

Fungicide efficacy and resistance in the top 10 fungicides for Botrytis fruit rot

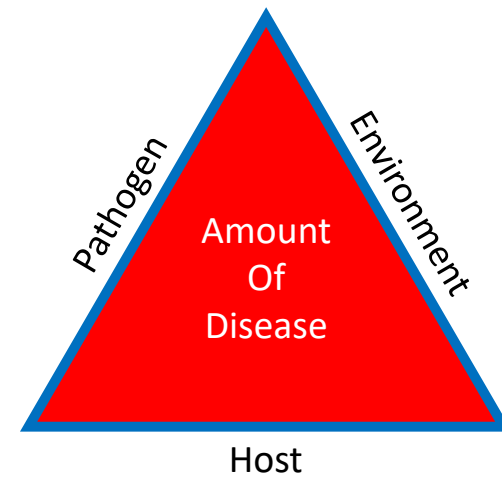
Kyle Blauer and Gerald Holmes
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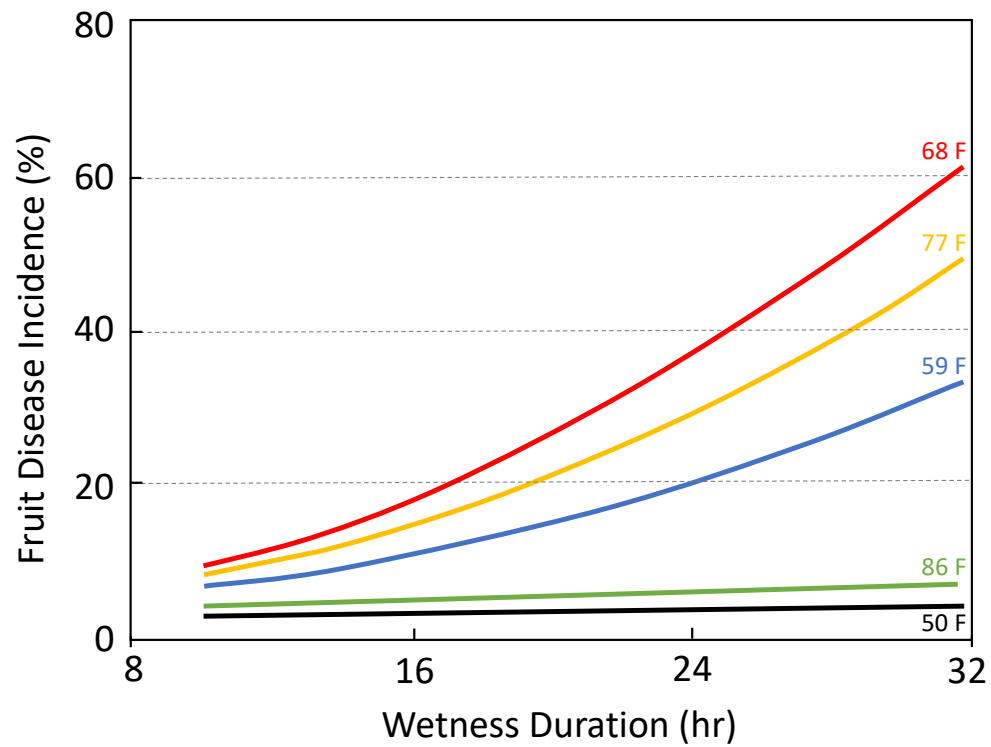


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3 important factors

- Environment: Timing
- Pathogen:
 - Fungicide efficacy
 - Fungicide resistance
- Host: susceptibility



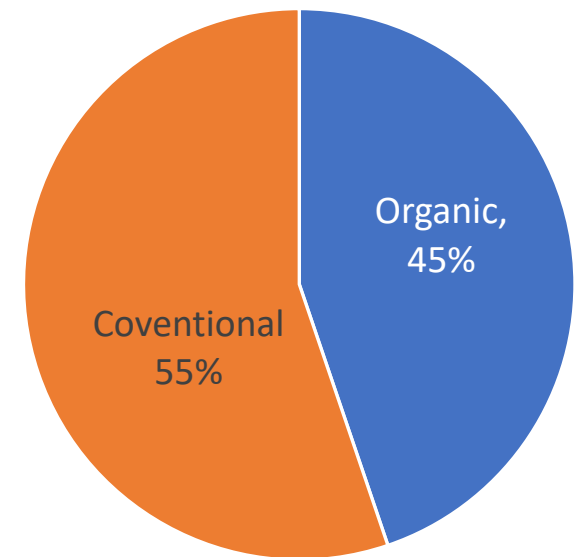


Effect of wetness duration and temperature at flower inoculation on the predicted proportion of ripe strawberry fruit infected by *Botrytis cinerea*.
 Modified from: Bulger, Ellis and Madden. 1987. Phytopathology 77:1225



