



# Fungal Diseases of Grapevine and Management Strategies

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Sonoma Grape Day,

Feb 6, 2024

# Outline

1. Introduction
2. Grapevine trunk diseases
3. Management of Powdery mildew
4. Management of Botrytis bunch rot
5. Conclusion

# Current project on grapevine

1. *In vitro* fungicide screening via spiral plater
2. Field fungicide trials to manage PM and Gray Mold
3. Grapevine Trunk Diseases
  - Dormant pruning wound protection
  - Biocontrol of GTD
  - Nursery practices for clean plant material
  - Aspergillus vine canker
  - Biocontrol of Pierce's diseases

# Grapevine Trunk Diseases

- Young Vine Decline
- Esca
- Eutypa Dieback
- Bot Canker
- Phomopsis Dieback

## Vascular diseases

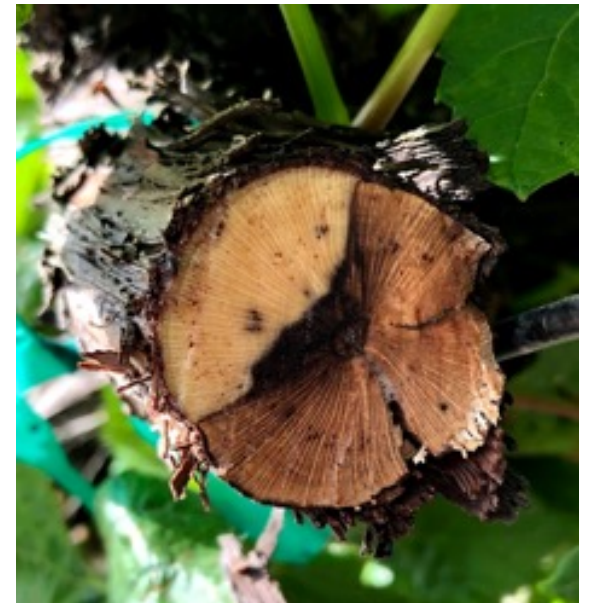


# Grapevine Trunk Diseases

- Young Vine Decline
- Esca
- Eutypa Dieback
- Bot Canker
- Phomopsis Dieback

Vascular diseases

**Canker diseases**



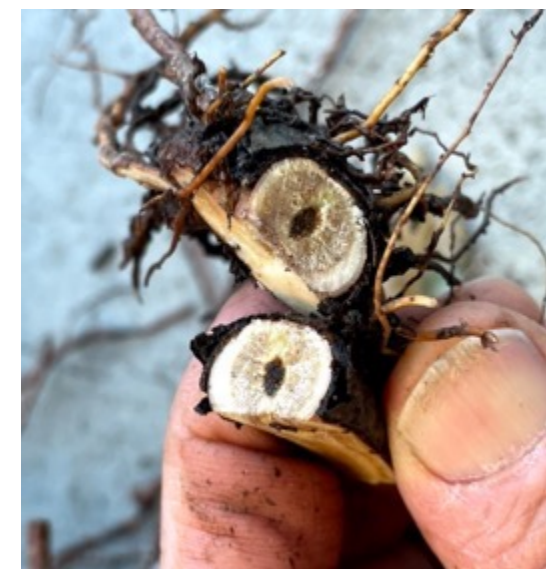
# Grapevine Trunk Diseases

- Young Vine Decline
- Esca
- Eutypa Dieback
- Bot Canker
- Phomopsis Dieback
- Black Foot

Vascular and Rot diseases

Canker diseases

**Rot diseases**



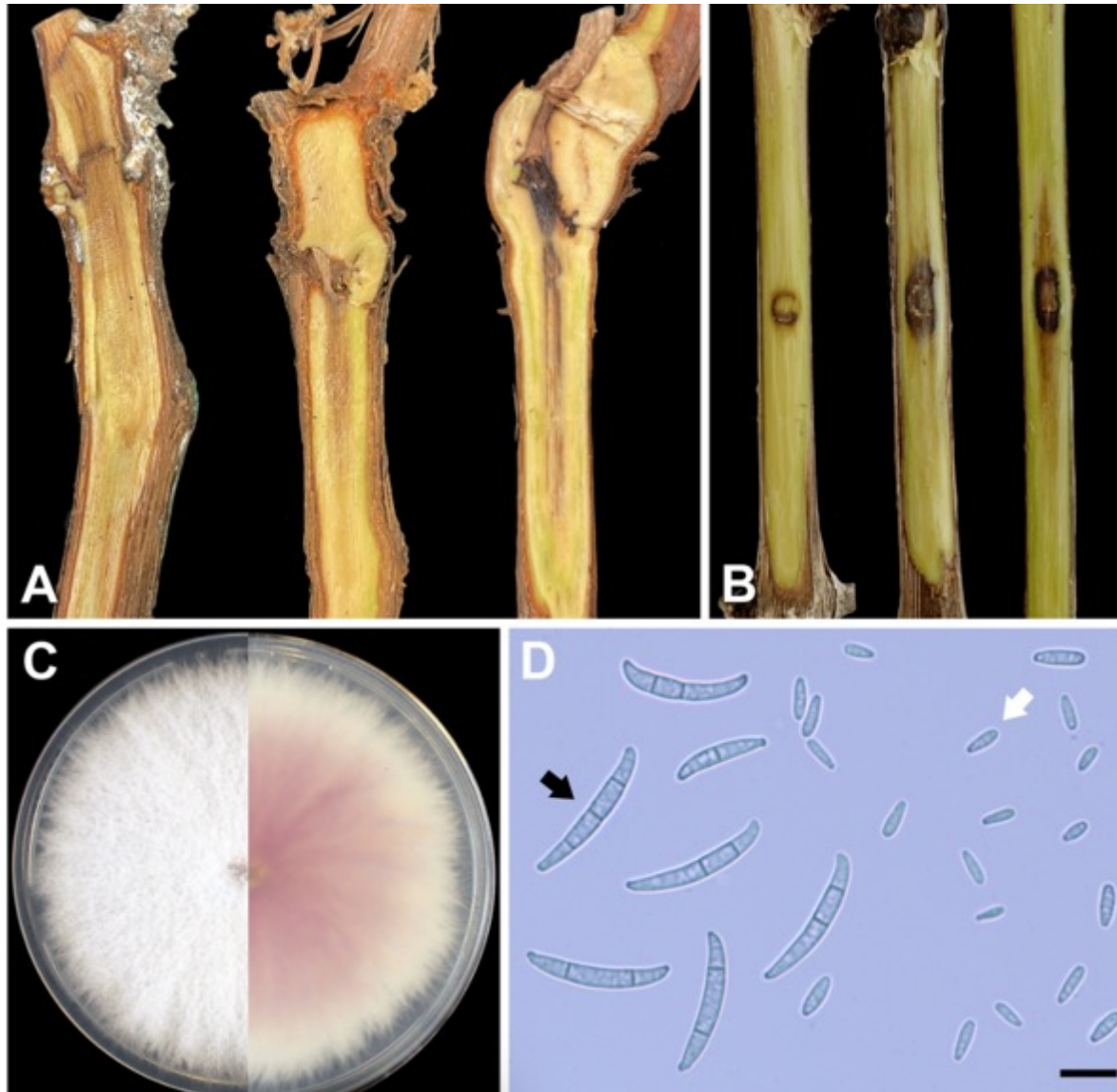
# Macrophomina Charcoal Rot (*Macrophomina phaseolina*)



Chardonnay/1103P



# *Fusarium annulatum*



Graft Union

Bustamante et al. 2022 First Report of *Fusarium annulatum* Associated with Young Vine Decline in California. [Plant Disease](#).

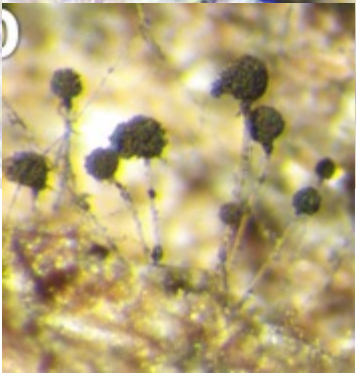


# Unusual fall symptoms on virus free grapevines



Grenache cv./ Freedom

# External Symptoms



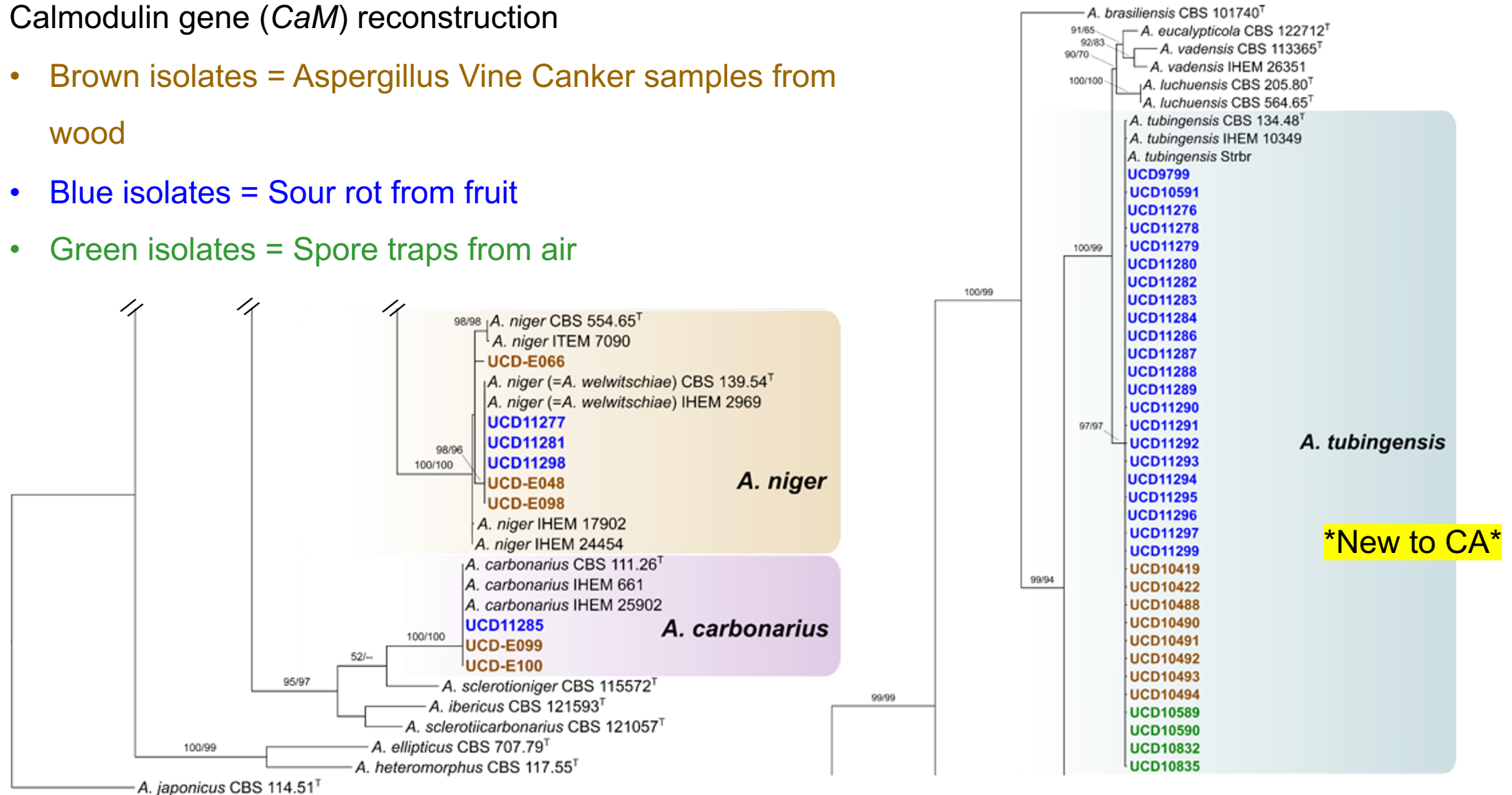
# Internal symptoms:



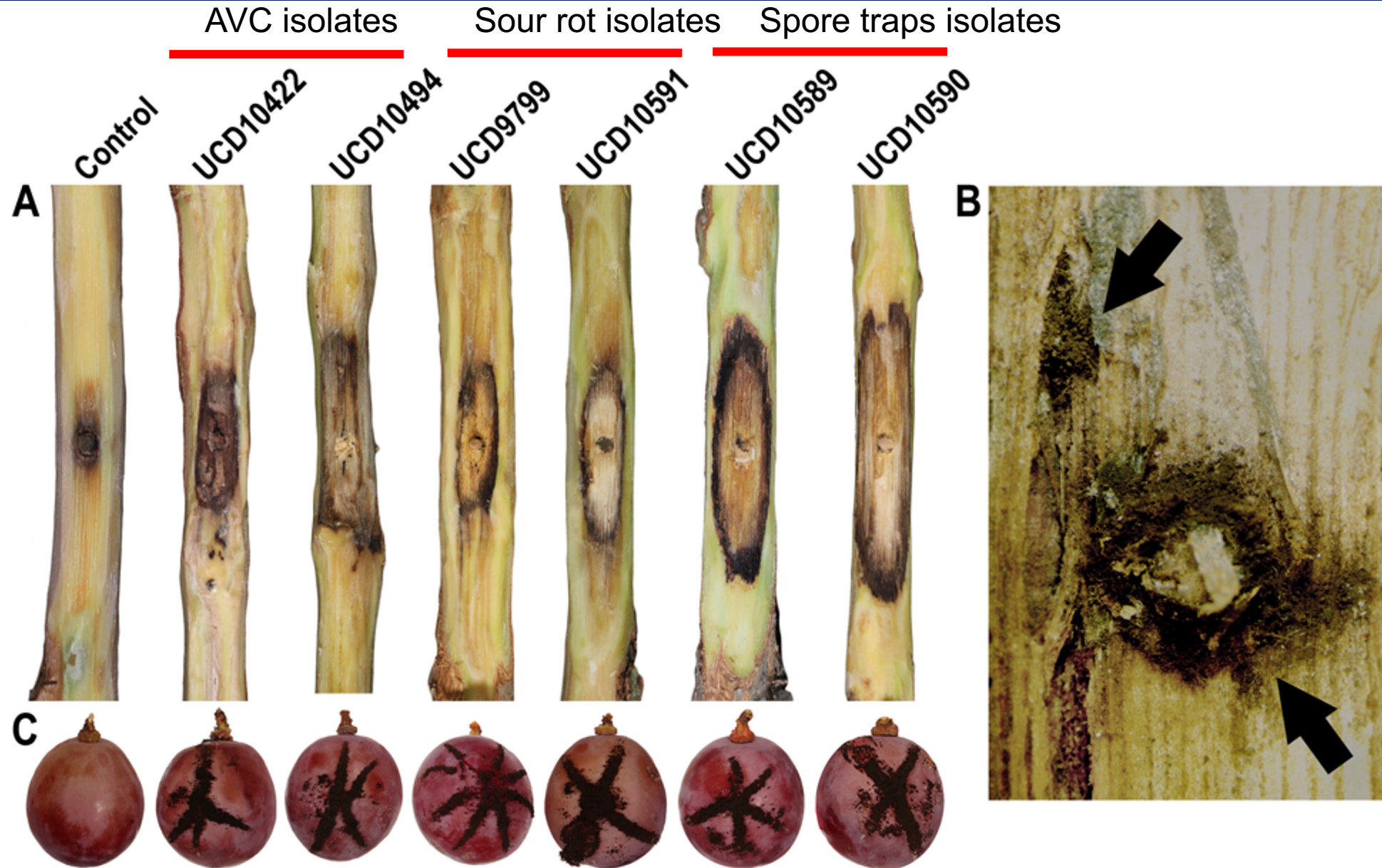
# Identification of *Aspergillus* spp.

## Calmodulin gene (*CaM*) reconstruction

- Brown isolates = *Aspergillus* Vine Canker samples from wood
- Blue isolates = Sour rot from fruit
- Green isolates = Spore traps from air



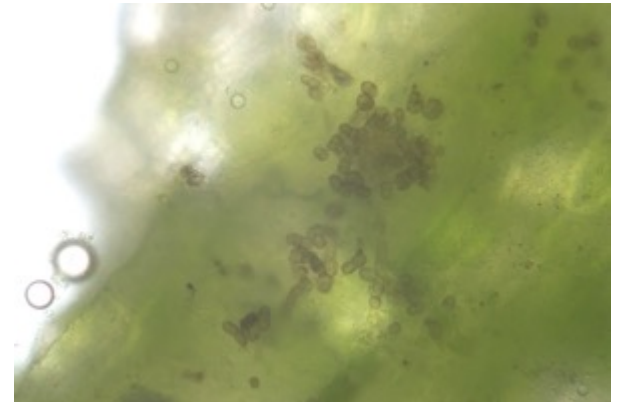
# Pathogenicity of *Aspergillus tubingensis*



# How do they infect their hosts?

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- **Pruning wounds**
- **Latent and Endophyte**



# Infection of GTD on different parts of the vine



**Spurs**



**Cordon**



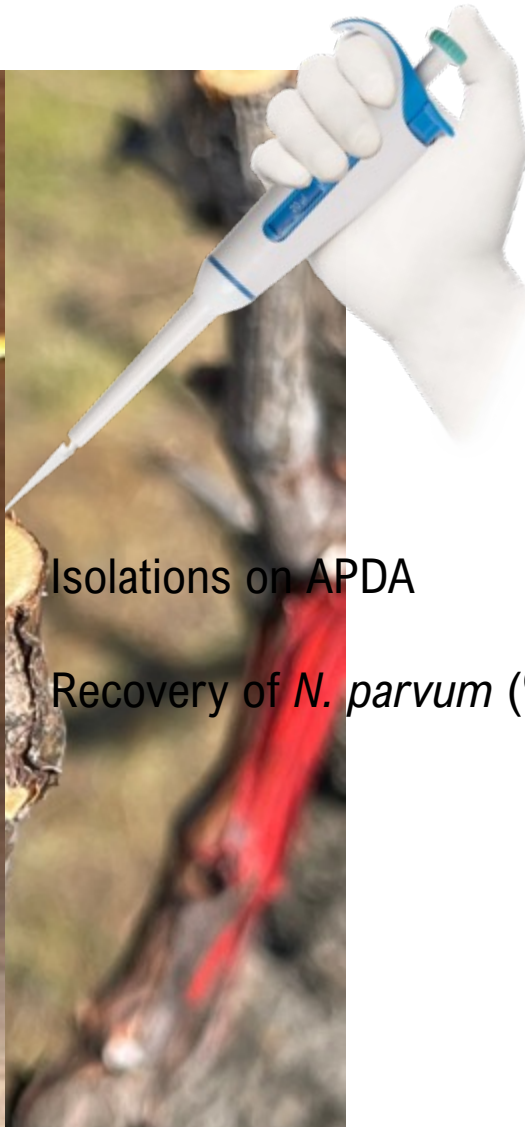
**Trunk**



**Rootstock**

# Field pruning wound protection trials

1) Treatment



2) Inoculation  
*N. parvum*  
(2,000 conidia)

3) Evaluation of infection

Isolations on APDA

Recovery of *N. parvum* (%)

