

Managing winegrape powdery mildew and Botrytis bunch rot using biofungicides

Shunping Ding, Ph.D.

Associate Professor of Plant Pathology

Wine & Viticulture, Plant Sciences
California Polytechnic State University

Vineyard Team, April 12, 2024



CAL POLY

Biopesticides

- Biopesticides include naturally occurring substances that control pests (biochemical pesticides), microorganisms that control pests (microbial pesticides), and pesticidal substances produced by plants containing added genetic material (plant-incorporated protectants) or PIPs. (EPA)

Biopesticides

plant extract,
microbial
metabolites

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Bacillus spp.,
Trichoderma spp.

Bt gene

- Biofungicides

California Grape Industry



\$5.23B in 2021

Total Grape Acres: 881,000

- 128,000 ac; table grape
- 138,000 ac; raisin grape
- **615,000 ac; wine grape**
 - **29,151 ac, organic wine grape (2022)**

Wine Grape Economic Impact

- Wine grapes account for **\$3.6 B**
- **81% of US** wine grape
- CA; **4th** leading wine producer (cdfa.ca.gov)

(Volpe, 2010)



Grapevine diseases

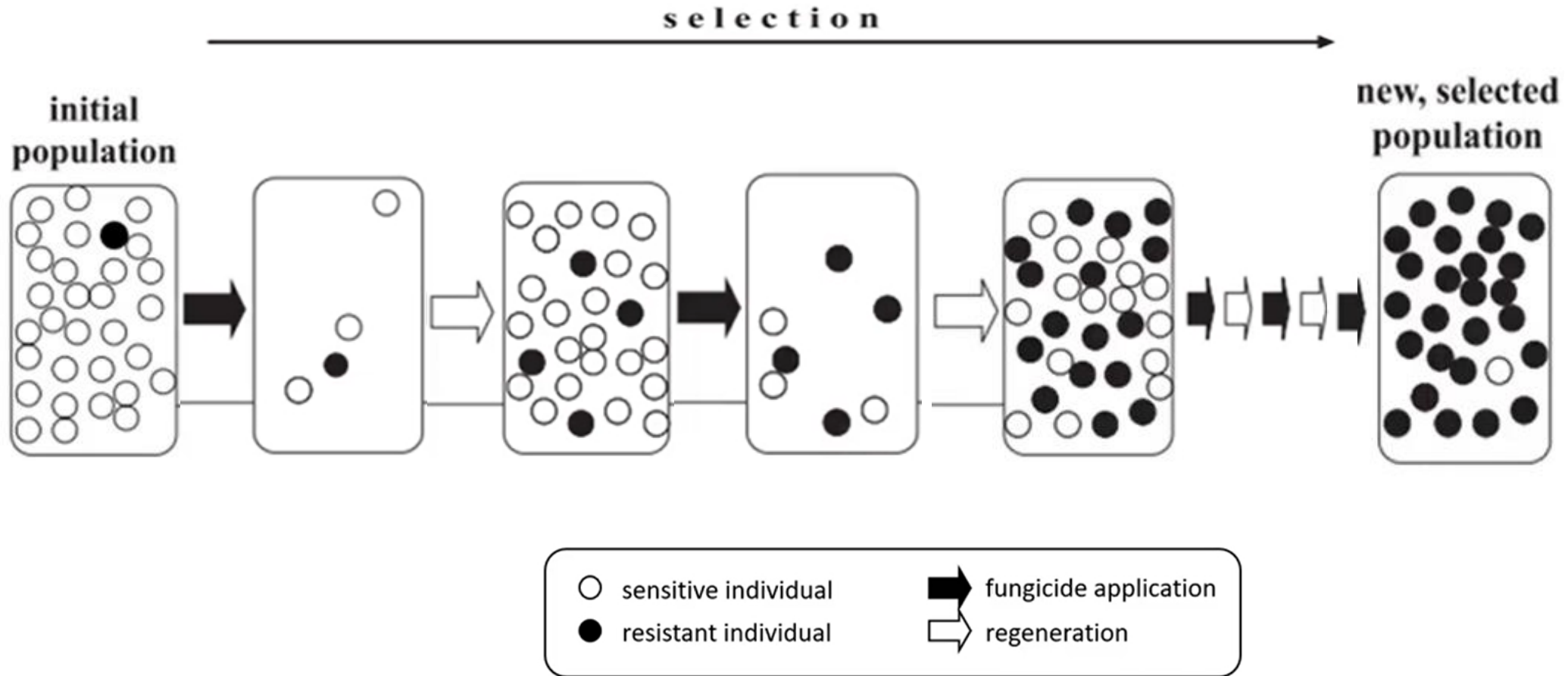
- Powdery mildew
- Botrytis bunch rot
- Grapevine trunk disease
- ...



Use of biofungicides

- A significant part of integrated pest management
 - Replace or reduce synthetic pesticides usage

Fungicide Resistance Accumulation



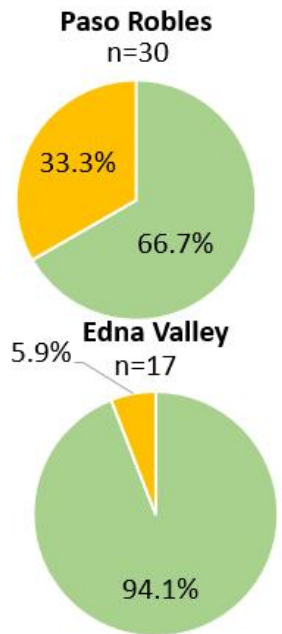
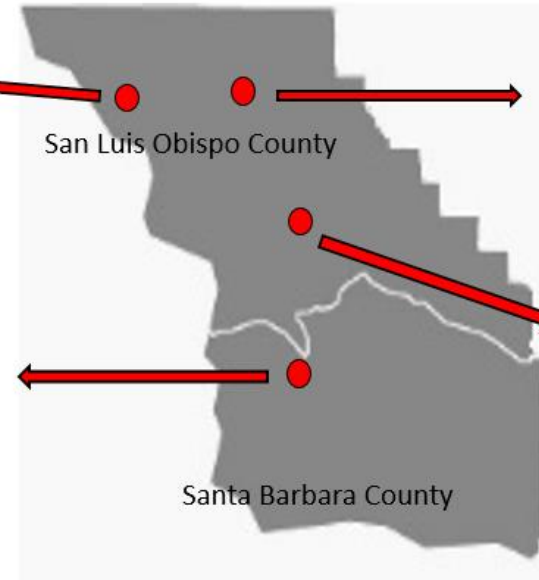
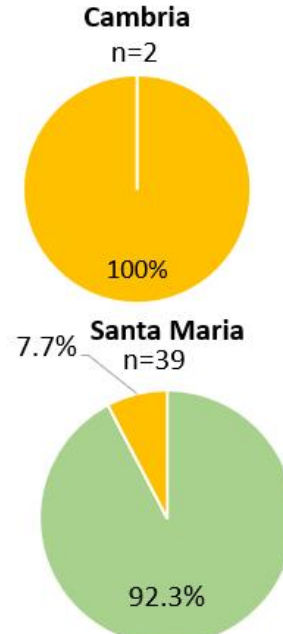
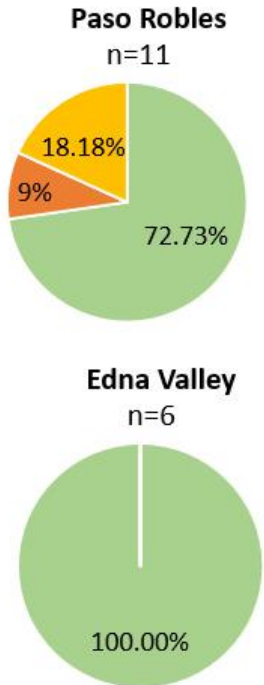
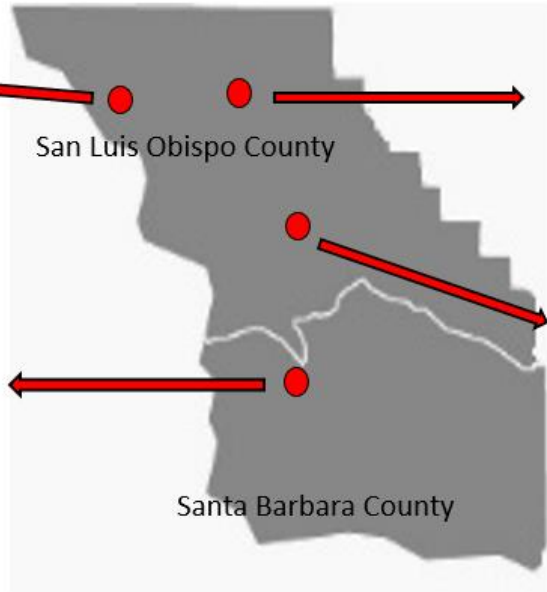
Pyrimethanil (FRAC 9) Screening Results

Botrytis cinerea

- Highly Resistant
- Moderately Resistant
- Highly Sensitive
- Moderately Sensitive

