may shift based on your spray program

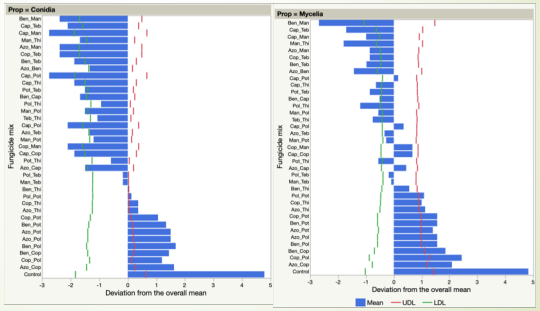


Looking for candidate product to be used in the field: plate assay
Options seem to be limited…

	C. siamense [z]				*C. fioriniae* [z]			
Active ingredient	Link[y]	Intercept[x]	Slope[x]	EC50[w]	Link[y]	Intercept[x]	Slope[x]	EC50[w]
Azoxystrobin	CLL	3.7 *	-1.6	472.8 +	probit	3.6 **	-1.4 **	385.3 +
Boscalid	logit	16.5	0.0	NC +	logit	11.3	-3.4	NC +
Captan	probit	1.8 **	-1.8 **	**8.9**	probit	2.7 **	-2.2 **	**16.6**
Copper hydroxide	probit	5.6 **	-3.3 **	**48.3**	logit	4.0 **	-2.9 **	**35.5**
Copper octanoate	probit	2.7 *	-1.7 **	**53.7**	probit	3.1 *	-2.0 **	**43.6**
Mancozeb	logit	21.6	-32.0	**3.5**	CLL	2.2	-3.1 *	**11.1**
Potassium phosphite	probit	5.1 **	-2.8 **	118.9	CLL	18.0 **	-10.2 **	87.7
Pyriofenone	CLL	4.8	-1.6	1140.9 +	CLL	1.1 **	-0.2	$7.1x10^{9}$ +
Tetraconazole	probit	3.8 **	-2.4 **	**39.5** +	probit	2.5 **	-2.0 **	**22.8** +
Thiophanate-methyl	CLL	6.2 **	-2.7 *	281.4	logit	7.5 **	-3.2 **	238.3

More on two modes of action (MOA) Plate assay (2018)

- Nine different MOA are tested at 100 ppm to see if they can inhibit the growth of five *Colletotrichum* species



Conidia		Mycelia	
MOA 1	**MOA 2**	**MOA 1**	**MOA 2**
Aprovia	Mancozeb	**Aprovia**	Mancozeb
Captan	**Tebuconazole**	Captan	**Tebuconazole**
Captan	Mancozeb	Captan	Mancozeb
Mancozeb	**Topsin-M**		
		Mancozeb	**Tebuconazole**
Abound	Mancozeb	Abound	Mancozeb
Copper	**Tebuconazole**	**Copper**	**Tebuconazole**
Aprovia	**Tebuconazole**	**Aprovia**	**Tebuconazole**
		Abound	**Aprovia**
Captan	**Prophyt**		
Captan	**Topsin-M**	Captan	**Topsin-M**
Prophyt	**Tebuconazole**	**Prophyt**	**Tebuconazole**
Aprovia	Captan	**Aprovia**	Captan
		Polyoxin-D	**Topsin-M**
Mancozeb	**Polyoxin-D**	Mancozeb	**Polyoxin-D**
Captan	**Polyoxin-D**		
Copper	Mancozeb		
Copper	Captan		
Abound	Captan		
		Tebuconazole	**Topsin-M**
		Prophyt	**Topsin-M**

Summary of 2-MOA plate assay

- Mancozeb, Captan, and Abound (QoI) are working (good confirmation!)
- Aprovia, tebuconazole, and Topsin-M are commonly included
- With Polyoxin-D, the effect was not very strong.
- Topsin-M and Tebuconazle may affect mycelial growth
- Prophyt is showing here and there, but it is probably due to tebuconazole

Not all DMI fungicides are equally effective against *Colletotrichum* species…

- For example, Chen et al. (2016) found that *C. nymphaeae* was insensitive fenbuconazole while *C. fioriniae* was sensitive.
- Moreover, different isolates of *C. fioriniae* exhibited differing levels of sensitivity to all tested DMI fungicides
- Thus, more investigation is necessary with our VA isolates.

Summary

- Captan and Mancozeb were effective
  - Pros: Cost effective, little or no resistance issues
  - Cons: Insensitivity of some *C. gloeosporioides* to Captan
- SDHIs were generally not effective
  - Aprovia (Benzovindiflupyr) seemed to work in the field, especially with additional mancozeb or captan sprays.
  - PHI = 21 days!
- Variability of Viathon (Potassium phosphite + tebuconazole) between years and locations
  - Dese potassium phosphite have any effect?
  - How about other DMIs?
- Abound (Azoxystrobin) and Topsin M (Thiophanate methyl) suppressed fungal growth only with another MOA
  - Resistance issues with QoIs and Topsin M

Mixing multiple MOA is probably the key for ripe rot management

Mixing partners for mancozeb/ziram or captan (Timing: bloom, berry touch, veraison)

Moderate level of reduction	Low level of reduction	No or limited effect
• **Aprovia** (Benzovindiflupyr, FRAC= 7) • **Cueva** (Copper (M1)) • **Intuity** (mandestrobin, (11)) • **Viathon** (Phos acid (33) + tebuconazole (3)) • **Switch** (cyprodinil (9) + fludioxonil (12))	• **Elevate** (fenhexamid (7)) alt. w/ **Rovral** (iprodione (2)) • **PhD** (polyoxin-D (19)) • **Luna Experience** (Fluopyram (7) + tebuconazole (3))	• **Endura** (Boscalid (7)) • **Oso** (polyoxin-D (19)) • **Rally** (myclobutanil (3)) • **Miravis** (Adepidyn (7))

The same MOA provided different level of control…

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Moderate level of reduction	Low level of reduction	No or limited effect
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What's next?

On-going

- Repeats of field trials using different set of materials
- Effect of high relative humidity on germination

Future

- Look into DMIs using plate and field assays
- Investigate the use of Copper and Topsin-M as a mixing partner
- Determine when the pathogens become active
  - Spore collection and detection