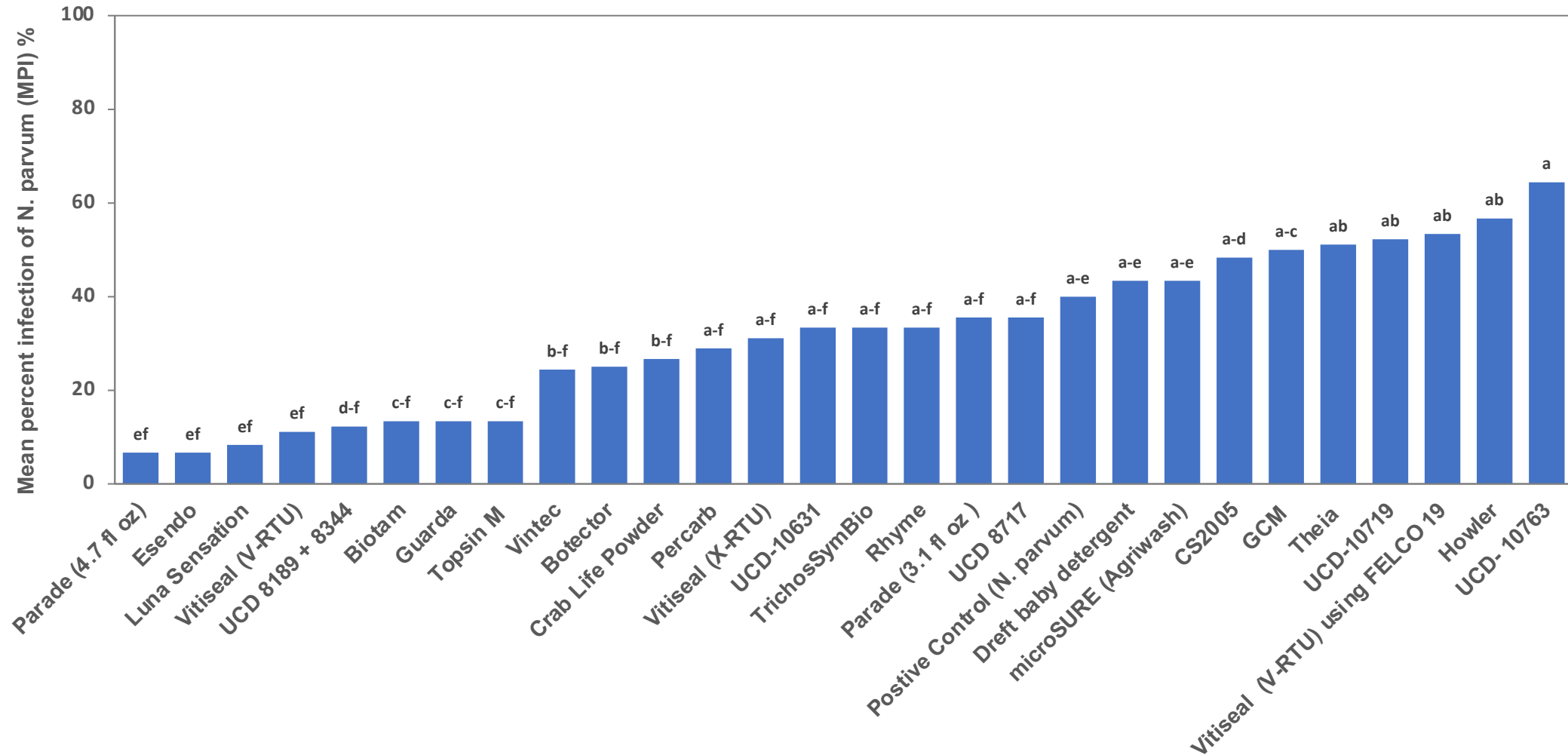




Product name	Active Ingredient	Manufacturer	MPI, % <sup>z</sup>
Untreated (non-inoculated)	-	-	0.0 f
Esendo, 2.8 lbs	pre-mix of Howler and azoxystrobin	AgBiome Innovations	6.7 ef
Parade, 4.7 fl oz	pyraziflumid	Nichino America	6.7 ef
Luna Sensation, 7.6 oz	fluopyram (17.54%), tebuconazole (17.54%)	Bayer CropScience	8.3 ef
1 L Vitiseal ready-to-use (V-RTU). This is NOT to be diluted.	Acrylic Co-Polymer	VitiSeal International LLC	11.1 ef
UCD 8189 + 8344, 1x10 <sup>5</sup> cfu/ml	<i>Aureobasidium pullulans</i> -8189+8344	N/A	12.2 def
Topsin M 1.25 lbs	Triophanate-methyl	United Phosphorus Inc.	13.3 cdef
Guarda, 2.56 fl oz/ga	thyme oil	BioSafe Systems, LLC	13.3 cdef
Biotam, 2 lbs	<i>Trichoderma asperellum</i> (ICC 012) + <i>Trichoderma gamsii</i> (ICC 080)	Isagro USA	13.3 cdef
Vintec, 2.8 oz	<i>Trichoderma atroviride</i> strain SC1	Bi-PA	24.4 bcdef
Botector, 8 oz	<i>Aureobasidium pullulans</i> strain DSM14940/14941 1	Westbridge Agricultural Products	25.0 bcdef
Crab Life Powder, 0.5 lbs	Chitin	Conchazul de Mexico	26.7 bcdef
PerCarb, 4 lbs	sodium carbonate peroxyhydrate (85%)	BioSafe Systems, LLC	28.9 abcdef
2 X 0.5 L experimental new Vitiseal formulation, ready-to-use (X-RTU). This is NOT to be diluted.	Acrylic Co-Polymer	VitiSeal International LLC	31.1 abcdef
Rhyme, 5 fl oz (applied as pruning wound spray)	Flutriafol (22.7 %)	FMC	33.3 abcdef
TrichosymBio, 25.6 fl oz	<i>Trichoderma harzianum</i> T78 (of 5 x 10 <sup>11</sup> cfu)	Symborg	33.3 abcdef

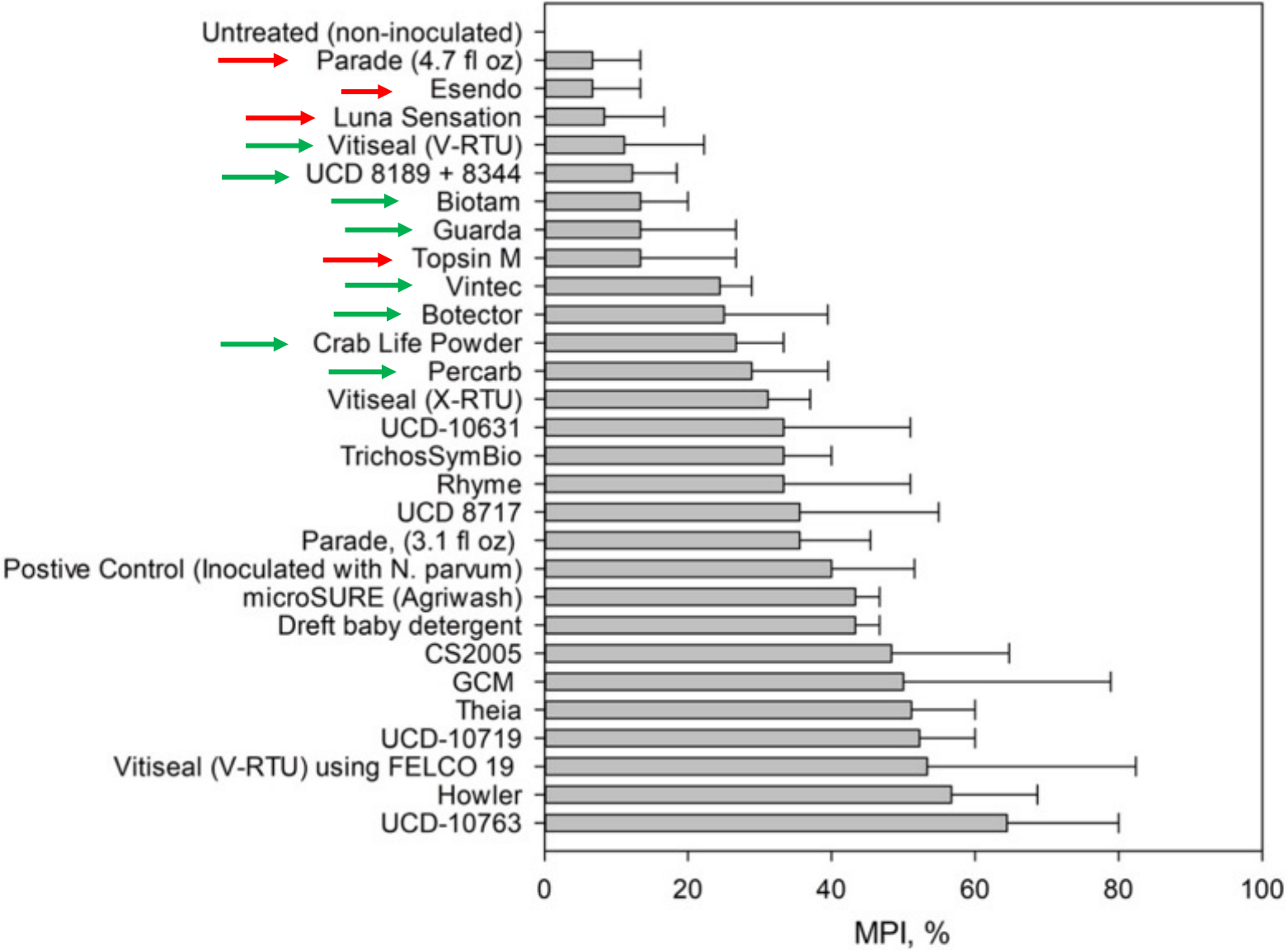
## Treatments of pruning wound protection trial in 2022

# Results of pruning wound protection trial for *Neofusicoccum parvum* in 2022



Evaluation of pruning wound treatments mean percent infection (MPI) rates with *N. parvum* located at UC Davis Plant Pathology Field Station, 2022. Bars = standard errors.

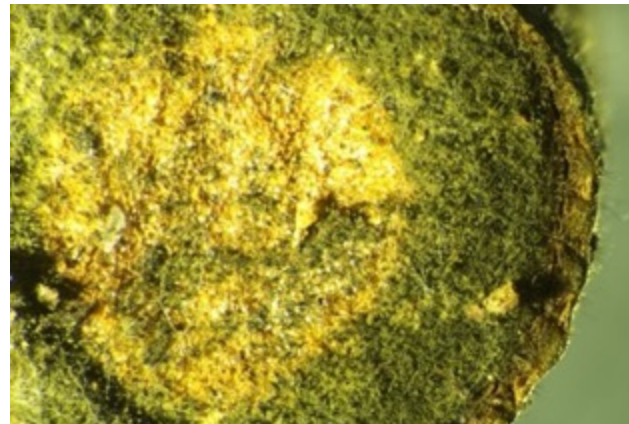
# Results of pruning wound protection trial for *Neofusicoccum parvum* in 2022



**Figure 2.** Evaluation of pruning wound treatments mean percent infection (MPI) rates with *N. parvum* located at UC Davis Plant Pathology Field Station, 2022. Bars = standard errors.

# Recovery of biological treatments from inoculated canes

Treatment	Recovery %			
	Sacramento County		Kern County	
	<i>E. lata</i>	<i>N. parvum</i>	<i>E. lata</i>	<i>N. parvum</i>
<i>Bacillus velezensis</i>	0	25	25	5
<i>Bacillus subtilis</i> strain QST 713	0	5	0	0
<i>Bacillus sp.</i>	0	5	10	0
<i>Trichoderma hamatum</i>	0	20	20	15
<i>Trichoderma asperellum</i> and <i>Trichoderma gamsii</i> + a blend of crab and lobster shell powder	35	10	30	30
<i>Trichoderma asperellum</i> and <i>Trichoderma gamsii</i>	60	45	20	30
<i>Aureobasidium pullulans</i> strain DSM14940/14941	65	100	25	30
<i>Trichoderma atroviride</i>	70	100	45	80
<i>Aureobasidium pullulans</i>	100	100	25	60