2020

2021



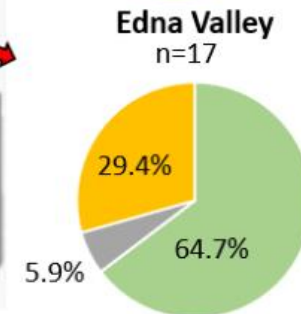
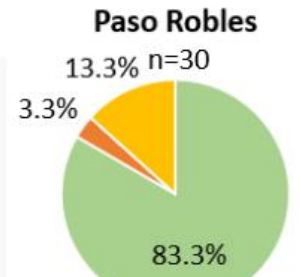
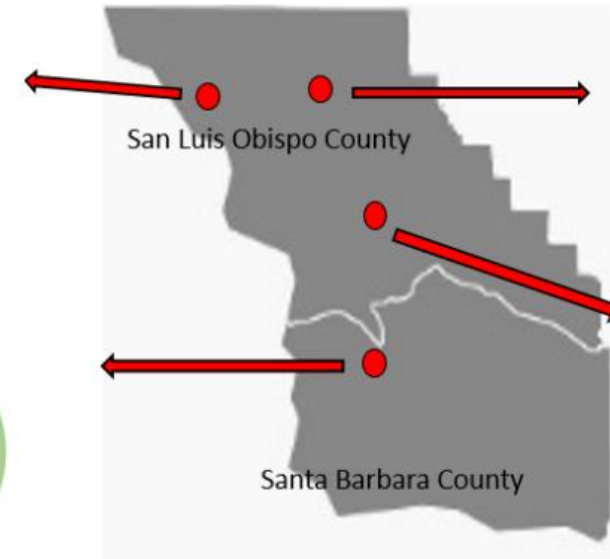
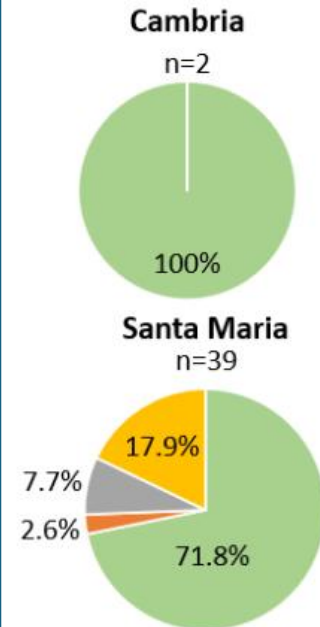
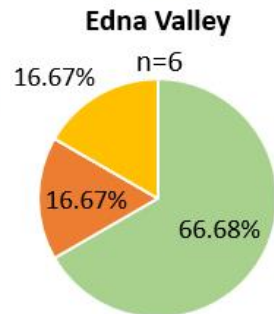
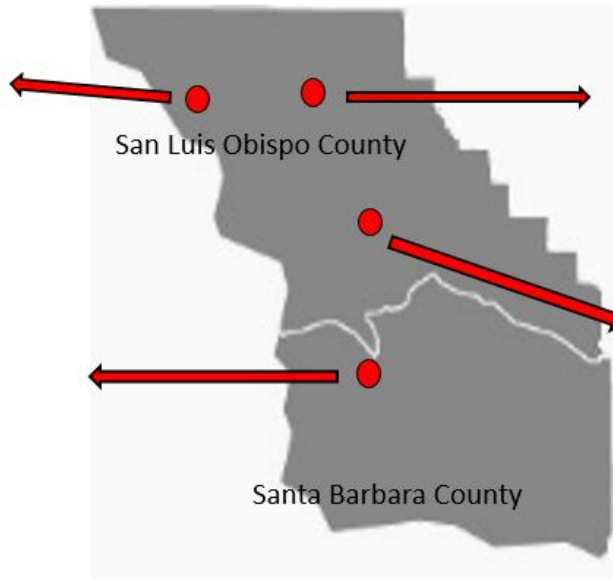
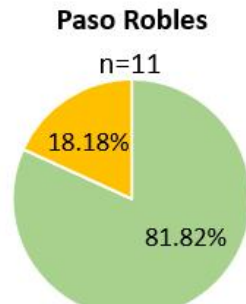
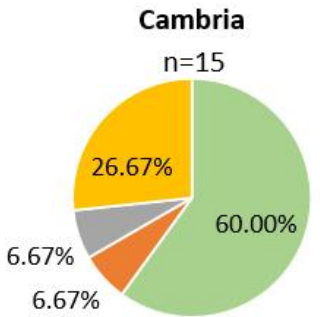
Boscalid (FRAC 7) Screening Results

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- Moderately Resistant
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- Moderately Sensitive

2020

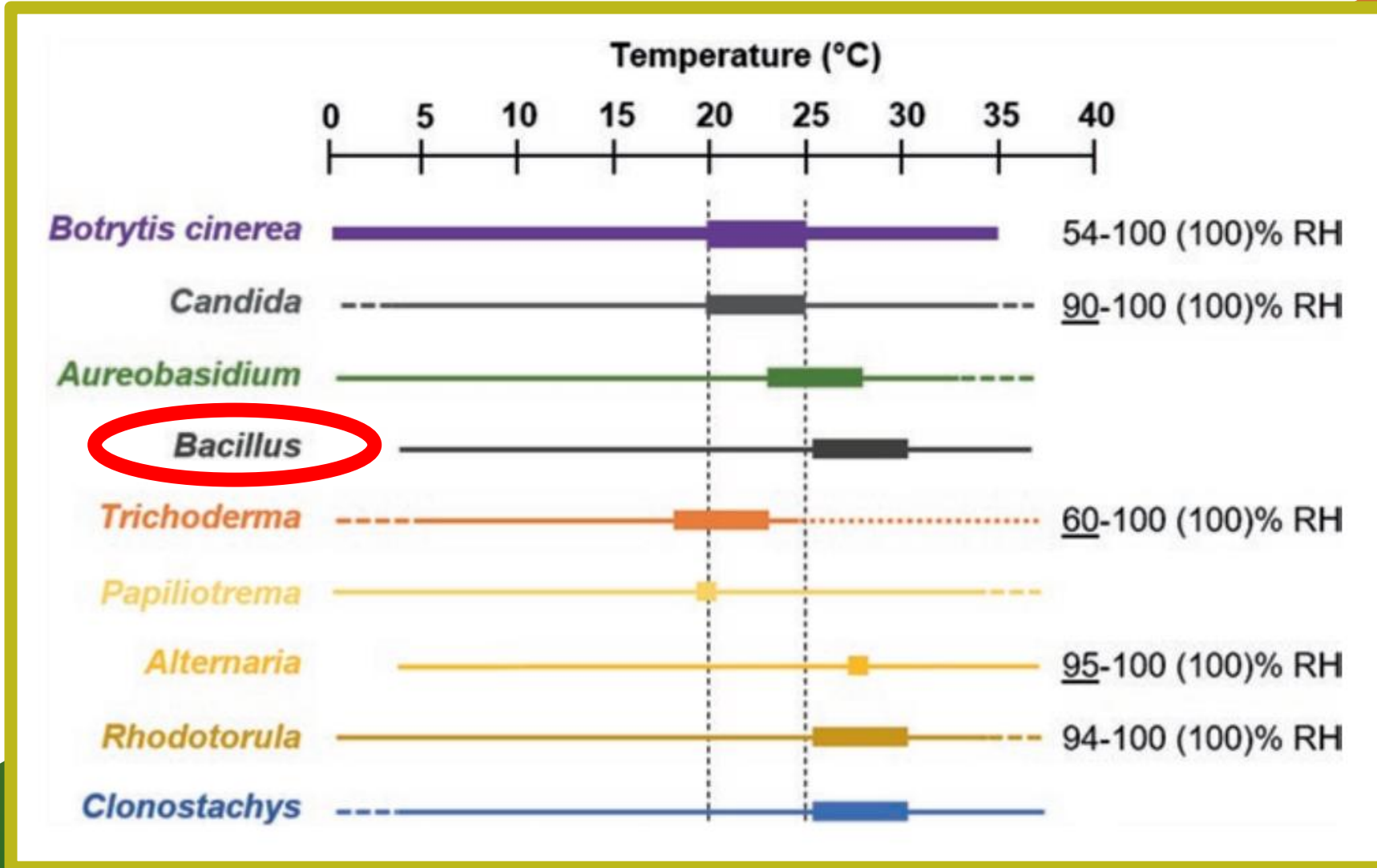
2021



Use of biofungicides

- A significant part of integrated pest management
 - Replace or reduce synthetic pesticides usage
- Multi-mode of action
 - Antibiosis, competition, hyper parasitism, etc.
- Long-term suppression of pest populations
 - Biocontrol microbial organisms may replicate and persist within the target
 - Reduced shelf life, efficacy varies due to biotic and abiotic environment

Optimal Growth Temperature of Microbes



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 - Quick decomposition
 - Target-specific

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 - Target-specific
 - Fast EPA registration
 - Efficacy??

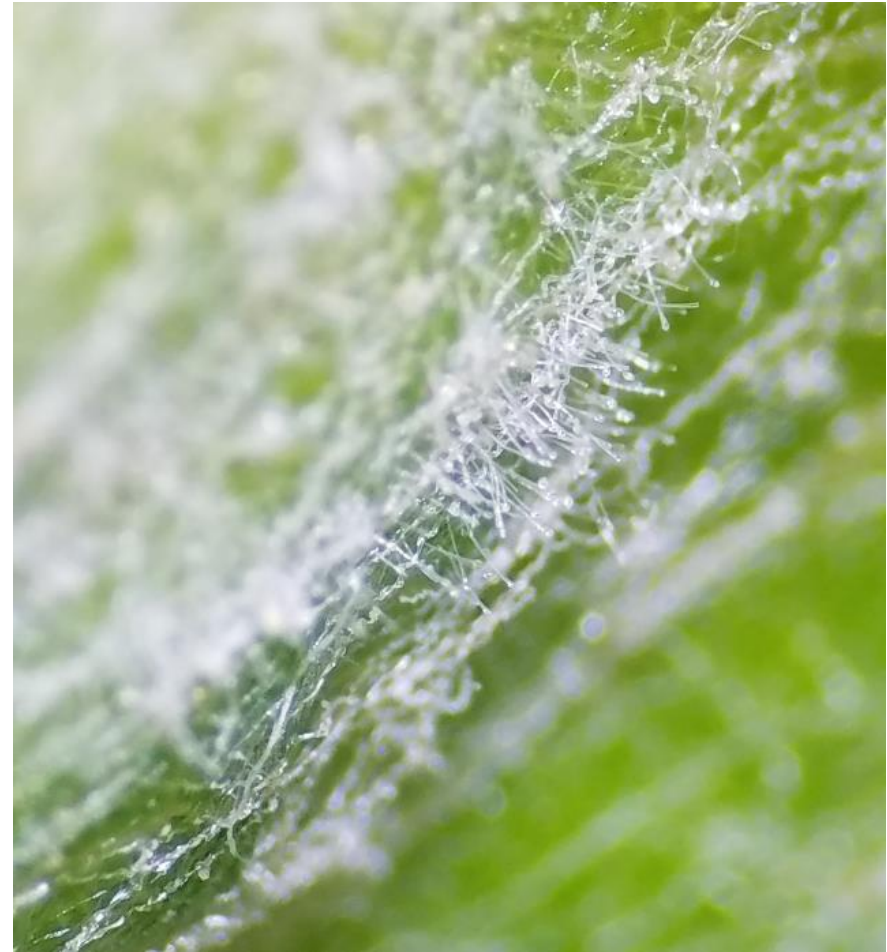
Powdery mildew - significance

- Powdery mildew management costs >\$300 million (Fuller et al., 2014)
- Reduction in yield and quality
- Sensory and compositional effects
 - 1-5% infection in Chardonnay (Stummer et al., 2003)



