
Final Report: Control of grape powdery mildew with synthetic, biological and organic fungicides: 2019 field trials

Robert Blundell, Ian Dao, Masury Lynch, Samuel Wells and Akif Eskalen
Department of Plant Pathology, University of California, Davis, CA, 95616

University of California Cooperative Extension,
Department of Plant Pathology,
University of California, Davis, August 2019

Published 2019 at: http://plantpathology.ucdavis.edu/Cooperative_Extension/
Copyright © 2019 by the Regents of the University of California, Davis campus. All Rights Reserved.

Report Summary

Powdery mildew is caused by the biotrophic fungus *Erysiphe necator* (1); this polycyclic disease of grape causes losses to crop quality and yield and is considered one of the most economically important disease of grapes worldwide. This report details the findings of our annual powdery mildew fungicide trials on grapevine (*Vitis vinifera*, Cultivar Chardonnay – 11- yrs-old). Along with Muscat blanc, Roussanne and Carignan, Chardonnay is one of the highly susceptible wine varieties (2).

This trial was conducted at Trinchero Family Estates Vineyards, Elk Grove (38.298781, -121.482366) from April to July 2019. Treatments were placed in four adjacent trials in the vineyard in a complete randomized block design. Spraying commenced on April 16th. By early June, mildew was evident on untreated clusters and to a degree on treated clusters. By the time of disease evaluation, disease incidence in some untreated plots reached 100%. Spraying was completed at veraison on July 25th, and treatments were evaluated for disease incidence and severity on July 22nd 2019.

The trials consisted of soft chemistry products and synthetic fungicides. Spray frequencies varied from 7 day to 21-day intervals.

Materials and Methods

A. Experimental design

Experimental design	Complete randomized block design with 5 replicates.
Experimental unit	2 adjacent vines = 1 plot
Plot area	110 ft ² (row spacing = 11 ft, vine spacing = 7 ft)
Area/treatment	550 ft ² (5 reps x 2 vines = 1 treatment) 0.0126 acre/treatment
Volume water/acre	50 gallons (pre-bloom to pea-sized berries) =0.63 gallons/5 reps 100 gallons (late April,) = 1.26 gallons/5 reps, 150 gallons (late May) = 2.52 gallons/5 reps
Application method	Milwaukee 2820 Backpack Sprayer and custom-made experiment sprayer.

B. Experimental treatments

The treatments described in this report were conducted for experimental purposes only and crops treated in a similar manner may not be suitable for commercial or other use.

Trial 1

Trt No.	Flag	Treatment Name	Application rate (100 ga/A)	Interval (days)
1	B	Luna Experience	6 fl oz	14 days
2	P	Lifeguard WG	4.5 oz	14 days
3	Pu	Luna Experience, Lifeguard	6 fl oz alt 4.5 oz	14 days
4	O	Lifeguard WG, Double Nickel	4.5 oz	14 days
5	YS	CX-10252	1% v/v	14 days
6	KS	1) Sulfur 2) Rally + Kinetic 3) Quintec + Kinetic 4) Torino + Kinetic	1) 5 lb 2) 5 oz + 0.125% v/v 3) 6.5 fl oz + 0.125% v/v 4) 3.4 fl oz + 0.125% v/v	14 days
7	BS	1) Sulfur 2) Rally + Kinetic 3) Quintec + Kinetic 4) Luna Experience + Kinetic	1) 5 lb 2) 5 oz + 0.125% v/v 3) 6.5 fl oz + 0.125% v/v 4) 6 fl oz + 0.125% v/v	14 days
8	RS	1) Sulfur 2) Rally + Kinetic 3) Quintec + Kinetic 4) Pristine + Kinetic	1) 5 lb 2) 5 oz + 0.125% v/v 3) 6.5 fl oz + 0.125% v/v 4) 12.55 fl oz + 0.125% v/v	14 days
9	GD	1) Sulfur 2) Rally + Kinetic 3) Quintec + Kinetic 4) Merivon + Kinetic	1) 5 lb 2) 5 oz + 0.125% v/v 3) 6.5 fl oz + 0.125% v/v 4) 4 fl oz + 0.125% v/v	14 days
10	YKD	1) Inspire Super 2) Quintec 3) Miravis Prime	1) 20 oz 2) 4 oz 3) 13.4 oz	14 days
11	BKS	1) Inspire Super 2) Approvia Top 3) Quintec 4) Miravis Prime	1) 20 oz 2) 13.3 oz 3) 4 oz 4) 13.4 oz	14 days
12	PKS	1) Inspire Super 2) Quintec 3) Miravis Prime	1) 20 oz 2) 4 oz 3) 13.4 oz	14 days
13	W	Untreated Control	-	-