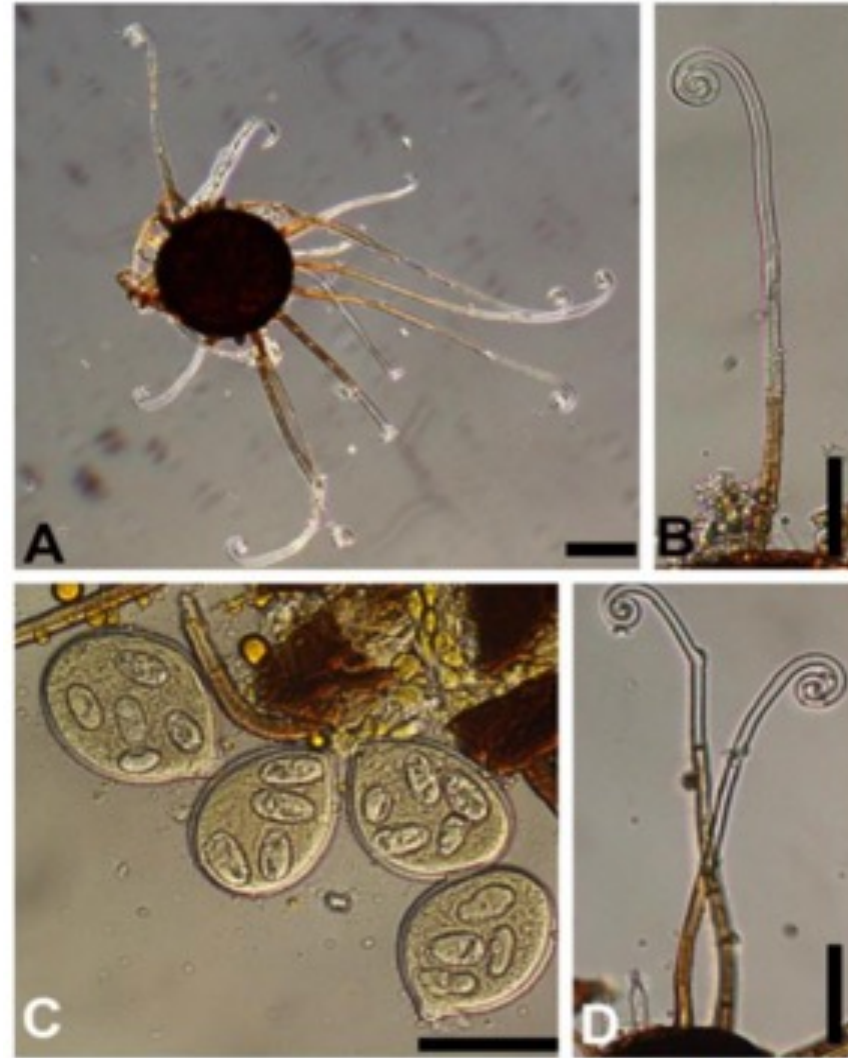
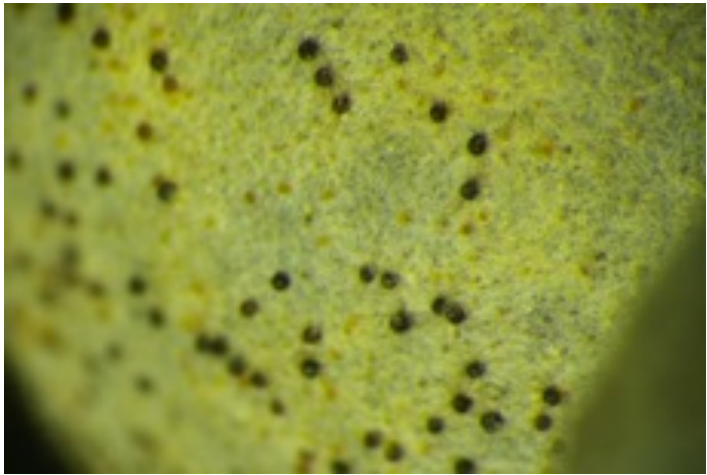
# Identification of Naturally Occurring Biological Control Agents in California Vineyards



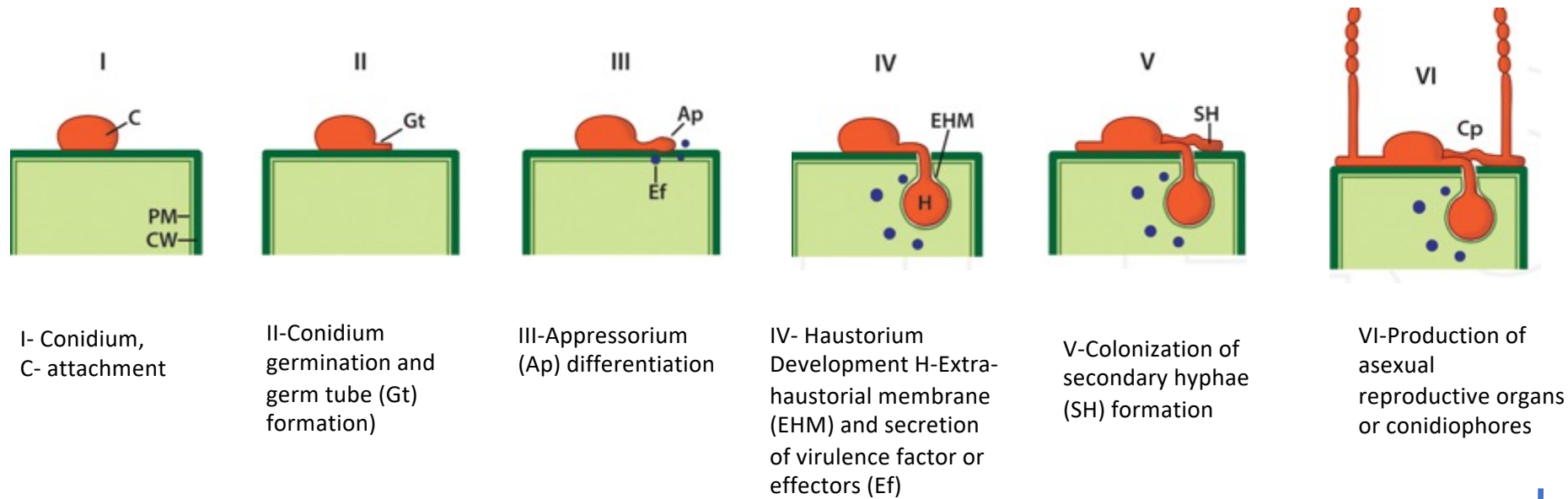
# Protecting pruning wound is essential

	Commercial name	Active ingredient	Manufacturer
<b>Biocontrol</b>	Biotam (Frac BM2)	<i>Trichoderma asperellum</i> + <i>T. gamsii</i>	SepRo
	Vintec (Frac BM2)	<i>Trichoderma atroviride</i> SC1	BI-PA
	Botector (Frac BM2)	<i>Aerobasidium pullulans</i>	Westbridge
	GCM	<i>Bacillus velezensis</i> CE100	BSR
<b>Plant extract</b>	Guarda	Thyme oil	Biosafe System
<b>Synthetic fungicides</b>	Topsin-M (FRAC1)	Triophanate-methyl	United Phosphorous
	Luna sensation (FRAC-7)	Fluopyram/Trifloxystrobin	Bayer CropScience
	Esendo (FRAC 11)	Azoxystrobin + Pseudomonas chlororapsis	Agbiome
	Rhyme (FRAC 3)	Flutriafol	FMC
	Parade	Pyraziflumid	Nichino America
<b>Sealant</b>	Vitiseal	Acrylic Co-Polymer	Vitiseal International
<b>Disinfectant</b>	PerCarb	Sodium carbonate peroxyhydrate (85%)	Biosafe Systems

# Management of Powdery mildew of grapevine)



# Infection by *Erysiphe necator*



6-8 days



# Field Trial to Evaluate Fungicides to control Powdery

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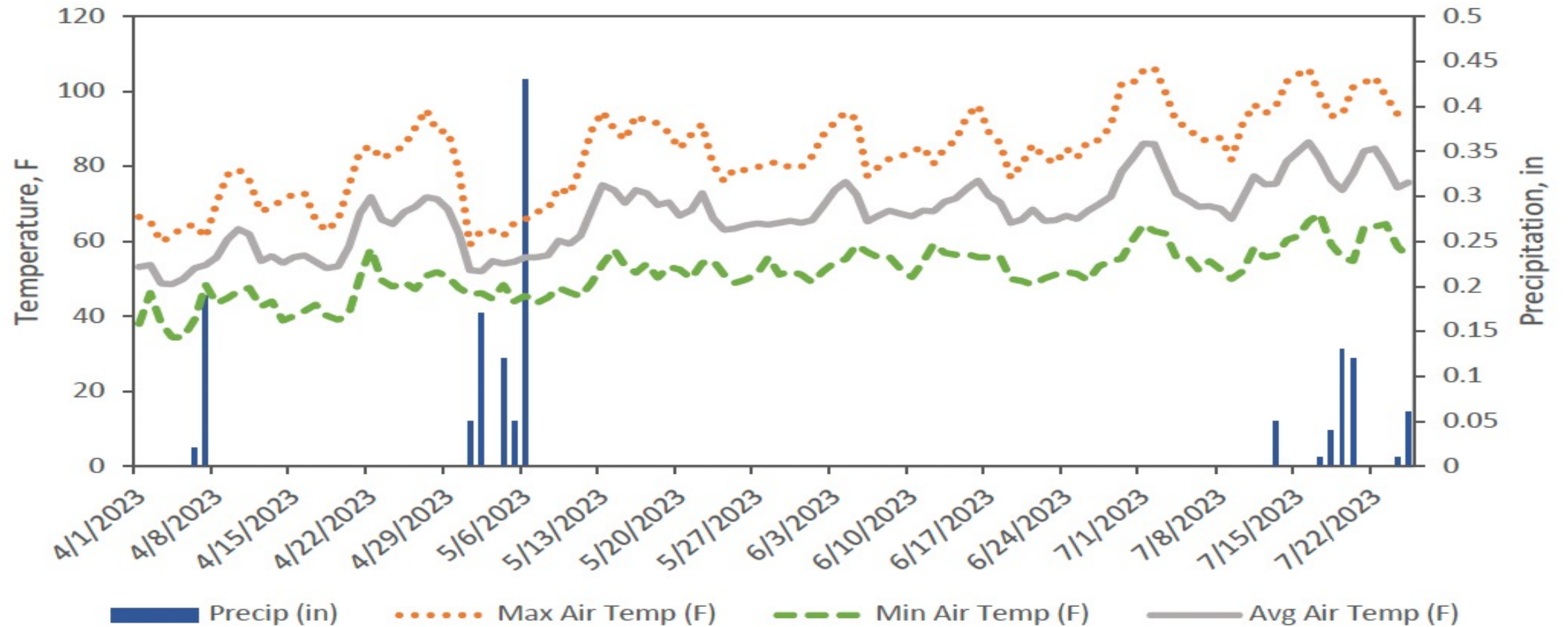


# 2023 Field fungicide efficacy trials

## Experimental design

Experimental design	Randomized complete block design with 5 replicates		
Experimental unit	2 adjacent vines = 1 plot		
Row and tree spacing	11 ft (row) and 7 ft (vine)	Plot unit area	154 ft <sup>2</sup>
Area/treatment	770 ft <sup>2</sup> or 0.0177 acre/treatment (5 replicates = 1 treatment)		
Volume water/Acre	50 gallons = 0.88 gal/5 reps		
	100 gallons (mid May,) = 1.77 gal/5 reps		
	150 gallons (early June ) = 2.65 gal/5 reps		
Equipment	Stihl SR 430 mist blower backpack sprayers		