Powdery mildew - management

- Season-long control
 - Polycyclic disease
 - Gubler-Thomas Risk Assessment Index
 - Temperature – 0-100-point index
 - 70 °F – 85 °F
- Biofungicides
 - Actinovate, Cinnacure, ProBlad Verde, Regalia, Serenade, Sonata, Taegro 2



UC IPM:

<https://ipm.ucanr.edu/agriculture/grape/fungicide-efficacybiologicals-and-natural-products/>

Botrytis cinerea – symptoms and signs



(S. Koike, UCCE 2012)



(Photo by S. Ding)



(Photo by S. Ding)

Botrytis cinerea – Management

- Fungicide application at bloom, pre-closure, and Veraison
- Biofungicides
 - ProBlad Verde, Regalia, Serenade, Sonata, Taegro 2, Timorex



UC IPM:

<https://ipm.ucanr.edu/agriculture/grape/fungicide-efficacybiologicals-and-natural-products/>

Cultural control

- Canopy management practices
 - Good coverage
 - Shoot thinning, hedging, and leaf removal
 - Avoid unnecessary irrigation or nitrogen fertilization
- Manage insect populations



Investigating the Impact of Biofungicides on Wine Grape Disease Control and Wine Quality

- 1) identifying the effective and economic use of biofungicides in wine grape powdery mildew and Botrytis bunch rot management.
- 2) studying the effect on the microbial community, especially pro-fermentation microbes, and the subsequent wine quality when using biofungicides solely and integrated in programs.



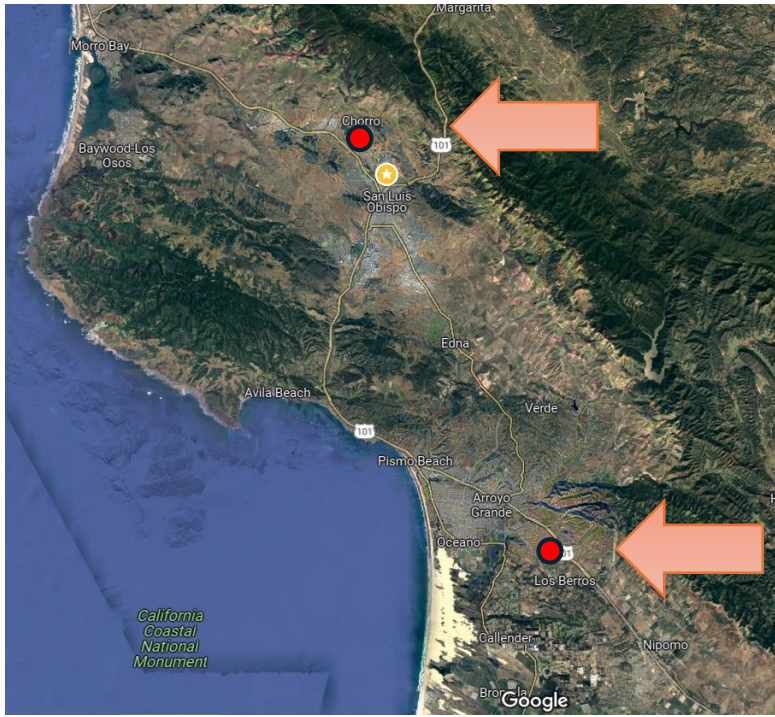
George Zhuang



Stephan Sommer



Kristy Qun Sun



- Central Valley
- Warm Mediterranean or even a desert climate
 - Cool and wet winter
 - Hot and dry summer
 - Rain early spring

- Central Coast
- Mediterranean climate
 - Mild winter
 - Warm to hot summer
 - Rain between December to April



(Volpe, 2010)

Biofungicides



Microbial fungicides

- Actinovate® AG, *Streptomyces lydicus*
- Serenade®, *Bacillus subtilis*



Biochemical fungicides

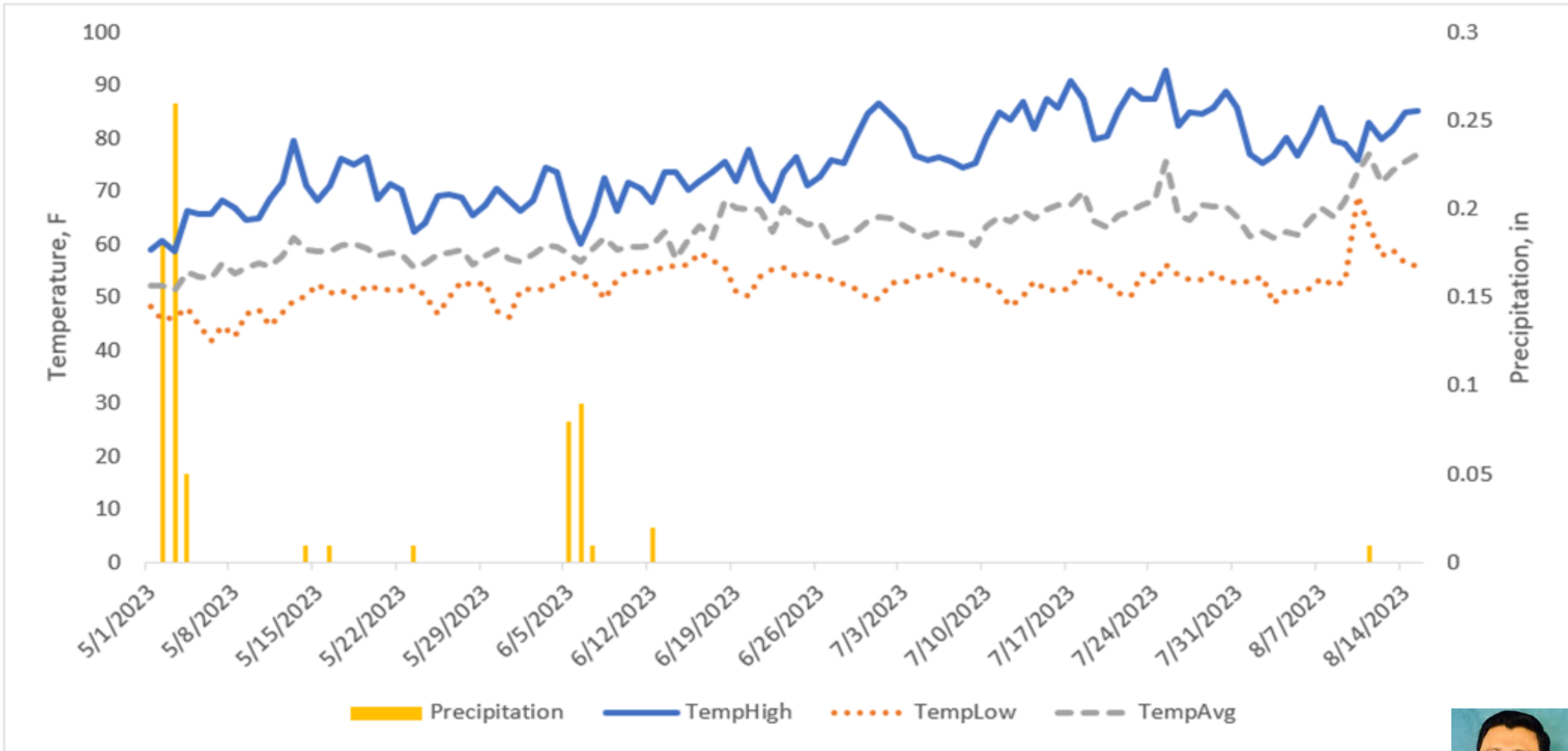
- Plant Extracts and compounds
- Regalia®, Extract of *Reynoutria sachalinensis*