Summary of fungicide evaluations

- 202 unique products
 - 28% (57) unregistered;
- 91 biological; 111 conventional
- Results available in publications
 - Plant Disease Management Reports
 - Efficacy tables
 - strawberry.calpoly.edu (Our Work tab)
 - ipm.ucanr.edu



Fungicide	Resistance risk (FRAC) ¹	Powdery mildew	Gray mold	Anthraco-nose	Common leaf spot	Rhizopus/ Mucor rot	Phytophthora diseases	Angular leaf spot
Bumper, Tilt	high (3)	5	NL (0)	NL (3)	4	NL (0)	NL	NL
Luna Privilege (foliar)/ Velum One (soil) ¹⁰	high (7)	5/3	5/2	NL	ND	ND	ND	NL
Luna Sensation ²	medium (7/11)	5	4	3 ^R	ND	2	NL	NL
Luna Tranquility ²	medium (7/9)	5	4	NL	ND	1	NL	NL
Miravis Prime	medium (7/12)	5	4	3	NL	3	NL	NL
Mettle, Perissim	high (3)	5	NL	NL	ND	NL	NL	NL
Procure	high (3)	5	NL	NL (2)	NL (0)	NL	NL	NL
Quadris Top ⁸	medium (3/11)	5	NL (3) ^R	4 ^R	0	NL	NL	NL
Quilt Xcel, Avaris 2XS	medium (3/11)	5	3	4 ^R	NL	2	NL	NL
Quintec	high (13)	5	NL (0)	NL (0)	NL (0)	NL (0)	NL	NL
Rally	high (3)	5	NL (0)	NL (3)	4	NL	NL	NL
Rhyme	high (3)	5	0	NL	NL	NL	NL	NL
Torino	high (U6)	5	NL	NL	NL	NL	NL	NL
Protocol	medium (1/3)	4	4 ^R	3	NL	NL	NL	NL
Abound ²	medium (11)	4	2 ^R	4 ^R	NL	NL (2)	NL	NL
Cabrio ²	medium (11)	4	2 ^R	4 ^R	0	NL (2)	NL	NL
Gatten*	high? (U13)	4	NL	NL	NL	NL	NL	NL
Evito* ²	medium (11)	4	2 ^R	3 ^R	NL	NL	NL	NL
Fontelis	high (7)	4	5 ^R	ND	NL	NL	NL	NL
Kenja	high (7)	4	5	ND	ND	NL (2)	NL	NL
Merivon ^{2,8}	medium (7/11)	5	5	ND	0	NL (4)	NL	NL
Ph-D,Oso	medium (19)	4	3	3	NL	NL	NL	NL
Pristine ^{2,8}	medium (7/11)	4	5 ^R	ND	0	NL	NL	NL
Sulfur	low (M2)	4	NL	NL	NL	NL	NL	NL
Topsin-M, T-Methyl, Incognito ²	very high (1)	4	4 ^R	0	NL (3)	NL	NL	NL
Flint Extra	high (11)	4	2 ^R	2 ^R	NL	NL	NL	NL
Intuity ²	medium (11)	2	3 ^R	NL	NL (0)	NL	NL	NL
Captan	very low (M4)	NL (1)	4	NL (4)	0	NL (2)	NL	NL
Elevate ^{2,6}	high (17)	NL (1)	5 ⁶	NL (2)	NL (0)	NL	NL	NL
Aliette ^{3,7} , Legion**	low (P07,33)	NL	NL	NL	NL	NL	4	NL
Captivate ²	medium (M4/17)	NL	4	4	NL	NL	NL	NL
Copper	low (M1)	0	0	0	0	0	0	4 ⁵
Fungi-Phite, K-Phite, Prophyt	low (P07,33)	NL	NL	NL	NL	NL	4	NL (2)
Ridomil Gold SL ^{2,4}	high (4)	NL	NL	NL	NL	NL	4 ⁴	NL
Rovral, Iprodione, Nevado	low (2)	NL (0)	4	0	0	NL	NL	NL
Scala	high (9)	2	3	NL	NL	NL	NL	NL
Switch ⁷	high (9/12)	2	5 ^R	4	NL	NL (4)	NL	NL
Thiram	low (M3)	NL (0)	2	3	0	NL	NL	NL
Zivion S	low (48)	ND	3	4	NL	3	NL	NL
Actigard	low (P1)	NL	NL	NL	NL	NL	NL	3