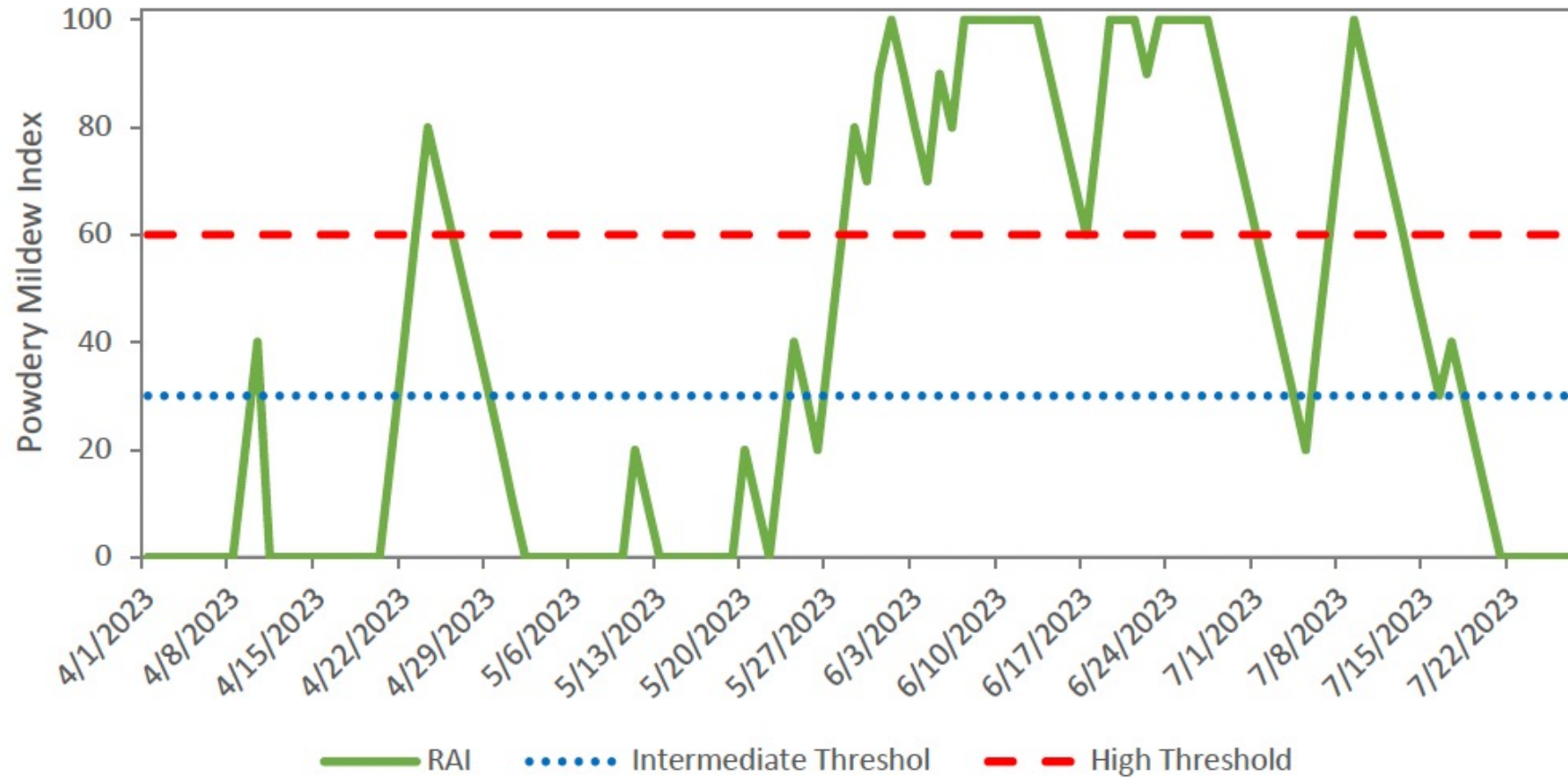
# 2023 Field climatic data



Average daily temperature (C) and precipitation (mm) from Apr 1 to July 25, 2022, from CIMIS station #226.

# Thomas-Gubler Risk Index data

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<https://ipm.ucanr.edu/weather/grape-powdery-mildew-risk-assessment-index/>

# 2023 Powdery Mildew Field Trial 1

Disease incidence and severity of synthetic fungicides and combinations of soft chemistry and synthetic products.

Treatment		Powdery mildew on the cluster <sup>x</sup>			
TRT	Rate/A <sup>y</sup>	Incidence, %		Severity, %	
8	Luna Experience 8.6 fl oz	4	e	0.1	b
	Pristine 23 oz				
	Endura 2.8 oz				
	Torjan 4 floz				
	Quintec 6 fl oz				
23	Cevya 4 floz + Syl-Coat 4 fl oz/100 gal	5	e	0.2	b
	Gatten 6.4 floz+ Syl-Coat 4 fl oz/100 gal				
	Luna sensation 5 floz + Syl-Coat 4 fl oz/100 gal				
	Vivando 15.4 floz+ Syl-Coat 4 fl oz/100 gal				
	Inspire super 16 floz+ Syl-Coat 4 fl oz/100 gal				
	Prolivo 4 floz+ Syl-Coat 4 fl oz/100 gal				
37	Inspire Super 20 fl oz + Dyne-Amic 0.125% v/v	4	e	0.2	b
	Aprovia Top 13.3 fl oz + Dyne-Amic 0.125% v/v				
	Quintec 6.6 fl oz + Dyne-Amic 0.125% v/v				
	Miravis Prime 13.4 fl oz + Dyne-Amic 0.125% v/v				
	Aprovia Top 13.3 fl oz + Dyne-Amic 0.125% v/v				
39	Aprovia Top + A9180A 13.3 fl oz + 1.0 oz + Dyne-Amic 0.125% v/v	5	e	0.2	b
	Quintec + A9180A 6.6 fl oz + 1.0 oz + Dyne-Amic 0.125% v/v				
	Miravis Prime + A9180A 13.4 fl oz/+ 1.0 oz + Dyne-Amic 0.125% v/v				
	Inspire Super + A9180A 20.0 fl oz + 1.0 oz + Dyne-Amic 0.125% v/v				
	Miravis Prime + A9180A 13.4 fl oz + 1.0 oz + Dyne-Amic 0.125% v/v				
10	Sulfur Dry Flowable 5 lb	10	e	0.3	b
	V6M-5-7 27.4 fl oz + Dyne-Amic 0.125% v/v				
	Luna Experience 8.6 fl oz				
	Pristine 23 oz				

# 2023 Powdery Mildew Field Trial 2

Disease incidence and severity of soft chemistry products, including biologicals, sulfurs, nutrient applications, oils, and other materials.

Treatment		Powdery mildew on the cluster <sup>x</sup>			
TRT	Rate/A <sup>y</sup>	Incidence, %		Severity, %	
41	Sulfur 5lb	24	f	1.4	f
	Saponel 0.5% + Sulphur 5lb				
	Saponel 1% + Kobber 30g/100L				
	HML32 1.25L/100L + Kobber 30g/100L + Sulphur 5lb				
15	Shielder (OR-536) 4 lbs/a + Oroboost (OR-097A) 32 fl. oz/100 gal	63	cde	6.7	ef
40	Sulfur 5lb	61	de	7.7	ef
	Saponel 0.5% + Sulphur 5lb				
	Saponel 1% + Kobber 30g/100L				
	HML32 1.25L/100L + Kobber 30g/100L + Potum 300g/100L				
35	Sulfur dry	63	cde	9.2	ef
	Kaligreen 5lb				
12	Milagrum Plus (OR-488) 40 fl oz/100 gal + Oroboost (OR-097A) 32 fl oz/100gal	67	bcde	11.1	ef
47	Sulfur DF 5 lb	56	e	12.0	ef
43	Sulfur 5lb	72	abcde	12.4	ef
	NSA 1% + Kobber 33g/100L +HML Silco (225ml/100L or 100g/100L				
42	Sulfur 5lb	67	bcde	16.9	ef
	Saponel 0.5% + Sulphur 5lb				
	Saponel 1% + Kobber 30g/100L				
	HML32 1.25L/100L + Kobber 30g/100L + HML Silco 225ml/100L				
	Saponel 1% + Kobber 30g/100L + HML Silco (225ml/100L or 100g/100L)				
25	Cinnaction (OR-489-E) 50 fl oz/100 gal + Attitude (OR-278F) 32 fl oz/100 gal	78	abcde	20.9	ef
46	PureSpray Green 1 gal	78	abcde	21.7	ef
	Sulfur Dry-Flowable 5 lb				
	Bio Project S10 68 fl oz + Bio Project ID 0.9 27 fl oz				

# Sulfur advantages

- Lime sulfur
- Dusting Sulfur
- Wettable sulfur
  - Micronized
  - Dry Flowable

- Is a natural product
- Inexpensive
- Effective
- Used hundreds of years
  - No Case of resistance

# Sulfur disadvantages

- Washes off easily with rain
- Less effective in cool weather
- May burn wines in hot weather