Treatments

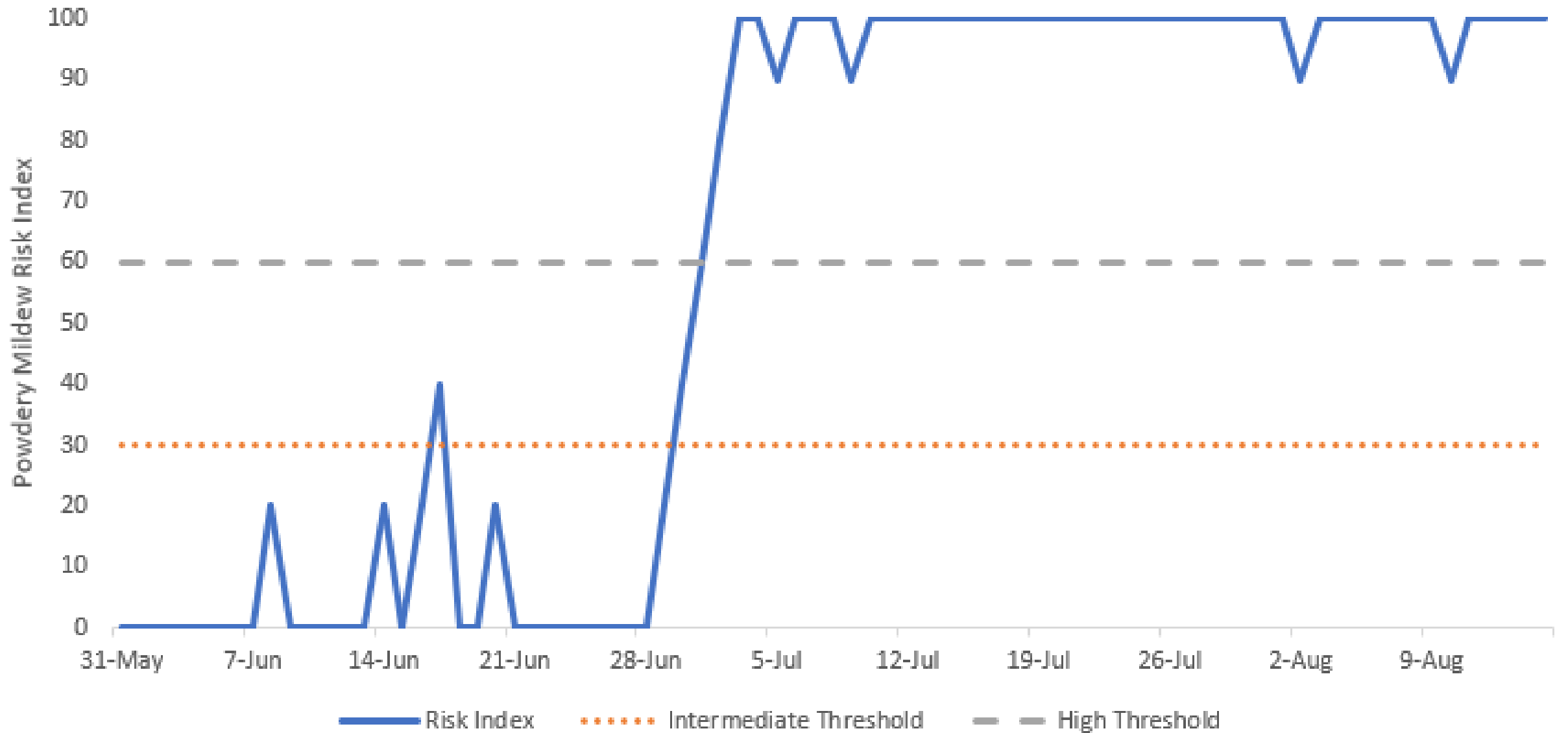
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Regalia	Regalia	Regalia	Regalia	Actinovate	Actinovate	Actinovate	Actinovate	Serenade	Serenade	Serenade	Serenade		
Weekly	Bi-weekly	Based Risk index		Weekly	Bi-weekly	Based Risk index		Weekly	Bi-weekly	Based Risk index			
			Integrated				Integrated				Integrated		
												Grower standard	Non-Treated

The diagram illustrates 14 treatment plots arranged in a row. Each plot is represented by a colored arrow pointing upwards. The arrows are: 1 (dark blue), 2 (purple), 3 (green), 4 (light blue), 5 (dark blue), 6 (purple), 7 (green), 8 (light blue), 9 (dark blue), 10 (purple), 11 (green), 12 (light blue), 13 (orange outline), 14 (orange outline).



Trestle Vineyard, average daily temperature (° F) and precipitation (inches) from May 1st to August 15th, 2023.





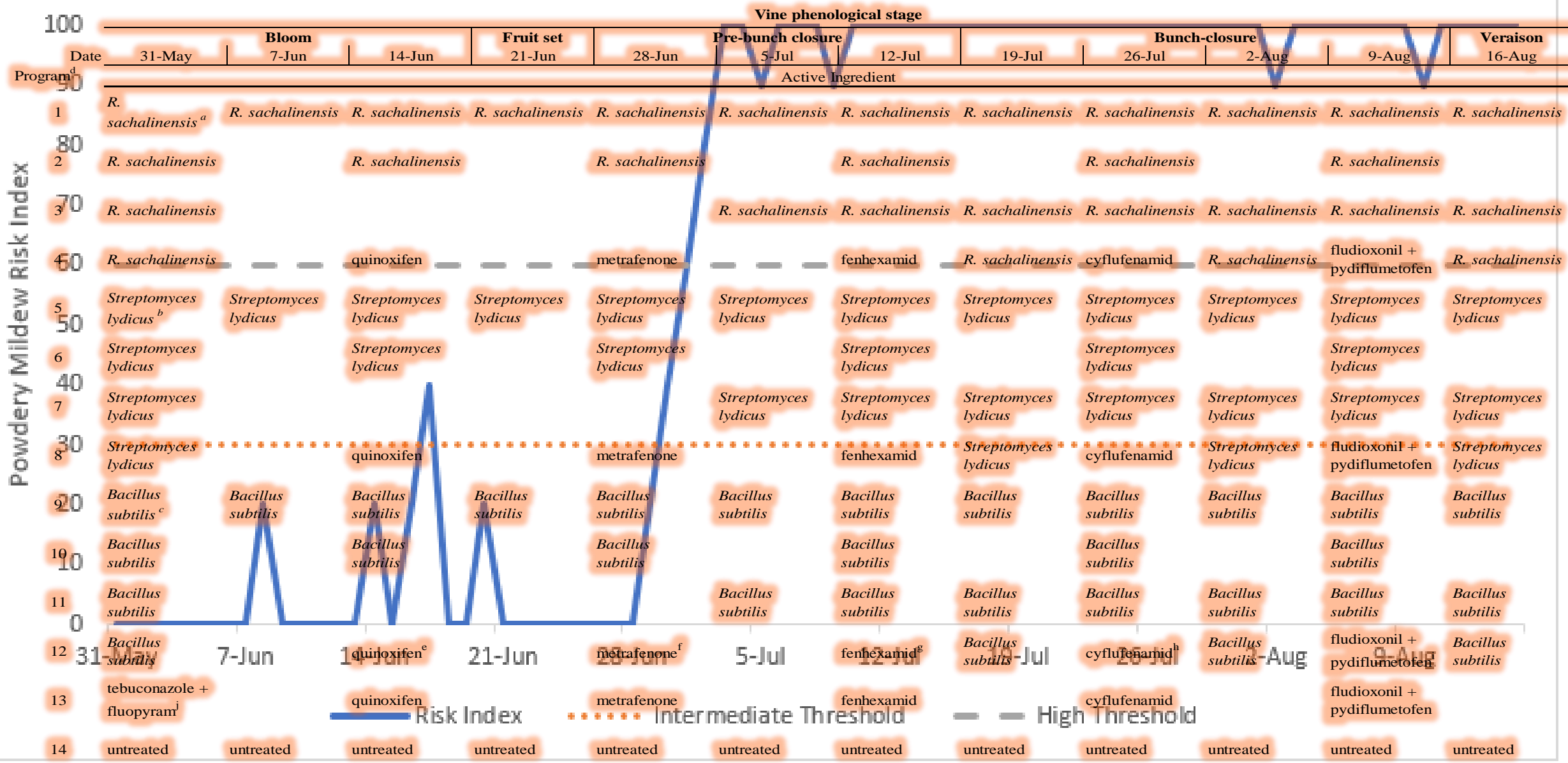
Trestle Vineyard, Thomas-Gubler Risk Index data from May 31st to August 15th, 2023.



Table 1. Fungicide application dates and product rotations for 2023.