Fungicide trade names	Active ingredient	Resis. risk/ FRAC code ¹	Powdery mildew ²	Gray mold	Anthraco-nose	Common leaf spot	Rhizopus/ Mucor rot	Phytophthora diseases ³	Angular leaf spot
Actinovate	<i>Sitreptomycetes lydicus</i> WYEC 108	low/BM 02	2	0	NL	NL	NL	0	1
Aleo, etc. ⁴	garlic oil	low/BM 01	ND	0	0	0	0	0	1
Aviv, etc.	<i>Bacillus subtilis</i> IAB/BS03	low/BM 02	3	ND	ND	ND	NL	ND	NL
Botector	<i>Aureobasidium pullulans</i> DSM 14940; DSM 14941	low/BM 02	NL	0	ND	NL	1	NL	NL
Cinerate	cinnamon oil	low/BM 01	ND	0	NL	NL	NL	NL	NL
Copper, etc. ⁵	Copper	low/M1	0	0	0	0	0	0	4
Double Nickel	<i>Bacillus amylo-liquefaciens</i> D747	low/BM 02	2	0	0	NL	NL	0	1
ProBlad Verde, etc.	<i>Banda de Lupinus albus doce</i>	low/NC	3	2	NL	NL	NL	NL	NL
Howler	<i>Pseudomonas chlororaphis</i> AFS009	low/BM 02	NL	0	ND	ND	NL	ND	0
Kaligreen, MilStop, etc.	potassium bicarbonate	low/NC	3	ND	ND	NL	NL	NL	NL
M-Pede, etc.	potassium salts of fatty acids	medium/28	2	NL	NL	NL	NL	NL	NL
Oso, etc.	Polyoxin D zinc salt	medium/19	4	3	3	NL	NL	NL	NL
Oxidate, Perasan, etc.	Hydrogen peroxide; peroxyacetic acid	low/NC	ND	0	NL	NL	NL	NL	2
Procidic, etc.	citric acid	low/NC	ND	0	NL	NL	NL	0	NL
Rango	cold pressed neem oil	low/NC	ND	2	ND	0	NL	0	NL
Regalia	<i>Reynoutria sachalinensis</i> extract	low/P5	1	0	ND	ND	NR	ND	NL
Serenade ASO, etc.	<i>Bacillus subtilis</i> QST 713	low/BM 02	3	2	0	NL (0)	NL (0)	NL (0)	NL
Sonata	<i>Bacillus pumilus</i> QST 2808	low/BM 02	3	2	0	NL	NL	NL	NL
Stargus	<i>Bacillus amylo-liquefaciens</i> F727	low/BM 02	NL	0	ND	NL	NL	NL	NL
Serifel	<i>Bacillus amylo-liquefaciens</i> MBI 600	low/BM 02	2	0	0	ND	NL	0	2
Taegro	<i>Bacillus amylo-liquefaciens</i> FZB24	low/BM 02	2	0	0	NL	NL	ND	NL (2)
Theia*	<i>Bacillus subtilis</i> AFS032321	low/BM 02	2	0	0	NL	NL	0	NL
Timorex Act	tea tree oil	low/BM 01	3	0	ND	NL	0	ND	ND

Rating: 5 = excellent and consistent, 4 = good and reliable, 3 = moderate and variable, 2 = limited and/or erratic, 1 = minimal and often ineffective, 0 = ineffective, NL = not on label, ND = no data.

* Registration pending in California.

** Not registered, label withdrawn or inactive in California.

¹ Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see <http://www.frac.info/>).

² Efficacy rating determined with fungicide susceptible populations of pathogen.

³ Efficacy rating for soil applied control of Phytophthora crown rot.

⁴ Generic products may not be all listed and "etc." indicates that other products may be available that have the same active ingredient.