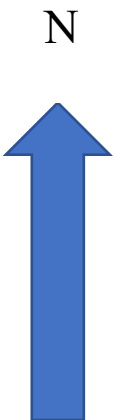
Trial 2

Trt No.	Flag	Treatment Name	Application rate (100 ga/A)	Interval (days)
1	W	Untreated Control	-	-
2	K	JMS Stylet-Oil	1 % v/v	10-14 days
3	Y	Prolivo + Kinetic	4 fl oz + 0.125 % v/v	14 days
4	B	Prolivo + Kinetic	5 fl oz + 0.125 % v/v	14 days
5	YC	NS1	1 L/100 L	10-14 days
6	P	All Phase	4.7 lbs/100 gal	14 days
7	GKD	Circadian Sunrise PM Plus	8.8 lbs/100 gal	14 days
8	Pu	All Phase	1.8 lbs/100 gal	7 days
9	PKC	Circadian Sunrise PM Plus	3.3 lbs/100 gal	7 days
10	YKS	All Phase + Circadian Sunrise PM Plus	1.8 lbs/100 gal + 6.6 lbs	14-21 days
11	BC	86 PM (Organic Oil)	1 gal concentrate/50 gal water	14 days
12	OC	Lalitha21 (Foliar)	6 fl oz	14 days
13	KS	Lalitha21 (Drip)	6 fl oz	14 days
14	OKS	EMP Barrier (Polymer)	1 % v/v	7-10 days
15	BKS	Terramera (Exp A)	1.2 % v/v	10-14 days
16	GKS	Terramera (Exp A) + EMP Barrier (Polymer)	0.6 % v/v + 1 % v/v	10-14 days
17	PKS	Terramera (Exp B)	0.4 % v/v	10-14 days
18	YKD	Terramera (Exp B) + Nu Film P + Microthiol Disperse	0.4 % v/v + 8 fl oz/100 gal + 5 lbs	10-14 days
19	RKD	Terramera (Exp B) + Nu Film P	0.4 % v/v + 8 fl oz	10-14 days
20	RS	Terramera (Exp B) + Nu Film P	0.8 % v/v + 8 fl oz	10-14 days
21	GS	Terramera (Exp A) + Terramera (Exp B) + Nu Film P	0.6 % v/v + .8 % v/v + 8 fl oz	14-21 days
22	BS	HML Silco	540 ml/100 L	10-14 days
23	BD	NS2 (Protector)	1 L/100 L protector	10-14 days
24	GD	HML32	1.25 ml/ 100L	10-14 days
25	P&Pu	GCM	12 fl oz	14 days
26	G	GCM + Syl-Coat	12 fl oz + 4 fl oz	14 days
27	KC	GCM + Quintec	12 fl oz + 4 fl oz	14 days
28	RC	Serifel + Syl-Coat	16 fl oz + 4 fl oz	14 days
29	O&K	OxiDate T&V + Kinetic	1.28 fl oz + 0.125 % v/v	7 days
30	W&P	1) OxiDate T&V + Kinetic, 2) PerCarb + Kinetic 3) OxiDate T&V + JMS Stylet-Oil 4) PerCarb + Kinetic	0.5 fl oz + 0.125 % v/v	7 days
31	KC&Y	OxiDate T&V + PureSpray Green	3 lbs + 0.125 % v/v.	7 days