Program ^d	Vine phenological stage											
	Date	Bloom		Fruit set	Pre-bunch closure			Bunch-closure			Veraison	
	31-May	7-Jun	14-Jun	21-Jun	28-Jun	5-Jul	12-Jul	19-Jul	26-Jul	2-Aug	9-Aug	16-Aug
Active Ingredient												
1	<i>R. sachalinensis</i> ^a	<i>R. sachalinensis</i>	<i>R. sachalinensis</i>	<i>R. sachalinensis</i>	<i>R. sachalinensis</i>	<i>R. sachalinensis</i>	<i>R. sachalinensis</i>	<i>R. sachalinensis</i>	<i>R. sachalinensis</i>	<i>R. sachalinensis</i>	<i>R. sachalinensis</i>	<i>R. sachalinensis</i>
2	<i>R. sachalinensis</i>		<i>R. sachalinensis</i>		<i>R. sachalinensis</i>		<i>R. sachalinensis</i>		<i>R. sachalinensis</i>		<i>R. sachalinensis</i>	
3	<i>R. sachalinensis</i>					<i>R. sachalinensis</i>	<i>R. sachalinensis</i>	<i>R. sachalinensis</i>	<i>R. sachalinensis</i>	<i>R. sachalinensis</i>	<i>R. sachalinensis</i>	<i>R. sachalinensis</i>
4	<i>R. sachalinensis</i>		quinoxifen		metrafenone		fenhexamid	<i>R. sachalinensis</i>	cyflufenamid	<i>R. sachalinensis</i>	fludioxonil + pydiflumetofen	<i>R. sachalinensis</i>
5	<i>Streptomyces lydicus</i> ^b	<i>Streptomyces lydicus</i>	<i>Streptomyces lydicus</i>	<i>Streptomyces lydicus</i>	<i>Streptomyces lydicus</i>	<i>Streptomyces lydicus</i>	<i>Streptomyces lydicus</i>	<i>Streptomyces lydicus</i>	<i>Streptomyces lydicus</i>	<i>Streptomyces lydicus</i>	<i>Streptomyces lydicus</i>	<i>Streptomyces lydicus</i>
6	<i>Streptomyces lydicus</i>		<i>Streptomyces lydicus</i>		<i>Streptomyces lydicus</i>		<i>Streptomyces lydicus</i>		<i>Streptomyces lydicus</i>		<i>Streptomyces lydicus</i>	
7	<i>Streptomyces lydicus</i>					<i>Streptomyces lydicus</i>	<i>Streptomyces lydicus</i>	<i>Streptomyces lydicus</i>	<i>Streptomyces lydicus</i>	<i>Streptomyces lydicus</i>	<i>Streptomyces lydicus</i>	<i>Streptomyces lydicus</i>
8	<i>Streptomyces lydicus</i>		quinoxifen		metrafenone		fenhexamid	<i>Streptomyces lydicus</i>	cyflufenamid	<i>Streptomyces lydicus</i>	fludioxonil + pydiflumetofen	<i>Streptomyces lydicus</i>
9	<i>Bacillus subtilis</i> ^c	<i>Bacillus subtilis</i>	<i>Bacillus subtilis</i>	<i>Bacillus subtilis</i>	<i>Bacillus subtilis</i>	<i>Bacillus subtilis</i>	<i>Bacillus subtilis</i>	<i>Bacillus subtilis</i>	<i>Bacillus subtilis</i>	<i>Bacillus subtilis</i>	<i>Bacillus subtilis</i>	<i>Bacillus subtilis</i>
10	<i>Bacillus subtilis</i>		<i>Bacillus subtilis</i>		<i>Bacillus subtilis</i>		<i>Bacillus subtilis</i>		<i>Bacillus subtilis</i>		<i>Bacillus subtilis</i>	
11	<i>Bacillus subtilis</i>					<i>Bacillus subtilis</i>	<i>Bacillus subtilis</i>	<i>Bacillus subtilis</i>	<i>Bacillus subtilis</i>	<i>Bacillus subtilis</i>	<i>Bacillus subtilis</i>	<i>Bacillus subtilis</i>
12	<i>Bacillus subtilis</i>		quinoxifen ^e		metrafenone ^f		fenhexamid ^g	<i>Bacillus subtilis</i>	cyflufenamid ^h	<i>Bacillus subtilis</i>	fludioxonil + pydiflumetofen ⁱ	<i>Bacillus subtilis</i>
13	tebuconazole + fluopyram ^j		quinoxifen		metrafenone		fenhexamid		cyflufenamid		fludioxonil + pydiflumetofen	
14	untreated	untreated	untreated	untreated	untreated	untreated	untreated	untreated	untreated	untreated	untreated	untreated

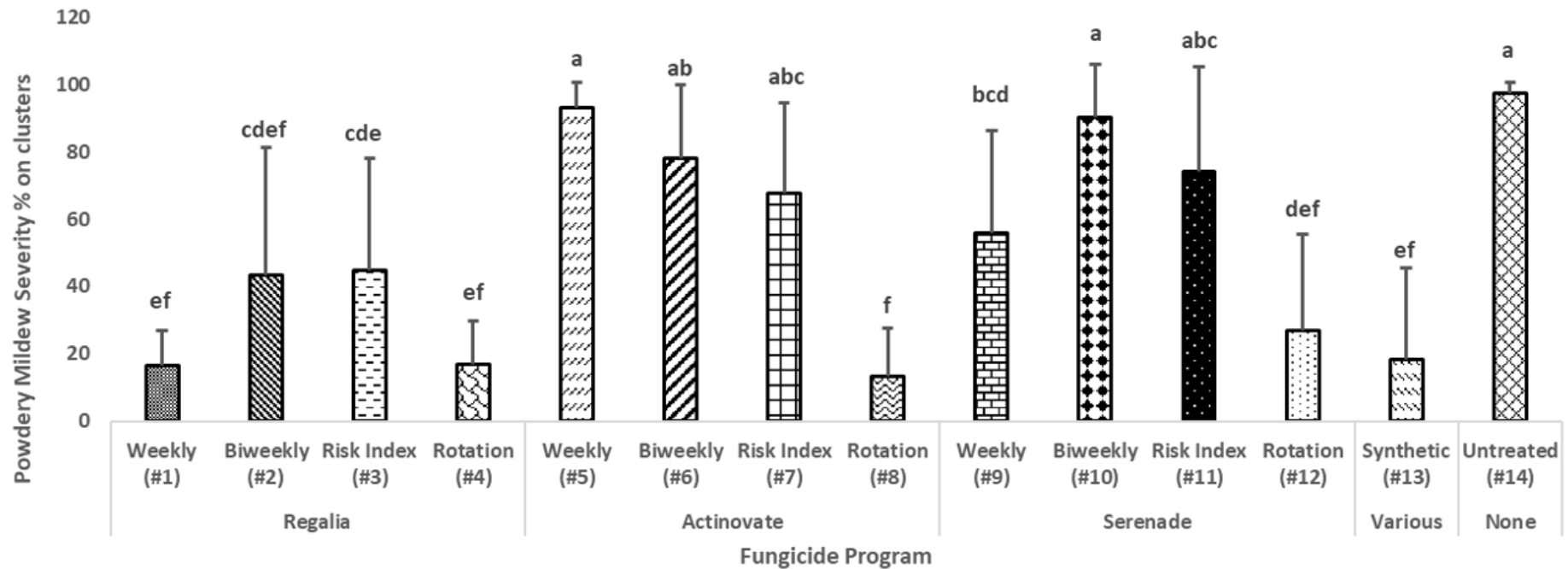
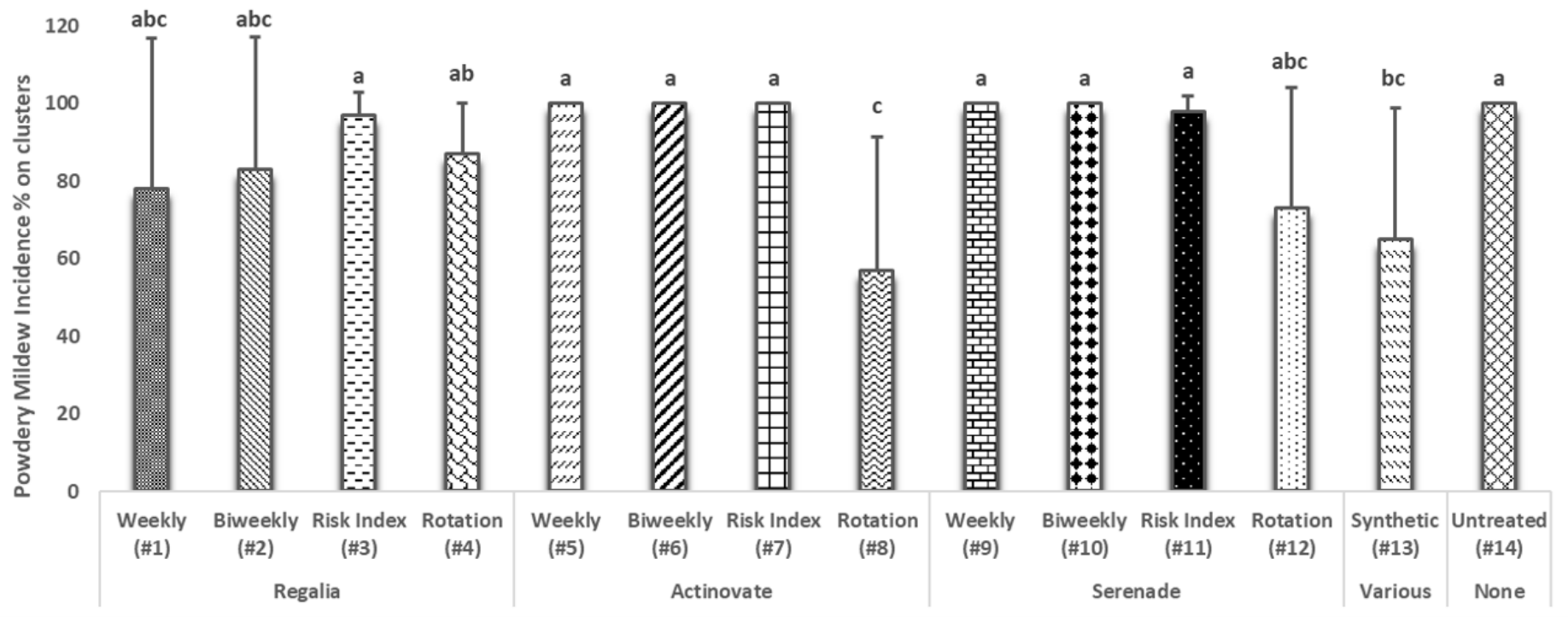
^a Extract of *Reynoutria sachalinensis* (Regalia (R) Biofungicide)^b Strain WYEC 108 (Actinovate)^c Strain QST 713 (Serenade ASO)^d A modified vegetable oil surfactant was added to all applications at a rate of 5 ml per gallon of spray solution. Always follow label instructions regarding fungicide group rotations.^e Quintec; ^f Vivando; ^g Elevate; ^h Torino; ⁱ Miravis Prime; ^j Luna Experience



Trestle Vineyard, Thomas-Gubler Risk Index data from May 31st to August 15th, 2023.