⁵ More than 4 applications cause severe stunting

Table cited from: Fungicides, Bactericides, Biocontrol, and Natural Product for Deciduous Tree Fruit and Nut Citrus, Strawberry, and Vine Crops in California 2022. <http://ipm.ucanr.edu/PDF/PMG/fungicideefficacytiming.pdf>



Trial Design – Set Up

- 'Fronteras' cultivar
- Industry standard beds
 - 64 in. between bed centers
 - 4 lines of plants
 - 16 in. plant spacing
- 20 ft long plots (about 60 plants)
- Replicated 4 times
- 5 spray applications
 - All fruit is removed prior to first application







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Strawberry

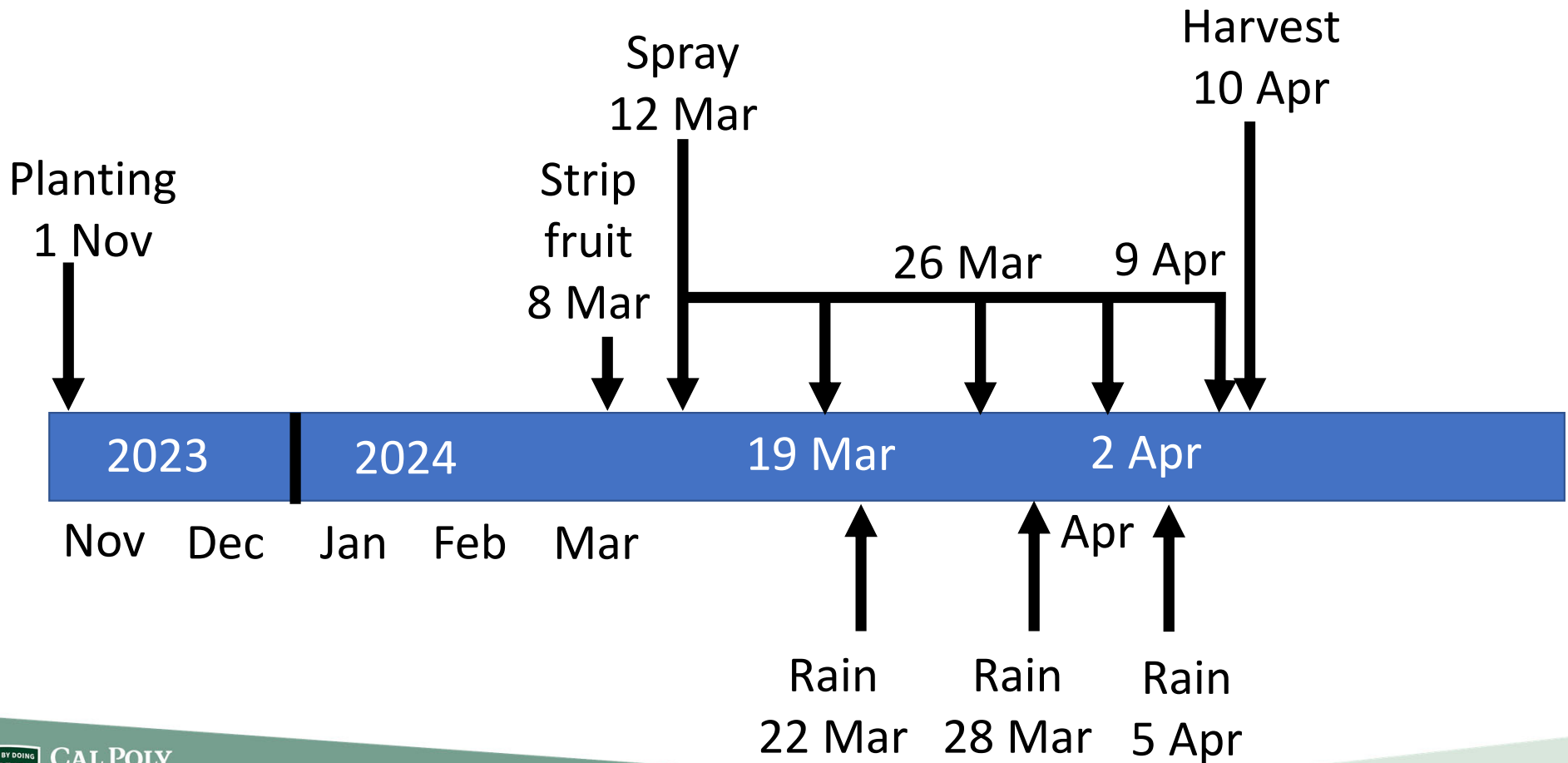


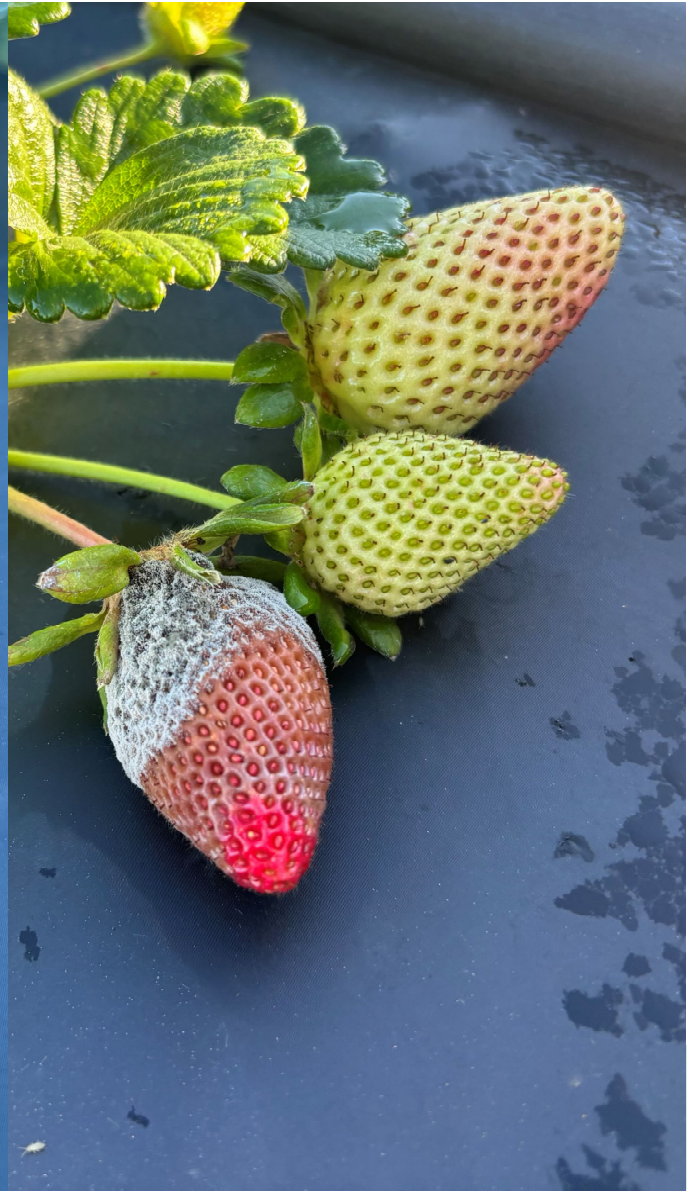




	BRF incidence (%) in non-treated plots	
Year	Spring (Mar-Apr)	Summer (Apr-May)
2015	--	0.38
2016	10.8	--
2017	20.6	7.8
2018	0.0	0.0
2019	10.5	3.3
2020	2.7	1.1
2021	3.4	0.0
2022	2.4 9.1	← one week apart
2023	--	2.4 1.5
2024	38.1	1.3 2.7