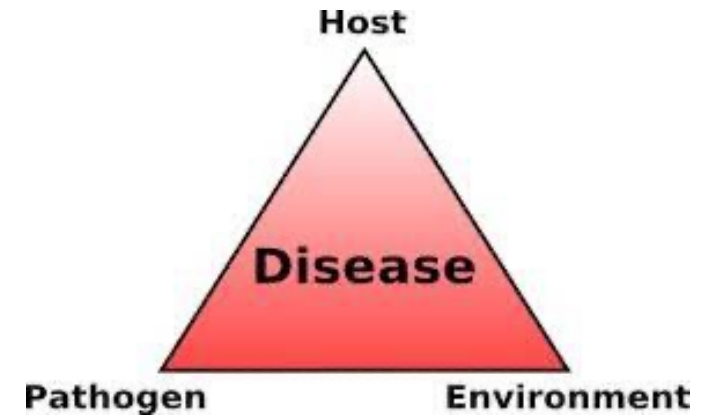
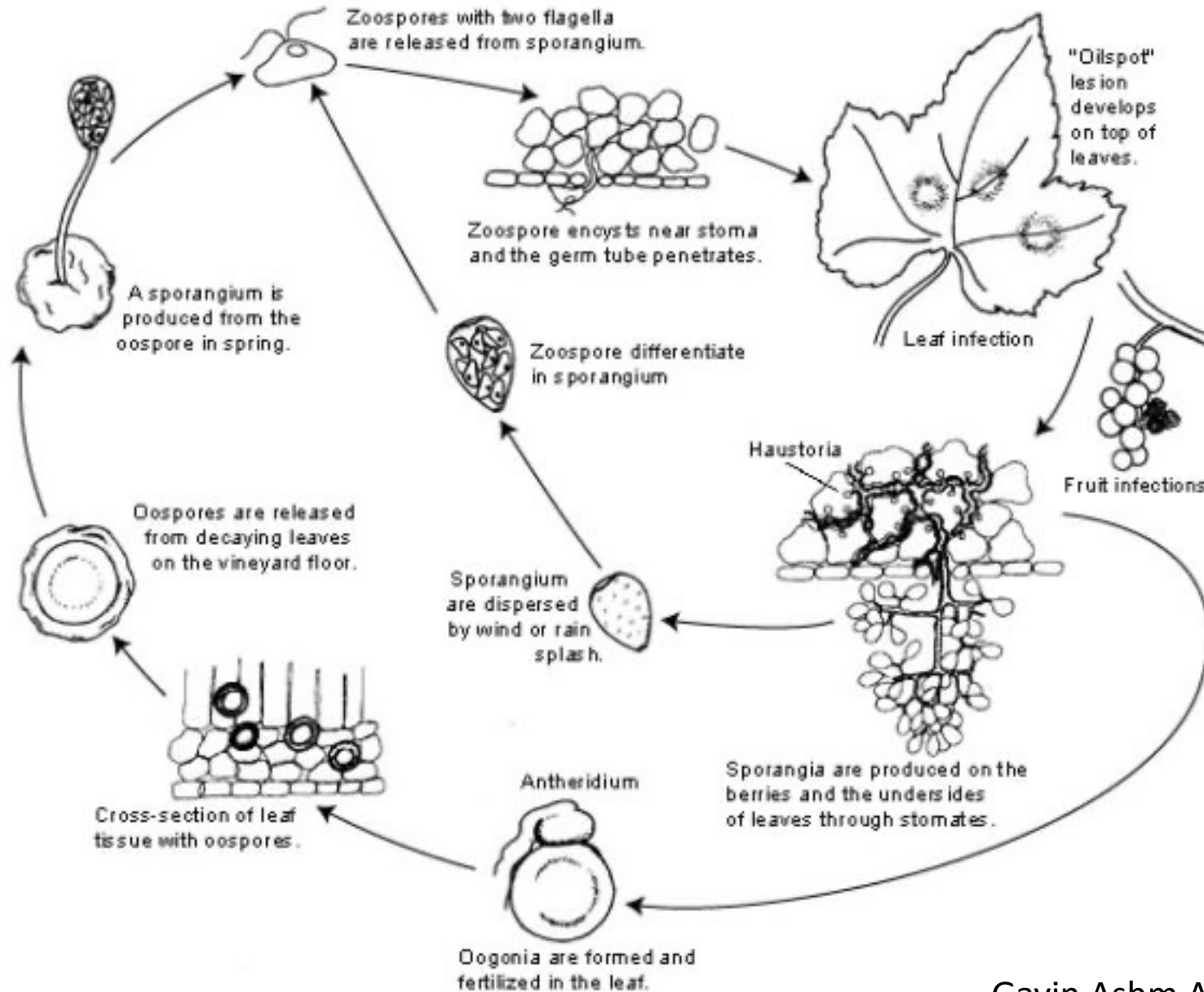




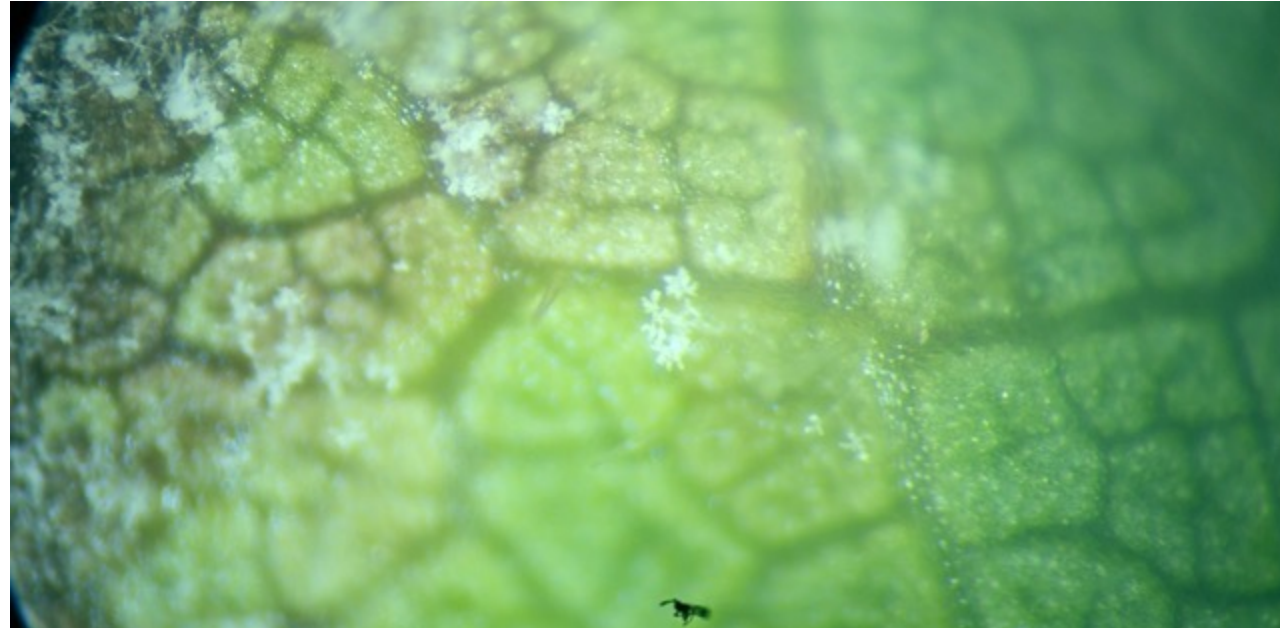
# Downy mildew *Plasmopara viticola* of grapevine



# Downy mildew of Grape Disease Cycle



# Downy mildew *Plasmopara viticola* of grapevine

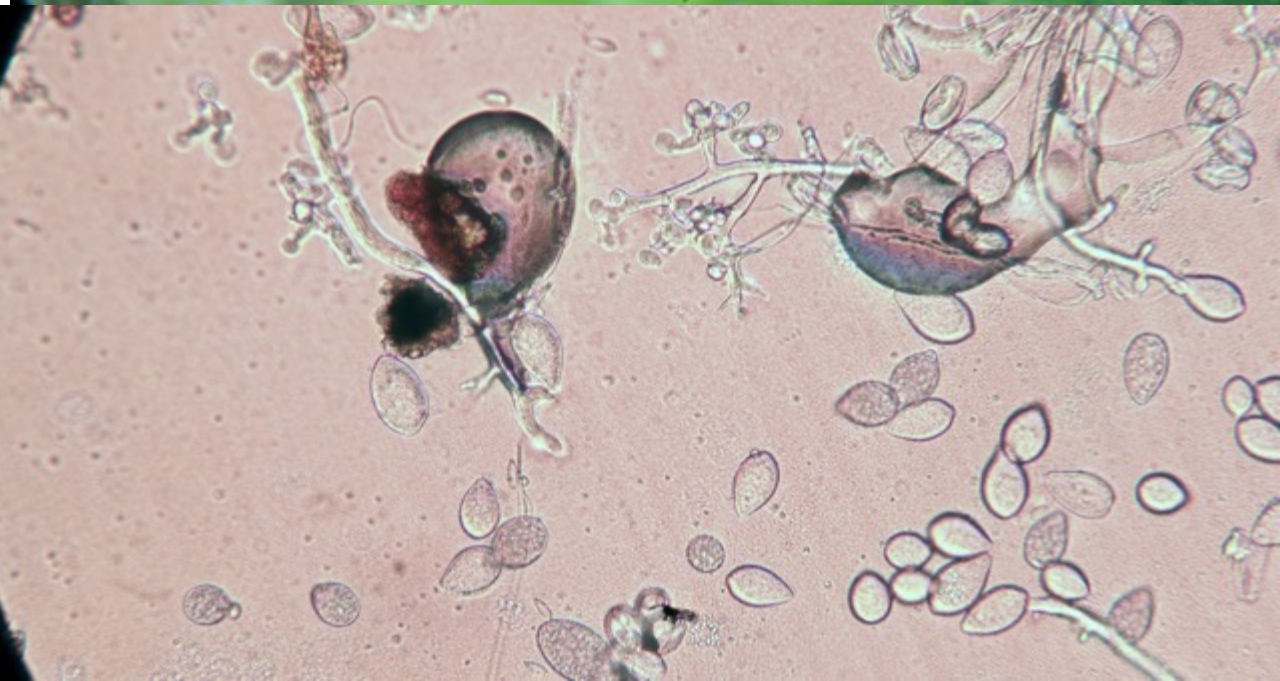


## Management:

Preventive management consists of effective soil drainage and reduction of sources of overwintering inoculum. In a vineyard that depends on sprinkler irrigation, extend the interval between irrigations as long as possible.

## Fungicides:

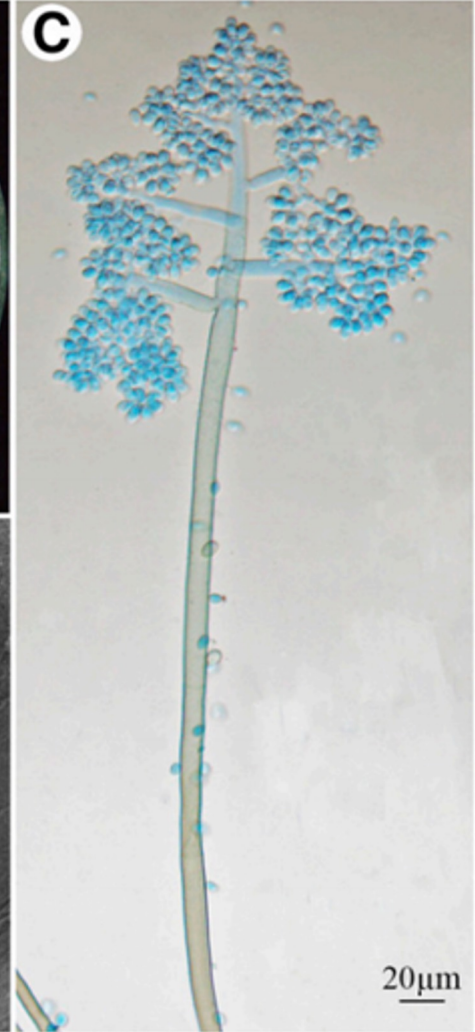
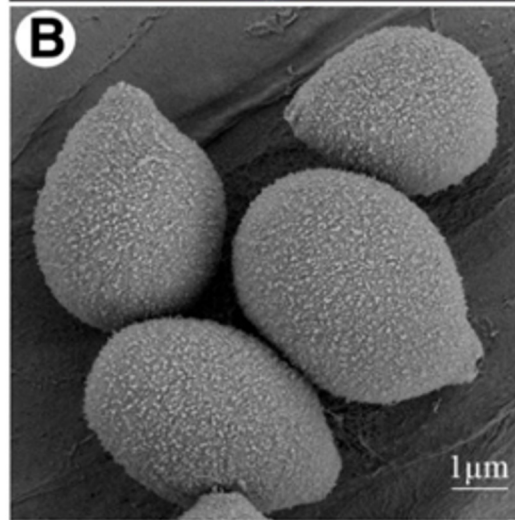
- Phosphonate (fosetyl-aluminum)
- Phenylamides (metalaxyl)
- **QoI (Azoxystrobin)**
- **Carboxylic acid amides (CAA; mandipropamid),**
- Copper Hydroxide



# Pathogens involved with Bunch Rot / Gray Mold



*Botrytis cinerea*



Zhou et al 2018, Plant Disease



Fungus is ubiquitous



Attacks juvenile tissue, ripe fruit Brix >8



After infection, the fungus can produce sclerotia (resting structure).