Trial 3

Trt No.	Flag	Treatment Name	Application rate (100 ga/A)	Interval (days)
1	W	Untreated Control	-	-
2	K	Quintec	4 fl oz	14 days
3	B	Quintec, Flint	4 fl oz alt 2 oz	14 days
4	YS	BAS 750 07F + Syl-Coat	5 oz + 4 fl oz	14 days
5	Y	Pyraziflumid SC + DYNE-AMIC	3.1 fl oz + 0.25% v/v	21 days
6	BS	Gatten + DYNE-AMIC	6.4 fl oz + 0.25% v/v	14 days
7	KS	Luna Experience	6.4 fl oz	14 days
8	RS	Flint Extra, Serenade ASO, Quintec, Flint Extra, Serenade ASO, Flint Extra, Scala	3.5 fl oz, 3 qt, 4 fl oz, 3.5 oz, 3 qt, 3.4 oz, 18 fl oz,	14 days
9	OS	Luna Sensation	5 fl oz	14 days
10	GS	Luna Tranquility	14 fl oz	
11	BKS	Rhyme, Quintec, Rhyme, Pristine, Inspire Super, Luna Experience, Vivando	5 fl oz, 5 fl oz, 5 fl oz, 18.5 oz, 6 oz, 20 fl oz, 6 oz, 8,6 fl oz, 15 fl oz.	6-10 inch green, 14 days for the rest
12	GKS	Rally, Quintec, Mettel, Pristine, VJR84-R002 + NIS, Inspire super, VJR84-R002 + NIS, Luna Experience, Vivando	5 fl oz, 5 fl oz, 4 fl oz, 18.5 oz, 6 fl oz, 20 fl oz, 6 fl oz, 8.6 fl oz, 15 fl oz.	6-10 inch green, 14 days for the rest
13	OKD	Rhyme, Rhyme, Quintec, Pristine, VJR84-R002 + NIS, Luna Experience, VJR84-R002 + NIS, Inspire Super, Vivando	5 fl oz, 5 fl oz, 5 fl oz, 18.5 oz, 5 fl oz + 0.25%v/v, 8.6 fl oz, 5 fl oz + 0.25%v/v, 20 fl oz, 15 fl oz,	6-10 inch green, 14 days for the rest
14	P & Pu	Rally, Quintec, Mettel, Pristine, Inspire Super, Luna Experience, Vivando, Merivon	5 fl oz, 5 fl oz, 4 fl oz, 18.5 oz, 20 fl oz, 8.6 fl oz, 15 fl oz, 4 fl oz.	6-10 inch green, 14 days for the rest
15	RKD	Spray#1: Rhyme + Sonata + Syl-Coat. Spray#2: Prolivo + Sonata + Syl-Coat. Spray#3: Laguna + Sonata + Syl-Coat. Spray#4: Quintec + Sonata + Syl-Coat. Spray#5: Luna Experience + Sonata + Syl-Coat. Spray#6: Torino + Sonata + Syl-Coat. Spray#7: Sonata + Syl-Coat.	5 fl oz + 64 fl oz + 4 fl oz, 5 fl oz + 64 fl oz + 4 fl oz, 5 fl oz + 64 fl oz + 4 fl oz, 5 fl oz + 64 fl oz + 4 fl oz, 6 fl oz + 64 fl oz + 4 fl oz, 3.4 fl oz + 64 fl oz + 4 fl oz, 96 fl oz + 4 fl oz.	Bloom, 14 days for the rest