Timeline of Events







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Switch rotated with Captan



Non-Treated



0 Days after Harvest (DAH)



Switch rotated with Captan



Non-Treated



6 DAH





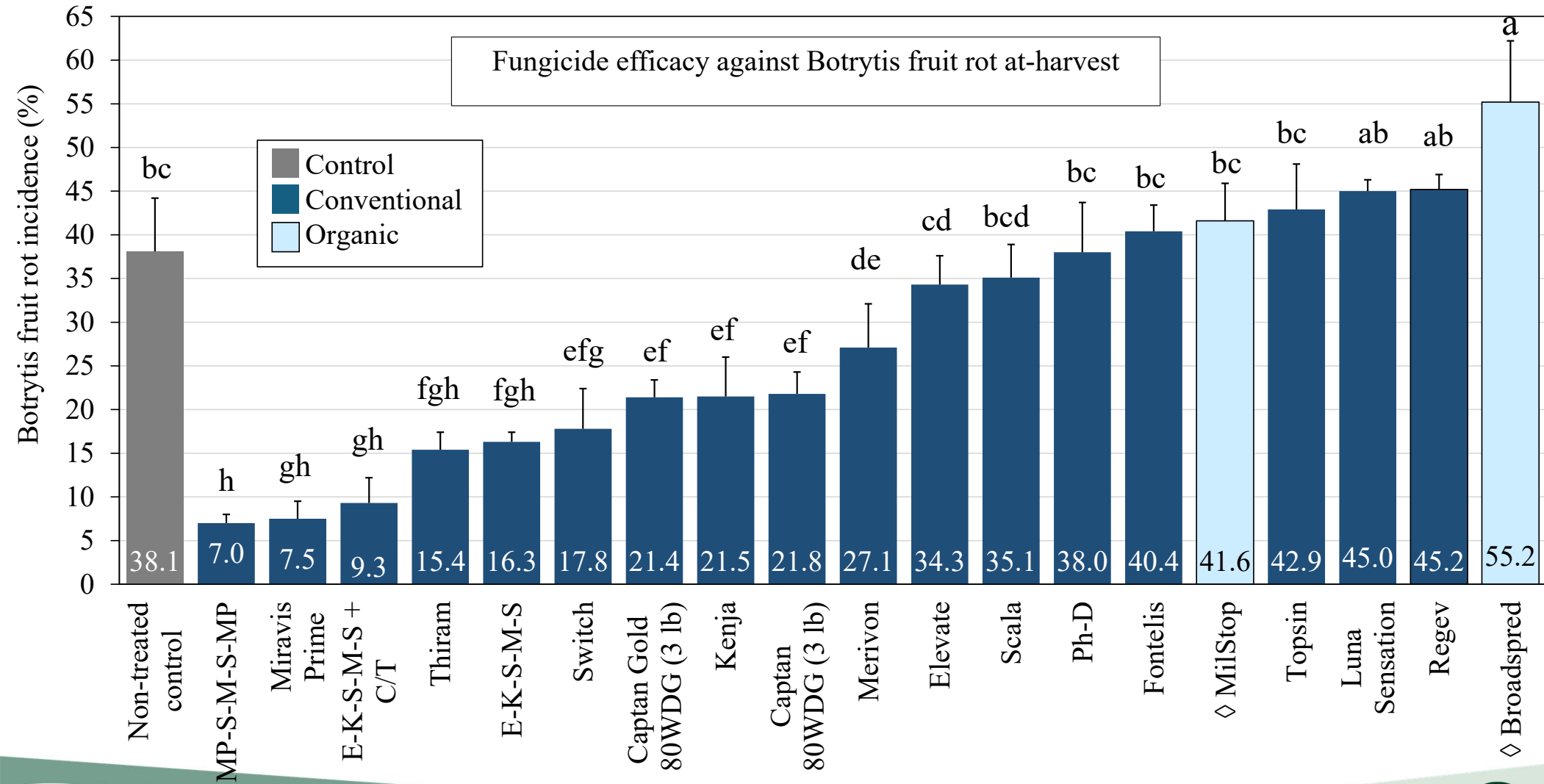
	BRF incidence (%) in non-treated plots	
Year	Spring (Mar-Apr)	Summer (Apr-May)
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2019	10.5	3.3
2020	2.7	1.1
2021	3.4	0.0
2022	2.4 9.1	--
2023	--	2.4 1.5
2024	38.1	1.3 2.7

Treatments

1	Non-treated control
2	Miravis Prime
3	Miravis Prime (MP) – Switch (S) – Merivon (M) – MP – S
4	Merivon
5	Kenja
6	Regev
7	Thiram
8	Captan 80WDG
9	Captan Gold 80WDG
10	Broadspred + MixWell + Acadian
11	Luna Sensation
12	Switch
13	Fontelis
14	Elevate
15	Topsin
16	PhD
17	Scala
18	Elevate (E) – Kenja (K) – Switch (S) – Merivon (M) – S + Captan (C) / Thiram (T)
19	E – K – S – M – S
20	MilStop