# Summer bunch rot (Sour rot)

- In California, sour rot has been attributed to a complex of microorganisms including *Botrytis cinera*, *Aspergillus niger*, *A. carbonarius*, and others (Latham et al 2008)



# Other common symptoms of sour rot



# Non-Summer Botrytis symptoms



Black Measles



Esca



Sunburn

# Pathogens involved with Summer Bunch rot (Sour Rot)



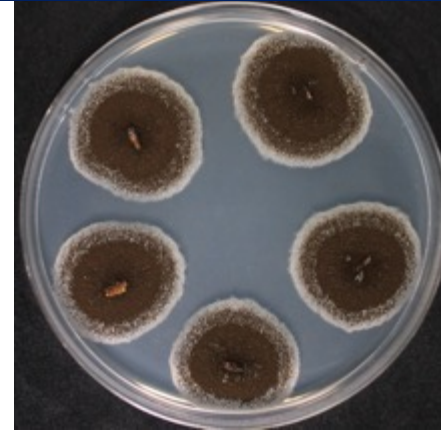
*Botrytis cinerea*



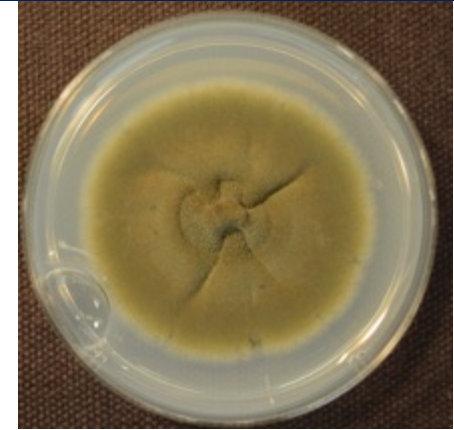
*Aspergillus carbonarius*



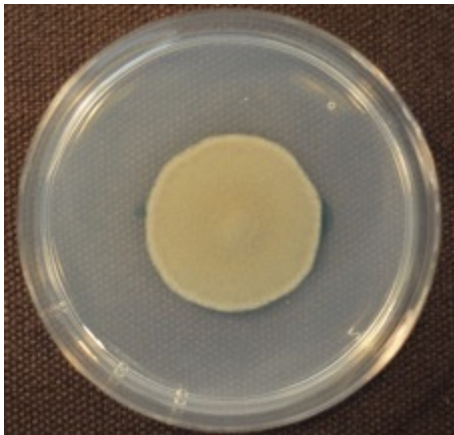
*Aspergillus niger*



*Aspergillus tubingensis*



*Cladosporium* sp.



*Penicillium* sp.



*Rhizopus* sp.



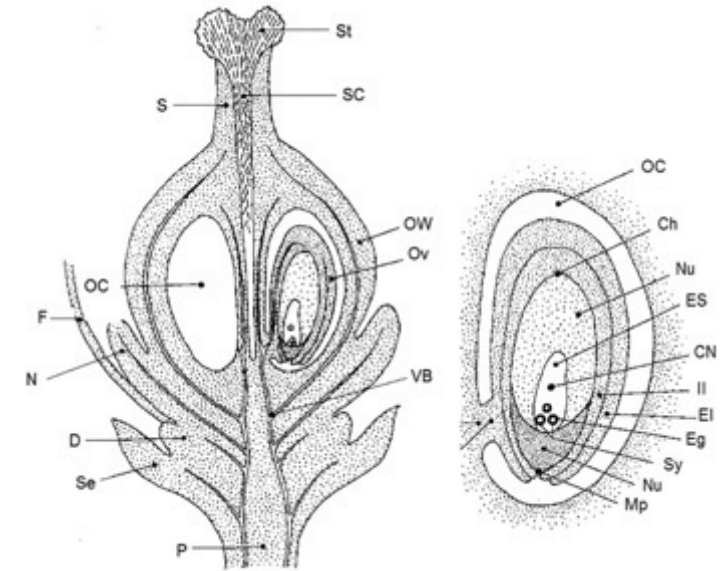
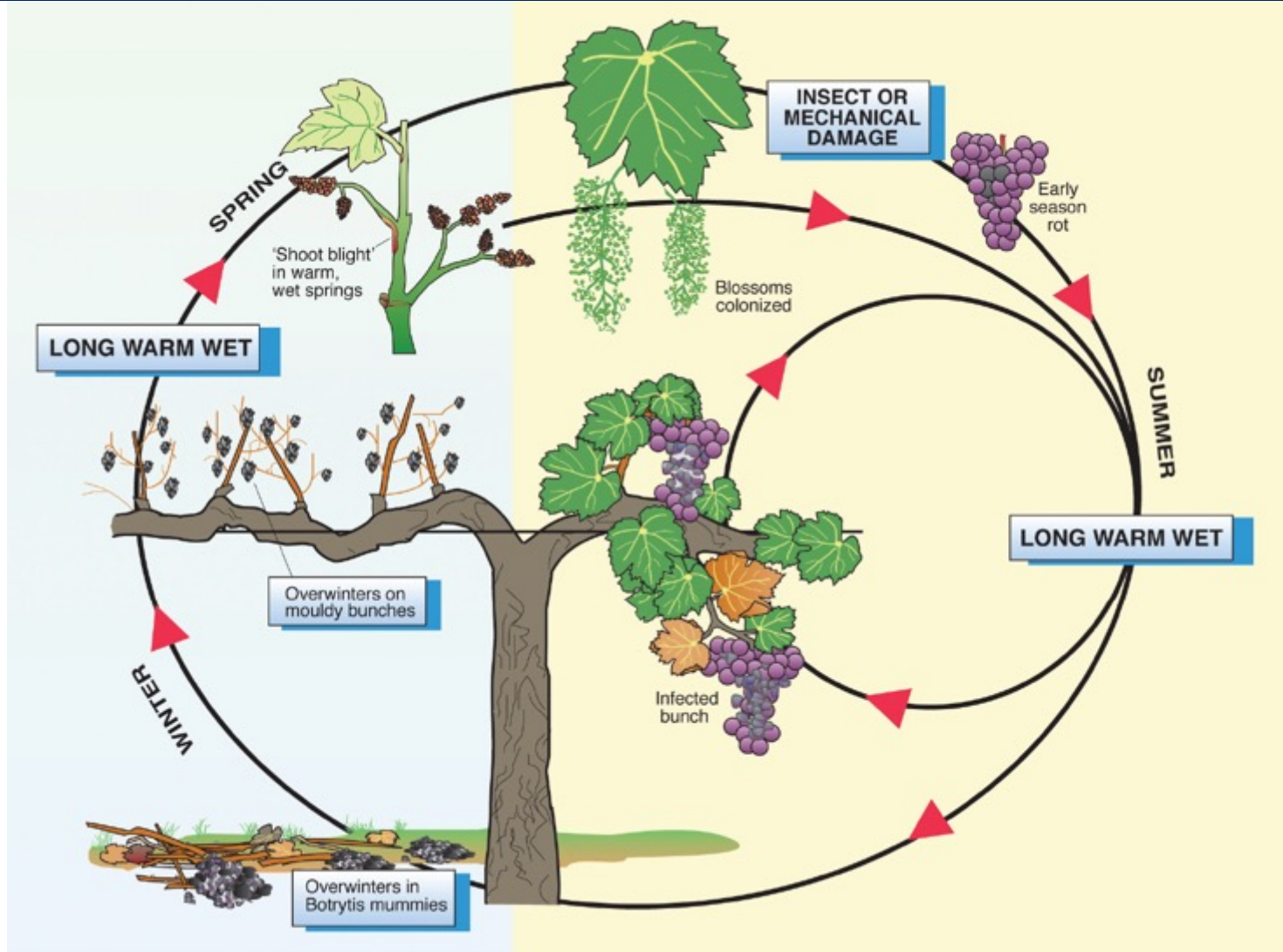
Yeast