16	GKD	Spray#1: Rhyme + Sulfur Dry-Flowable +Syl-Tac. Spray#2: Prolivo + Sulfur Dry-Flowable + Syl-Tac. Spray#3: Laguna + Sulfur Dry-Flowable + Syl-Tac. Spray#4: Quintec + Sulfur Dry-Flowable + Syl-Tac. Spray#5: Luna Experience + Sulfur Dry-Flowable + Syl-Tac. Spray#6: Torino + Sulfur Dry-Flowable + Syl-Tac. Spray#7: Sonata+ Syl-Tac.	5 fl oz + 5 lbs + 12.8 fl oz, 5 fl oz + 5 lbs+ 12.8 fl oz, 5 fl oz + 5 lbs + 12.8 fl oz, 5 fl oz + 5 lbs + 12.8 fl oz, 6 fl oz + 5 lbs + 12.8 fl oz, 3.4 fl oz + 5 lbs + 12.8 fl oz, 96 fl oz + 12.8 fl oz.	Bloom, 14 days for the rest
17	BC	Spray#1: Sonata + Sulfur Dry-Flowable + Syl-Coat. Spray#2: Sonata + Sulfur Dry-Flowable + Syl-Coat. Spray#3: Sonata + Sulfur Dry-Flowable + Syl-Coat. Spray#4 Sonata + PureSpray GreenI + Syl-Coat. Spray#5 Sonata + PureSpray Green + Syl-Coat. Spray#6 Sonata + PureSpray Green + Syl-Coat.	96 fl oz + 5lbs + 4 fl oz, 96 fl oz + 5lbs + 4 fl oz, 96 fl oz + 5lbs + 4 fl oz, 96 fl oz + 1 Gal + 4 fl oz, 96 fl oz + 1 Gal + 4 fl oz, 96 fl oz + 1 Gal + 4 fl oz.	Bloom, 14 days for the rest
18	KC	Spray#1: Sonata + WE1819-1 + Sulfur Dry-Flowable + Syl-Coat. Spray#2: Sonata + WE1819-1 + Sulfur Dry-Flowable + Syl-Coat. Spray#3: Sonata + WE1819-1 + Sulfur Dry-Flowable + Syl-Coat. Spray#4 Sonata + WE1819-1 + PureSpray Green + Syl-Coat. Spray#5 Sonata + WE1819-1 + PureSpray Green + Syl-Coat. Spray#6 Sonata + WE1819-1 + PureSpray Green + Syl-Coat.	96 fl oz + 0.23 lbs + 5lbs + 4 fl oz, 96 fl oz + 0.23 lbs + 5lbs + 4 fl oz, 96 fl oz + 0.23 lbs + 5lbs + 4 fl oz, 96 fl oz + 0.23 lbs + 1 Gal + 4 fl oz, 96 fl oz + 0.23 lbs + 1 Gal + 4 fl oz, 96 fl oz + 0.23 lbs + 1 Gal + 4 fl oz	Bloom, 14 days for the rest
19	YC	Merivon, Sulfur/oil, Sulfur/oil, Merivon, Vivando + Serifel + DYNE-AMIC, Pristine + DYNE-AMIC, BAS 750 07 F + DYNE-AMIC	5.5 fl oz, Sulfur oil, Sulfur oil 5.5 fl oz, 15 fl oz + 4 fl oz + 0.125% v/v, 23 oz/A + 0.125% v/v, 5 fl oz + 0.125 %v/v	14 days
20	B &G	Mastercop, Luna Experience, Incognito 85 WDG	3pt, 6 fl oz, 1.2 lbs	
21	P	OxiDate T&V + Luna Experience	0.5 fl oz/A + 6 fl oz	14 days
22	OKS	1)OxiDate T&V + Luna Experience 2)PerCarb + Kinetic 3)OxiDate T&V + Luna Experience	0.5 fl oz/A + 6 fl oz	7 days



Hard Chem

10	GKD	RS	B	BKS	GKS	Y	W	BS	OKD	YC	K	BC	RKD	GKS	X	GKD	Y	BC	RS	OS	BKS	OKD	YS	YC	KS	KC	K	GS	BS	W	B	P&Pu	X	P	P	OKS	OKS
9	P&Pu	OS	YS	RKD	KC	GS	KS	Y	B	KC	OS	W	OKD	P&Pu	RS	BC	YS	BS	KS	K	BKS	GKD	GS	GKS	YC	RKD	OKD	YS	Y	YC	B	BC	X	P	OKS	OKS	X
8	B	GKS	P&Pu	KC	GKD	OKD	GS	RKD	OS	BC	RS	YS	BKS	K	BS	YC	KS	W	Y	K	RKD	BKS	OS	KC	KS	GKS	RS	W	P&Pu	GKD	BS	GS	X	P	P	OKS	X

Soft Chem

7	YKD	G	GD	O	GKD	P	G	B	YD	BKS	YKS	GS	W	P&Pu	OC	BD	BC	YC	RKD	Y	KC	OKS	BS	PKC	RC	KS	K	Pu	RS	OKD	B&G	GKS	X				
6	X	RC	B	PKS	BS	OKS	O	B&G	YKS	YC	RS	BD	K	GS	P	BC	BKS	KC	PKC	RKD	P&Pu	YD	Pu	W	KS	GKS	OC	G	GKD	GD	Y	OKD	YKD	O&K	KC&Y	O&K	
5	X	BKS	RC	P	OC	YKS	GKS	OKD	PKC	YKD	GD	W	YC	KC	BD	KS	PKS	RKD	PKS	Y	Pu	B&G	GKD	K	OKS	YD	P&Pu	RS	B	GS	BS	BC	O	KC&Y	KC&Y	W&P	O&K
4	X	BS	YKS	K	O	GKD	GD	BKS	GKS	BD	RKD	YC	W	KC	B	PKC	RS	KS	YD	Pu	G	Y	OC	YKD	OKD	OKS	BC	P	GS	G	P&Pu	B&G	RC	W&P	W&P	O&K	
3	O	OC	RKD	BKS	KS	GKD	K	OKD	BS	YKD	OKS	BC	YD	PKS	RC	GD	RS	P&Pu	B	BD	Pu	PKC	W	Y	YKS	KC	P	GS	GKS	YC	B&G	PKS	X	O&K	KC&Y	W&P	