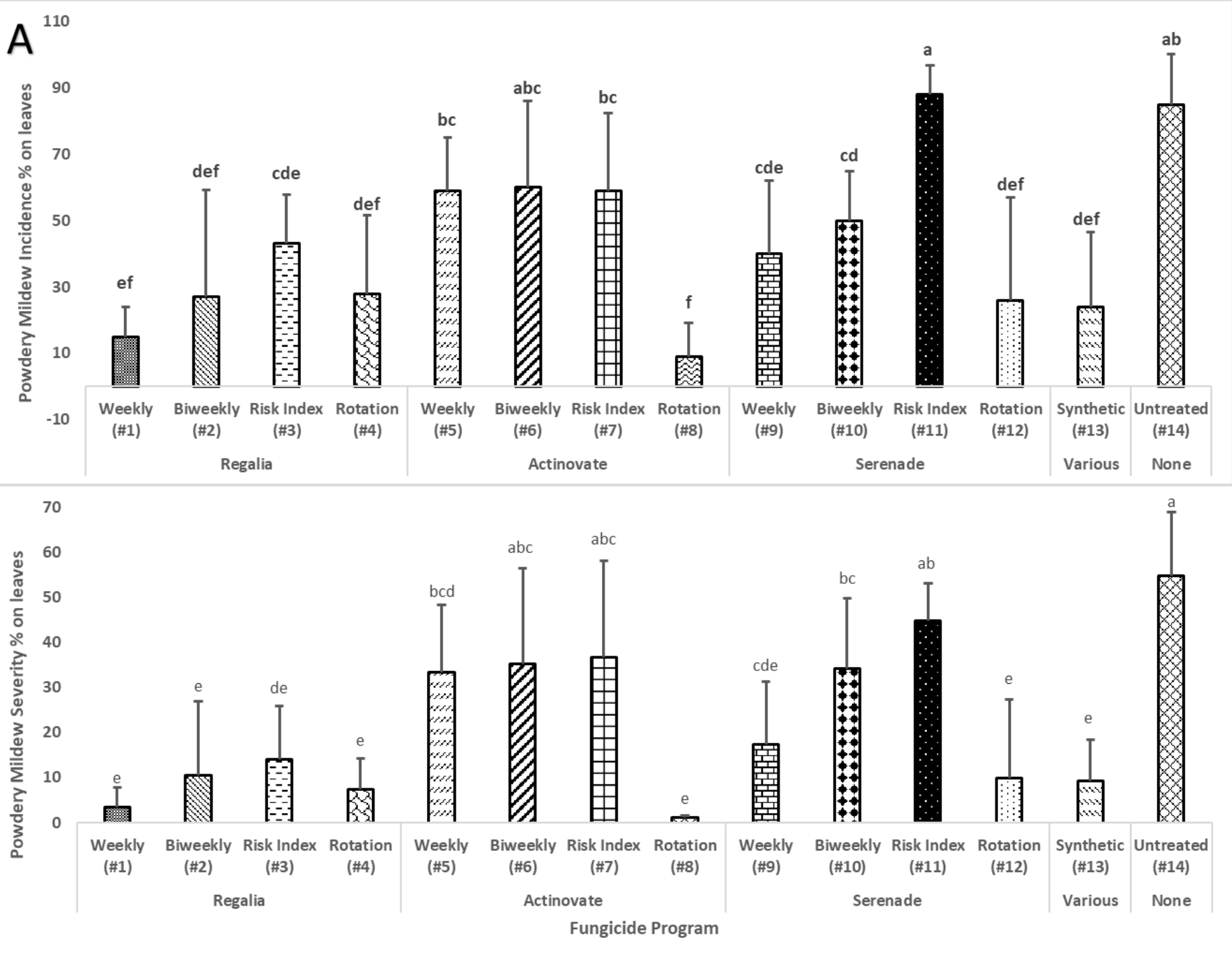
Chardonnay:

Powdery mildew
on clusters



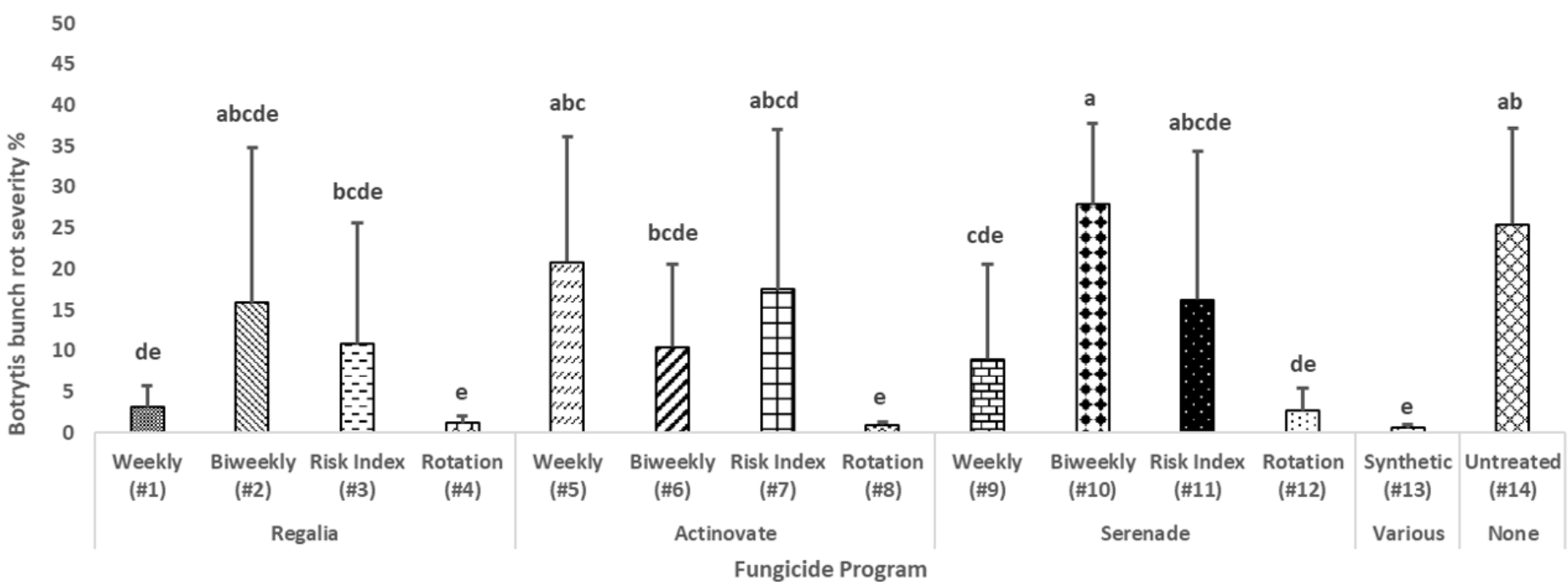
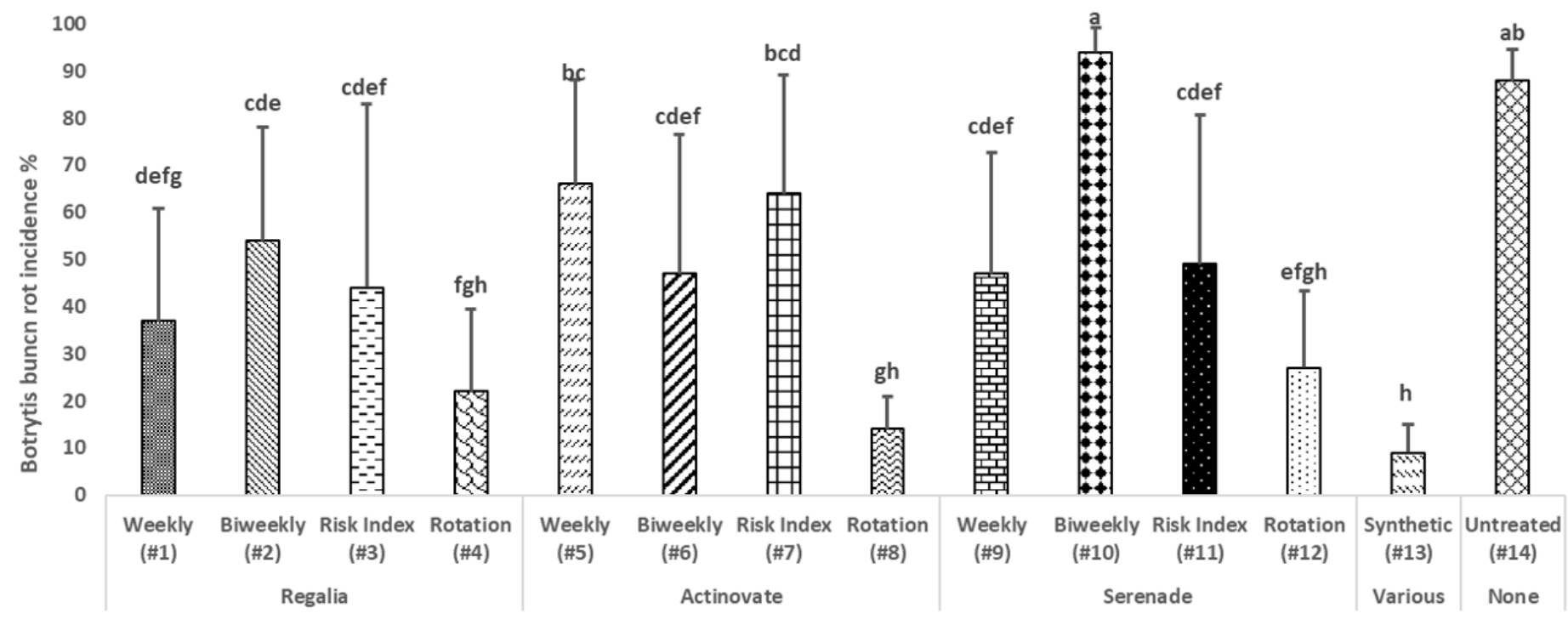
Chardonnay:

Powdery mildew
on leaves



Chardonnay:

Botrytis bunch rot



Chardonnay:

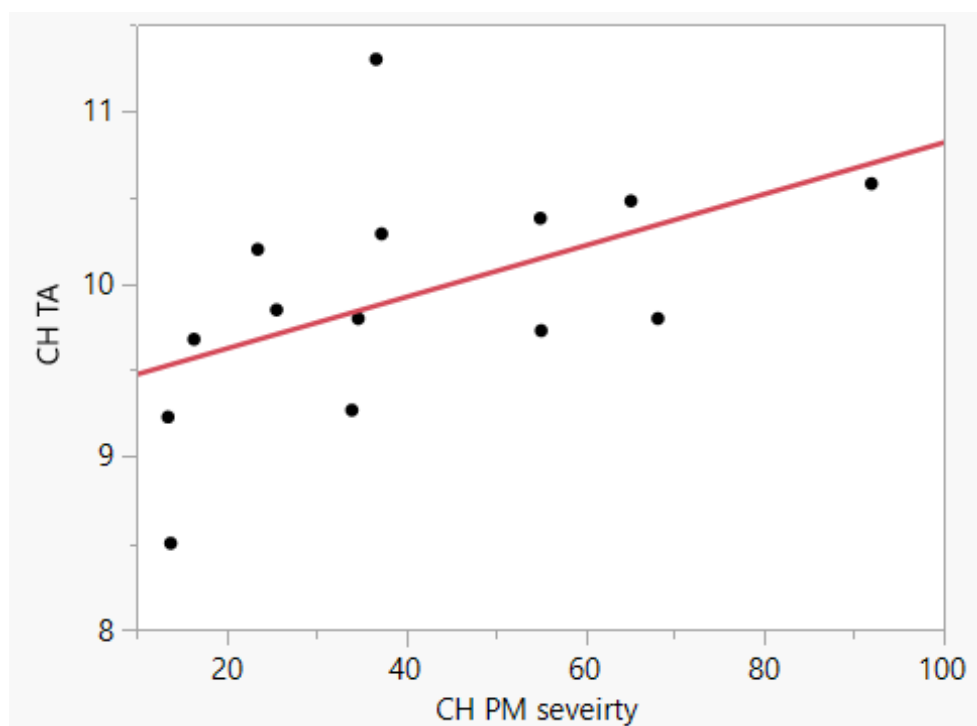
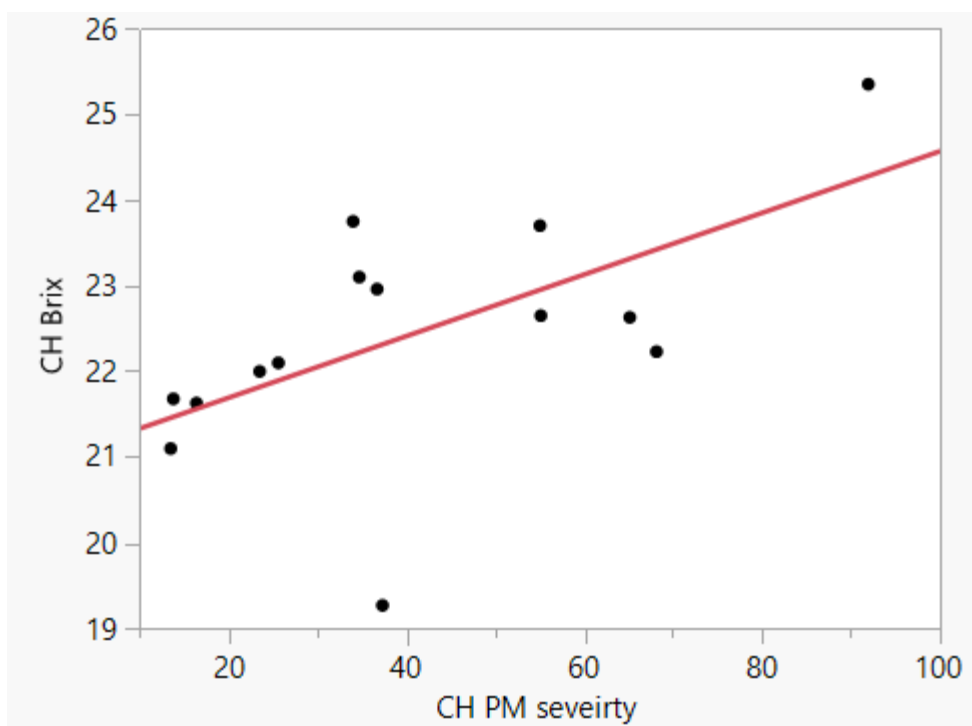
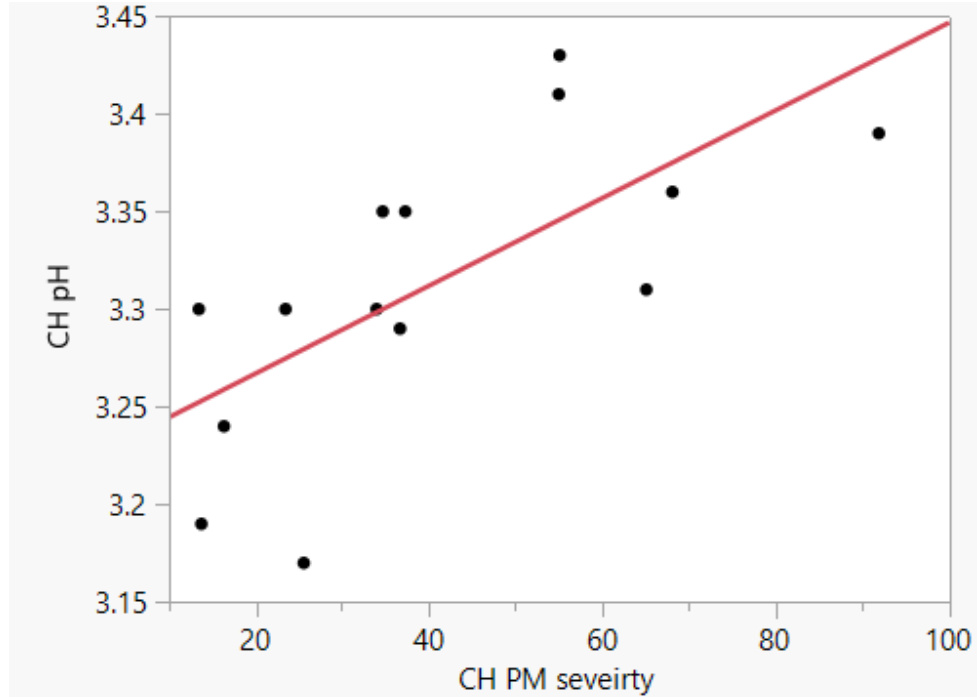
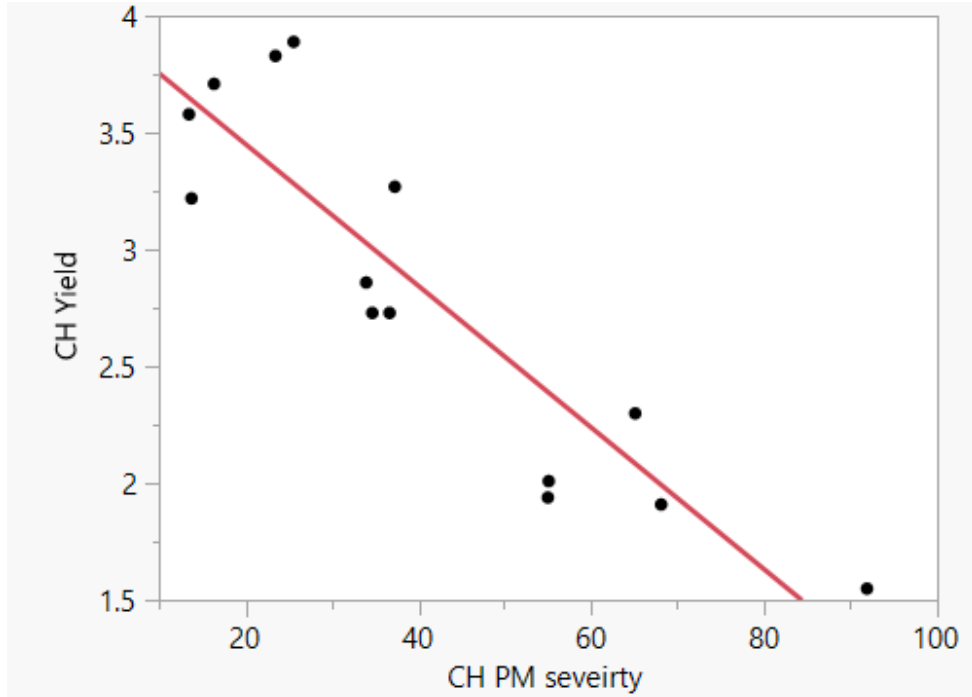
Yield and berry chemistry