Fungicide efficacy against Botrytis fruit rot at-harvest



Scott Cosseboom

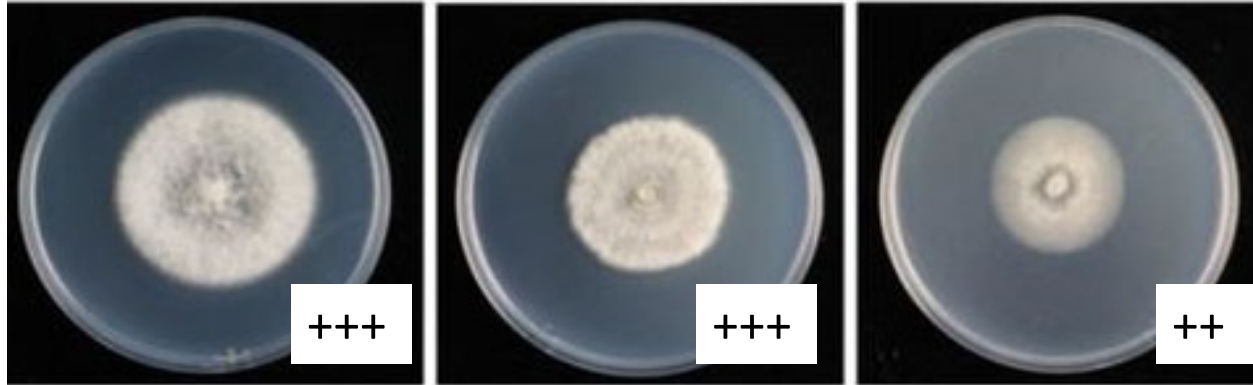


Fungicide Resistance

- 2 years (2023 & 2024)
- Oxnard, Santa Maria, Watsonville-Salinas
- Resistance assay completed by Dr. Mengun Hu's lab at University of Maryland