Ceris & Corteva & Syngenta

2	Pu	GD	B	O	RS	BS	W	KS	YS	Pu	P	GD	RS	BS	O	W	B	YS	P	GD	KS	Pu	Pu	GD	O	BS	B	YS	P	W	KS	RS	X	X	KC&Y	O&K	W&P
1	P	O	RS	BS	KS	B	W	Pu	KS	BS	P	GD	RS	W	O	YS	B	YKD	BKS	PKS	PKS	YKD	BKS	YKD	PKS	BKS	BKS	YKD	PKS	PKS	BKS	YKD					

Symbol	Meaning
X	no flag
W	white
Pu	purple
R	red
O	orange
B	blue
Y	yellow
P	pink
K	black
G	green
C	checker
S	stripe
D	dot

C. Maps

Trial 2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
4	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
5	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
6	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
7	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
8	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
9	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
10	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
11	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
12	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
13	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
14	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
15	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
16	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
17	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63																																					

E. Vine Management

During the application period, vines were irrigated by drip irrigation. Sucker shoot removal and leafing were done during the duration of trial.

F. Data Collection and Statistics

Daily temperature and precipitation events were obtained from Trinchero Family Estates, Elk Grove.

Ten precipitation events were recorded between the dates of trial (Figure 1) and daily temperature during the trial period is recorded in figure 1. Powdery mildew incidence and severity were assessed in each treatment by evaluating fifteen random clusters. Incidence was defined as the proportion of clusters in a plot having some living powdery mildew. Severity was determined by estimating the percentage of area of a cluster that was infected; the severity value of all clusters was then averaged to give a plot-wide estimate of disease severity. Mean incidence and severity values for each treatment were computed. Trial models were analyzed using the ANOVA Tests for data. Means comparisons were made using Fisher's LSD or Tukey's Kramer with $\alpha=0.05$.