Bacteria

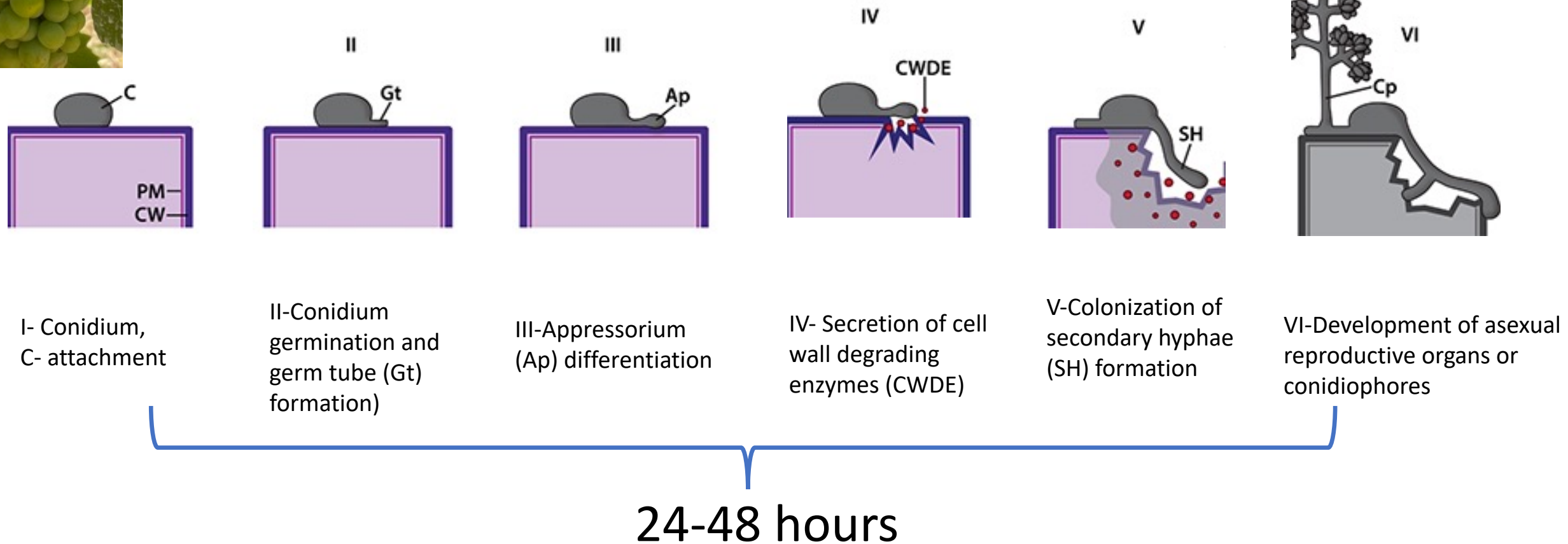


# Life cycle of Botrytis bunch rot



Drosophila

# Infection by *Botrytis cinerea*



# Grape Bunch Rot- Sour Rot Fungicide Efficacy Field Trial

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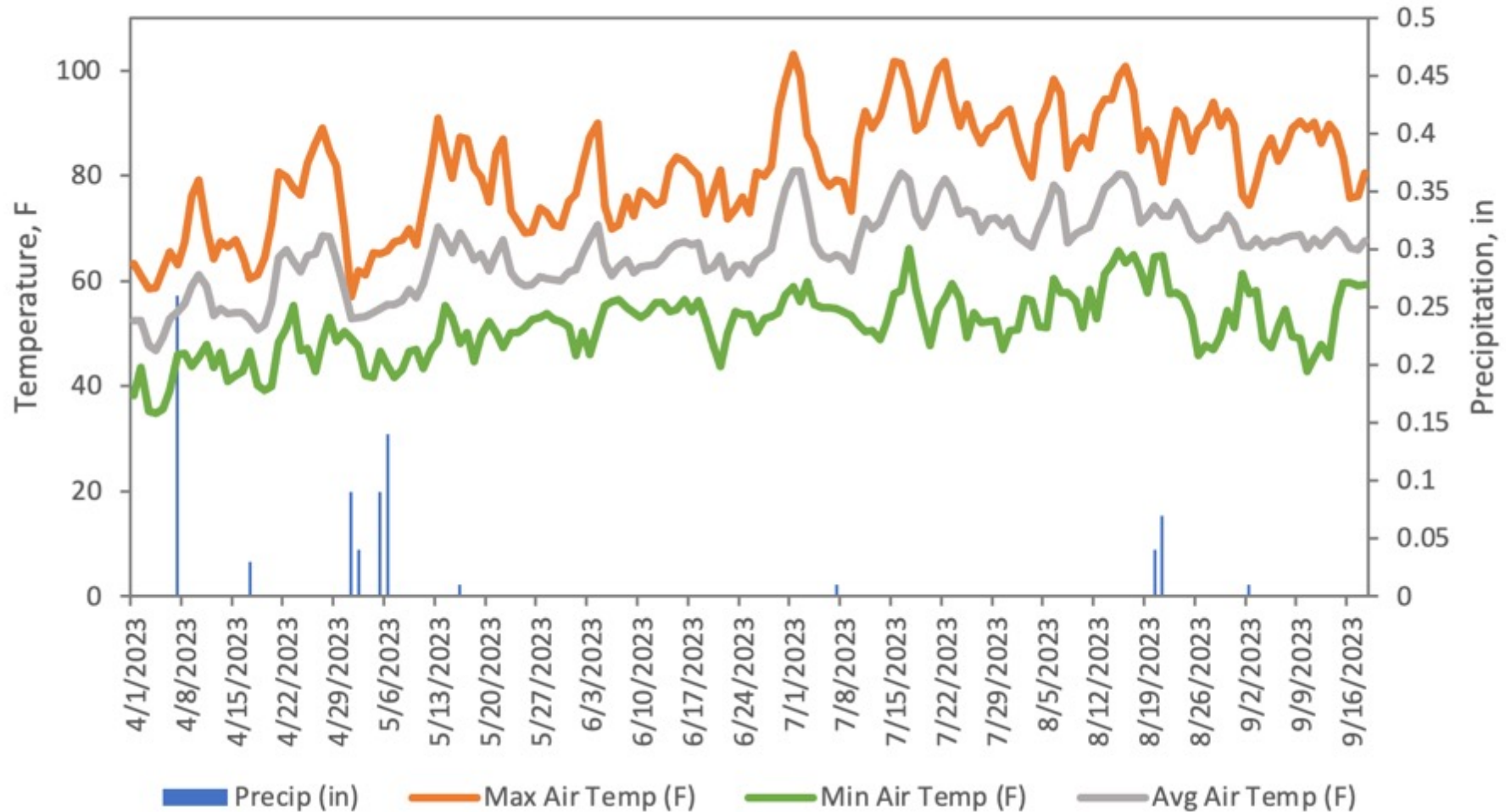


# 2023 Field fungicide efficacy trials

## Experimental design

Experimental design	Completely randomized design with 5 replicates		
Experimental unit	3 adjacent vines = 1 plot		
Row and tree spacing	11 ft (row) and 5 ft (vine)	Plot unit area	165 ft <sup>2</sup>
Area/treatment	825 ft <sup>2</sup> or 0.01956 acre/treatment (5 replicates = 1 treatment)		
Fungicide	A bloom, May 25 <sup>th</sup> , 100 gallons = 1.5152 gal/5 reps		
Applications, Volume water/Acre	B pre-close, June 22 <sup>th</sup> , 150 gallons = 2.2727 gal/5 reps		
	C veraison, August 6 <sup>st</sup> , 150 gallons = 2.2727 gal/5 reps		
	D pre-harvest, August 23 <sup>rd</sup> , 150 gallons = 2.2727 gal/5 reps		
Equipment	Stihl SR 430 Backpack Sprayers		

# 2023 Field climatic data



Average daily temperature (°C) and precipitation (mm) from Apr 1 to July 25, 2022, from CIMIS station #243.

# 2023 Summer Bunch Rot Field Trials

Treatment <sup>x</sup>			Applicati on time <sup>y</sup>	Bunch rot on the clusters <sup>z</sup>	
No.	Flag	Rate/Acre		Incidence , %	Severit y, %
40	BKC	Evoca 3 lb + Activator-90 16 fl oz/100 gal	A,D	8.0 a	1.0 a
		Pristine 23 oz	B		
		Elevate 16 oz	C		
50	B+G	SA-0650004 28 fl oz	A	14.4 ab	0.9 a
		Vanguard WG 10 oz	B		
		SA-0650004 28 floz	C		
		Ph-D 6.2 oz + Syl-Coat 4 fl oz	D		
29	GD	Miravis Prime 13.4 fl oz + Dyne-Amic 0.125% v/v	A, C	15.2 a-c	1.4 a
		Vanguard 10.0 oz + Dyne-Amic 0.125% v/v	B		
		Switch 14.0 oz + Dyne-Amic 0.125% v/v	D		
42	PWD	Mevalon 55 fl oz	A	16.0 a-d	1.0 a
		Vanguard WG 10 oz	B		
		Elevate 50WDG 1 lb	C		
		Ph-D 6.2 oz + Syl-Coat 4 fl oz	D		
6	O	V6M-5-7 27.4 fl oz + Dyne-Amic 0.125%v/v	A,B,C,D	17.6 a-e	1.8 a
30	GS	Vanguard 10.0 oz+ Dyne-Amic 0.125% v/v	A, D	17.6 a-e	2.0 a
		Miravis Prime 13.4 fl oz + Dyne-Amic 0.125% v/v	B, C		
27	RKC	Kaligreen 5lb	A,B,C,D	20.0 a-g	2.6 a-c
41	Pu	Evoca 3 lb + Activator-90 16 fl oz	A, B, D	20.0 a-g	0.9 a
		Elevate 16 oz	C		

# Eskalen lab website

## Flag 18-YKC-2022- Powdery Mildew Trial

Jul 25 - 26, 2022 - Shared



## G. Results

### Trial I

**Table 1.** Disease incidence and severity of synthetic fungicides and combinations of soft chemistry and synthetic products. Product names are followed by rate (per acre). Treatment means followed by the same letter are not significantly different according to Fisher's LSD at  $\alpha=0.05$ ;

Pictures - Flag	Treatment Rate/A <sup>z</sup>	Application date (Julian day)	Powdery mildew on the cluster <sup>y</sup>		
			Incidence, %	Severity, %	
18	YKC	Abound 15.5 fl oz + Syl-Coat 4 fl oz	105	0.0 a	0.00 a
		Prolivo 5 fl oz + Syl-Coat 4 fl oz	119		
		Kenja 22 fl oz + Rally 4 oz + Syl-Coat 4 fl oz	132		
		Quintec 4oz + Syl-Coat 4 fl oz	147		
		Torino 3.4 oz + Syl-Coat 4 fl oz	161		
		Merivon 4oz + Syl-Coat 4 fl oz	178		
		Vivando 15.4 oz + Syl-Coat 4 fl oz	193		
37	BC	PureSpray Green 1 gal	103, 110, 117	0.0 a	0.00 a
		Luna Experience 8.6 fl oz	124, 182		
		Pristine 23 oz	138		
		Elevate 16oz	152		
		Parade 3.1 fl oz	166		
41	Pu	Parade 3.1 fl oz + Dyne-Amic 0.25% v/v	108, 122, 136, 150, 165, 179, 194	0.0 a	0.00 a
62	Y+O	Aprovia Top 13.3 fl oz +Syl-Coat 0.125% v/v	122, 179	0.0 a	0.00 a
		Quintec 6.6 fl oz + Syl-Coat 0.125% v/v	136, 194		
		Miravis Prime 13.4 fl oz +Syl-Coat 0.125% v/v	165		
		Inspire Super 20.0 fl oz +Syl-Coat 0.125% v/v	150		
63	Y+W	Aprovia Top 13.3 fl oz + A9180B 0.5 oz +Syl-Coat 0.125% v/v	122, 179	0.0 a	0.00 a
		Quintec 6.6 fl oz + A9180B 0.5 oz + Syl-Coat 0.125% v/v	136, 194		

# Acknowledgements

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Mark Battany – UCCE San Luis Obispo, Santa Barbara

Larry Bettiga – UCCE Monterey

Monica Cooper – UCCE Napa

Carmen Gispert – UCCE Riverside

Glenn McGourty – UCCE Mendocino

Rhonda Smith – UCCE Sonoma

Gabriel Torres – UCCE Tulare

Jose Ramon Úrbez-Torres – Agriculture and Agri-Food Canada

Lynn Wunderlich – UCCE Central Sierra

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## **Funding:**



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