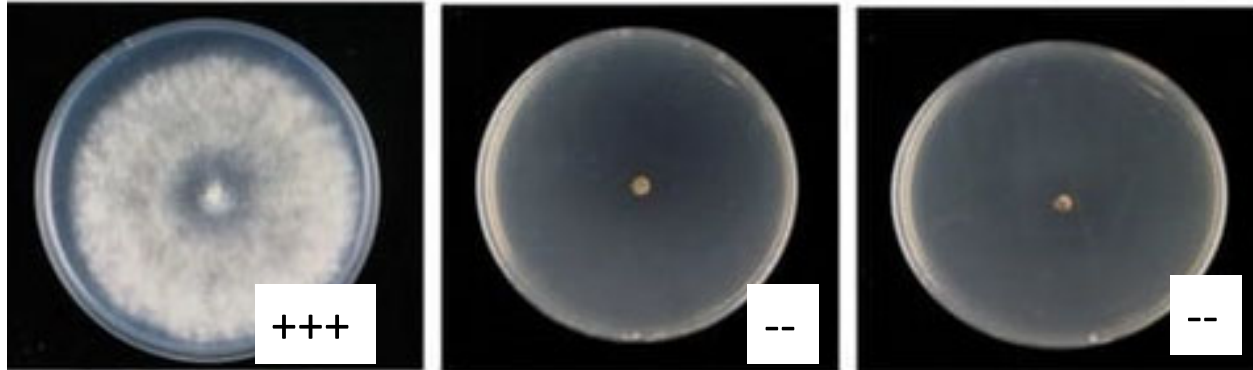


Fungicide B



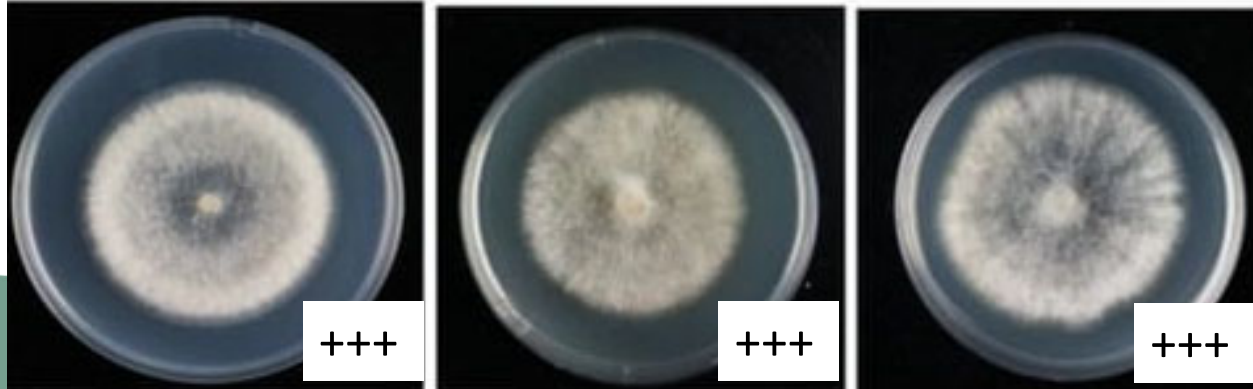
66% resistant

Fungicide A



33% resistant

Control



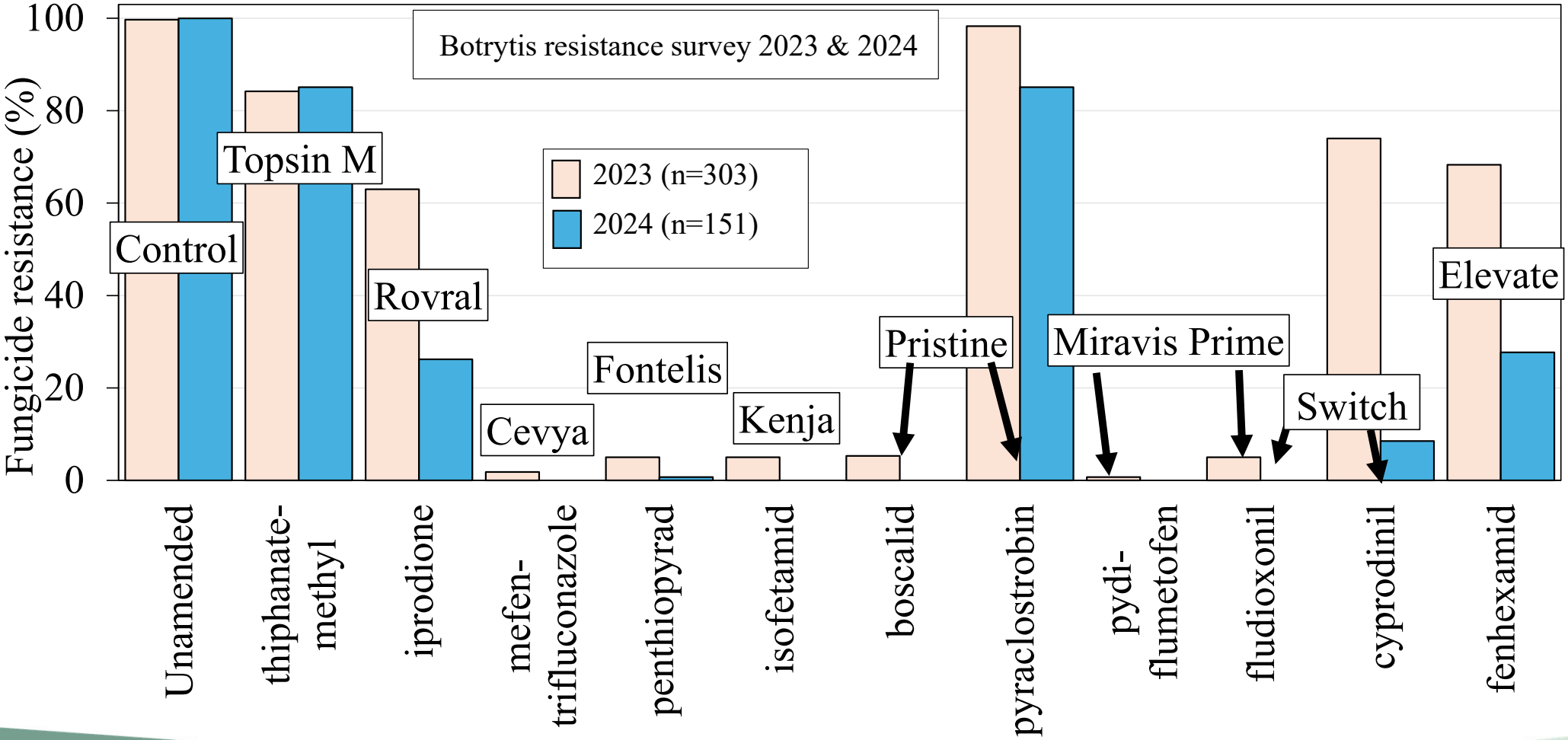
100%



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Botrytis resistance survey 2023 & 2024





Questions?

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