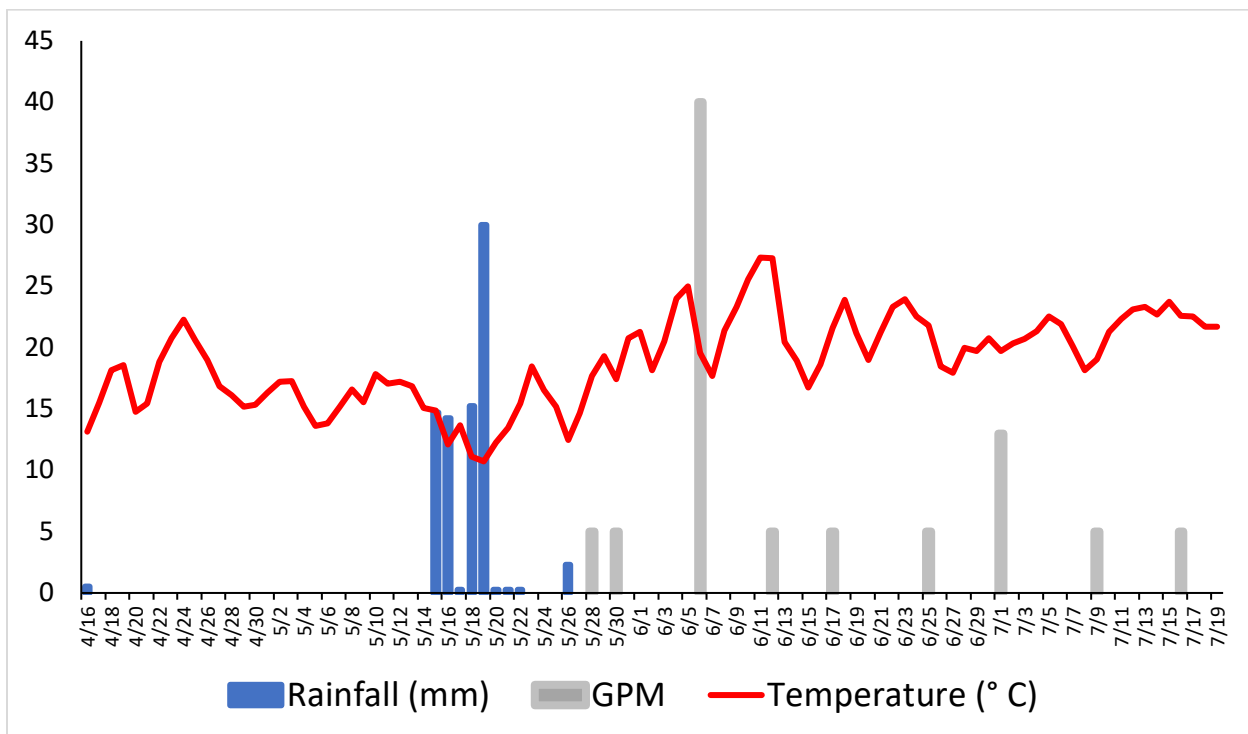


Figure 1. Average daily precipitation (mm), average daily temperature (°C) from April 16th 2019 to July 23rd 2019 recorded at Trinchero Family Estates, Elk Grove and Grape Powdery Mildew (GPM) spore count recorded from April 16th 2019 to July 23rd 2019 recorded at Trinchero Family Estates, Elk Grove.

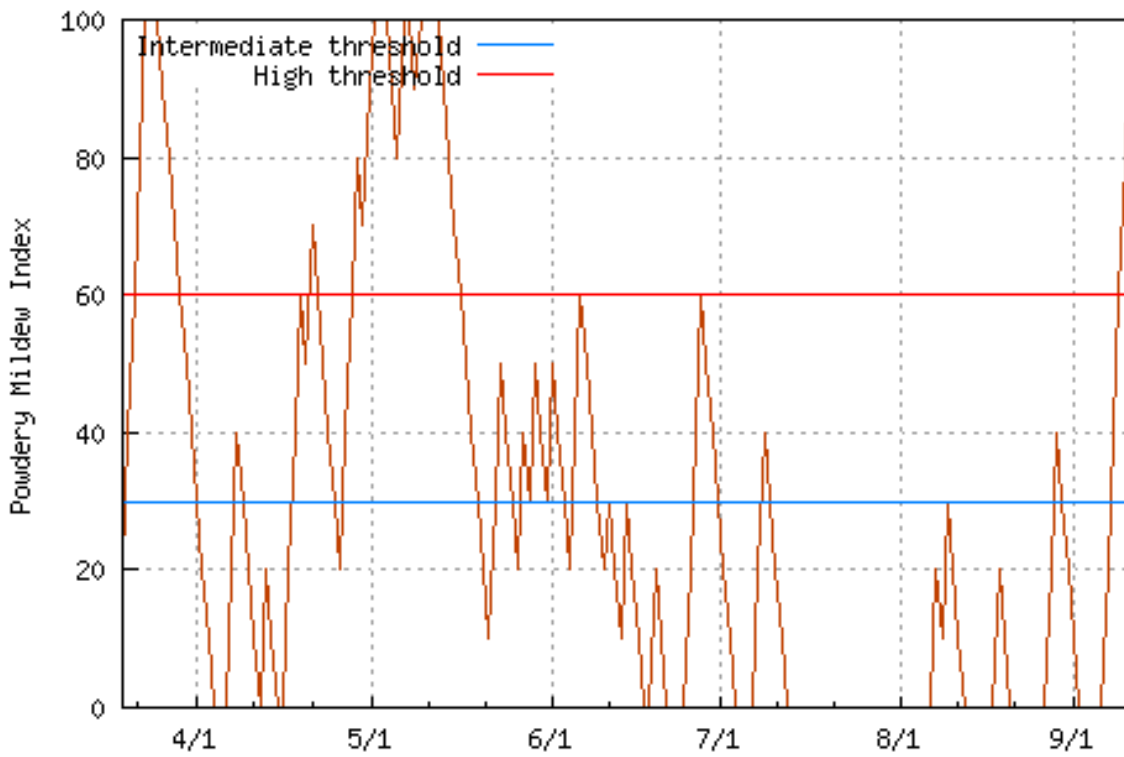


Figure 2. Thomas-Gubler Risk Index data from Apr 1st to Sept 1st. The Red line data points indicate risk index > 60 , between blue and red data points indicate risk index data between 30 and 60 and blue data points are values below 30.