Oenological Parameters

		Treatment #	Yield/vine (Kg)	pH	Brix	Titrateable acidity (g/L)	
F u n g i c i d e P r o g r a m	Regalia	Weekly	1	3.83 ± 0.89 ^a	3.30 ± 0.08 ^{cd}	22.00 ± 0.75 ^{bc}	10.20 ± 0.83
		Biweekly	2	2.86 ± 0.93 ^{abcde}	3.30 ± 0.06 ^{cd}	23.75 ± 2.55 ^{ab}	9.27 ± 1.98
		Risk Index	3	2.73 ± 0.24 ^{abcde}	3.35 ± 0.04 ^{abc}	23.10 ± 0.6 ^{ab}	9.80 ± 1.28
		Rotation w/synthetics	4	3.71 ± 0.85 ^a	3.24 ± 0.01 ^{de}	21.63 ± 0.82 ^{bc}	9.68 ± 1.03
	Actinovate	Weekly	5	1.94 ± 0.63 ^{de}	3.41 ± 0.10 ^{ab}	23.70 ± 1.23 ^{ab}	10.38 ± 1.09
		Biweekly	6	2.30 ± 1.06 ^{bcde}	3.31 ± 0.12 ^{bcd}	22.63 ± 1.16 ^{ab}	10.48 ± 0.93
		Risk Index	7	2.73 ± 1.34 ^{abcde}	3.29 ± 0.04 ^{cd}	22.96 ± 0.71 ^{ab}	11.30 ± 1.04
		Rotation w/synthetics	8	3.58 ± 1.44 ^{ab}	3.30 ± 0.02 ^{cd}	21.10 ± 0.42 ^{bc}	9.23 ± 1.11
	Serenade ASO	Weekly	9	3.27 ± 1.52 ^{abc}	3.35 ± 0.08 ^{abc}	19.27 ± 5.88 ^c	10.29 ± 1.16
		Biweekly	10	1.91 ± 0.51 ^{de}	3.36 ± 0.11 ^{abc}	22.23 ± 2.31 ^b	9.80 ± 1.31
		Risk Index	11	2.01 ± 1.10 ^{cde}	3.43 ± 0.20 ^a	22.65 ± 1.24 ^{ab}	9.73 ± 1.48
		Rotation w/synthetics	12	3.89 ± 1.15 ^a	3.17 ± 0.05 ^e	22.10 ± 0.79 ^b	9.85 ± 0.93
	Grower Standard	13	3.22 ± 1.68 ^{abcd}	3.19 ± 0.04 ^e	21.68 ± 0.54 ^{bc}	8.50 ± 1.06	
	Untreated control	14	1.55 ± 0.56 ^e	3.39 ± 0.07 ^{abc}	25.35 ± 1.02 ^a	10.58 ± 0.49	

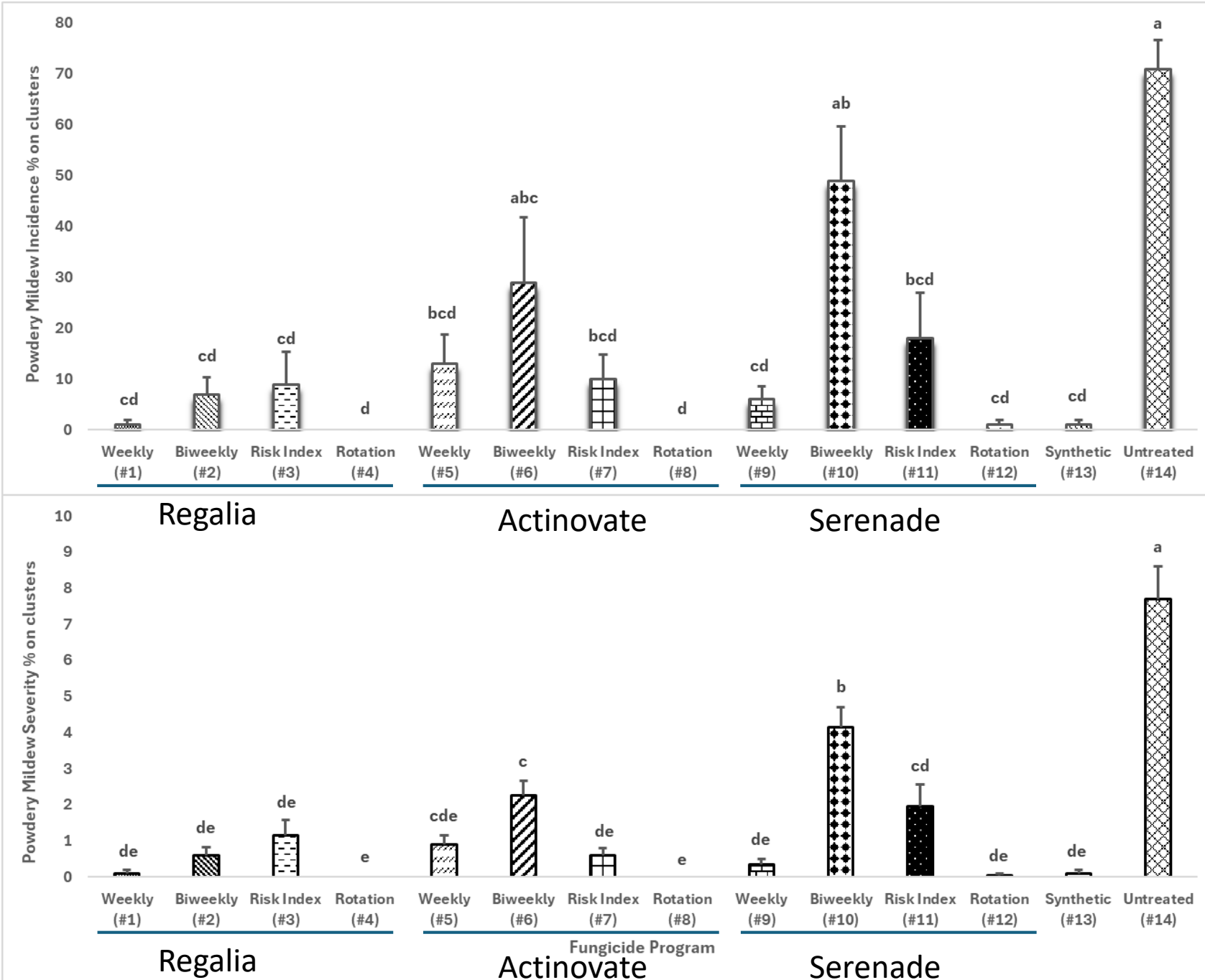
Chardonnay:

Powdery mildew
vs.
berry chemistry



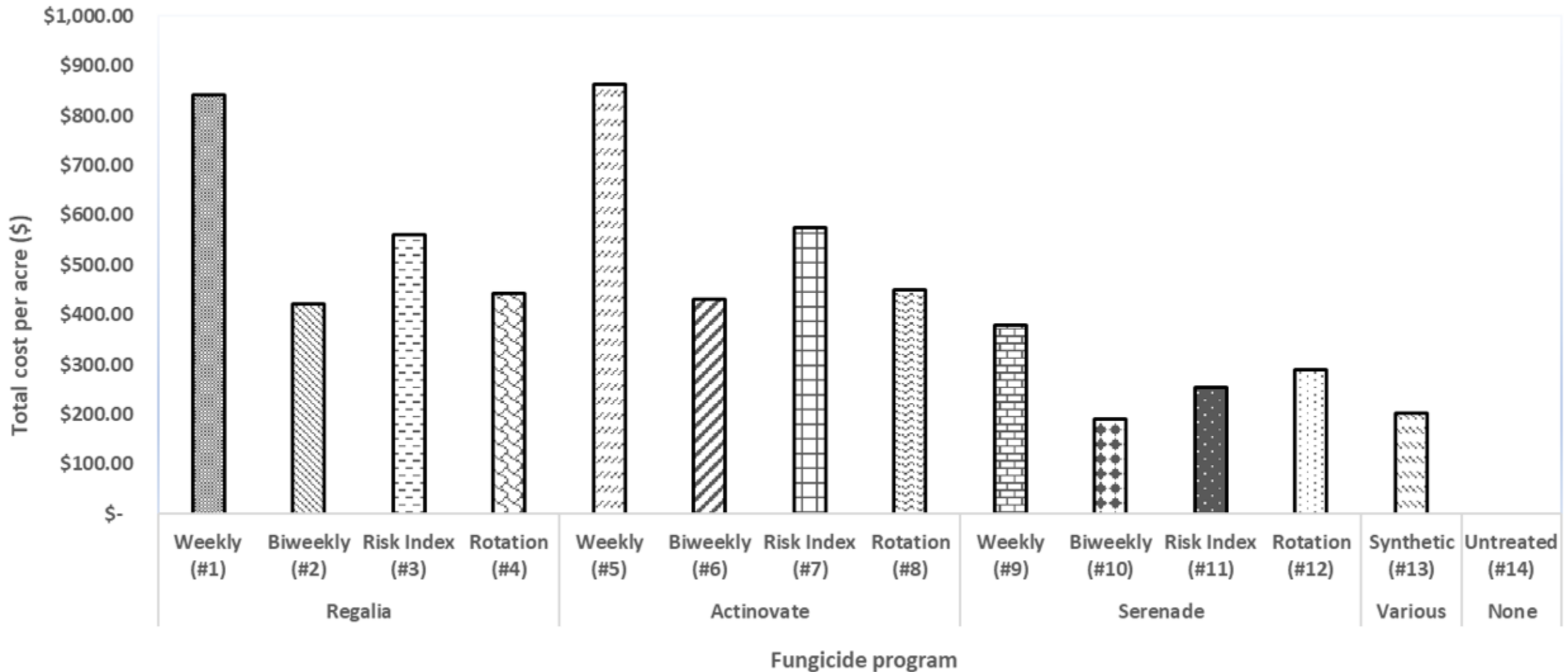
Pinot Noir:

Powdery mildew
on clusters





Cost per acre for each fungicide program



Takeaways

- Weekly applications and rotational programs were most effective
- Powdery mildew risk index may help reduce the use of biofungicides
- Biofungicides may improve disease control when combined with other disease management practices



Acknowledgement

- **Edgar Godoy** and Quinn Cahoon
- Marco Fernandez, Jim Green, and Kallol Das
- Ding Lab student researchers: Lauren Taylor, Evan Tamayo, Abraham Ahumada, Skye Reading, Emma Baswell, Emily Locke-Paddon
- Cal Poly WVIT undergraduate students
- George Zhuang (UCCE)
- Kristy Qun Sun (CSU-Fresno)
- Stephan Sommer (University of Missouri)
- Grower collaborators for host our trials
- Biofungicides were donated by Bayer, Novozymes, and ProFarm





Thank you!

-
- Shunping Ding, sding01@calpoly.edu