Results

Table 1. Disease incidence and severity in trial 1. Product names are followed by rate (per acre) and the frequency of application. Treatment means followed by the same letter are not significantly different according to Fisher's LSD at $\alpha=0.05$; alt = alternated with; fb = followed by.

Treatment	Flag	Mean Severity (%)	Mean Incidence (%)		
Sulfur, 5 lb fb Rally, 5 oz + Kinetic, 0.125% v/v fb Quintec, 6.5 fl oz + Kinetic, 0.125% v/v fb Luna Experience, 6 fl oz + Kinetic, 0.125% v/v, 14d	BS	4.5	C	62.7	A
Sulfur, 5 lb fb Rally, 5 oz + Kinetic, 0.125% v/v fb Quintec, 6.5 fl oz + Kinetic, 0.125% v/v fb Torino, 3.4 fl oz + Kinetic, 0/125 % v/v, 14 d	KS	5.8	C	60.0	A
Sulfur, 5 lb fb Rally, 5 oz + Kinetic, 0.125% v/v fb Quintec, 6.5 fl oz + Kinetic, 0.125% v/v fb Merivon, 4 oz + Kinetic, 0.125% v/v, 14d	GD	6.5	C	72.0	A
Inspire Super, 20 fl oz fb Quintec, 4 fl oz fb Miravis Prime, 13.4 fl oz, 14d	YKD	6.7	C	76.0	A
Inspire Super, 20 fl oz fb Quintec, 4 fl oz fb Miravis Prime, 13.4 fl oz	PKS	6.9	C	77.3	A
Inspire Super, 20 fl oz fb Approvia Top, 14 fl oz fb Quintec, 4 fl oz fb Miravis Prime, 13.4 fl oz, 14d	BKS	7.1	C	72.0	A
Luna Experience, 6 fl oz, Lifegard, 4.5 oz, 14d	Pu	8.2	C	61.0	A
Luna Experience, 6 fl oz, 14d	B	8.9	C	86.7	A
CX-10252, 1% v/v, 14d	YS	9.5	BC	80.0	A
Sulfur, 5 lb fb Rally, 5 oz + Kinetic, 0.125% v/v fb Quintec, 6.5 fl oz + Kinetic, 0.125% v/v fb Pristine, 12.5 oz + Kinetic, 0.125% v/v, 14d	RS	9.9	BC	88.0	A
Lifegard WG, 4.5 oz, Double Nickel, 1 qt, 14d	O	19.0	ABC	92.0	A
Lifegard WG, 4.5 oz, 14d	P	24.8	AB	85.3	A
Untreated Control	W	31.7	A	78.7	A

Table 2. Disease incidence and severity in trial 2. Product names are followed by rate (per acre) and the frequency of application. Treatment means followed by the same letter are not significantly different according to Fisher's LSD at $\alpha=0.05$; alt = alternated with; fb = followed by.

Treatment	Flag	Mean Severity (%)	Mean Incidence (%)	
OxiDate T & V, 0.5 fl oz + Kinetic, 0.125% v/v fb PerCarb, 3 lbs + Kinetic, 0.125% v/v fb OxiDate T & V, 1.28 fl oz + JMS Stylet-Oil, 1.0%v/v fb PerCarb, 3 lbs + Kinetic, 0.125% v/v, 7d	W&P	3.4	H	52.0 HI
Prolivo, 5 fl oz + Kinetic, 0.125% v/v, 14d	B	3.9	H	52.0 HI
OxiDate T & V, 1.28 fl oz + PureSpray Green, 1 gal, 7d	KC&Y	4.9	GH	68.0 EFGH
Prolivo, 4 fl oz + Kinetic, 0.125% v/v, 14d	Y	5.1	GH	66.7 FGH
JMS Stylet-Oil, 1% (v/v), 10-14d	K	5.6	GH	42.7 I
OxiDate T & V, 1.28 fl oz + Kinetic, 0.125% v/v, 7d	O&K	5.9	GH	66.7 FGH
86 PM (Organic Oil), 1 gal, 14d	BC	7.5	GH	61.3 GHI
GCM, 12 fl oz + Quintec, 4 fl oz, 14d	KC	8.3	FGH	85.3 ABCDEF
Terramera (Exp B), 0.4% v/v + Nu Film P, 8 fl oz, 10-14d	RKD	8.6	EFGH	61.3 GHI
All Phase, 1.8 lbs, 7d	Pu	10.0	EFGH	80.0 ABCDEFG
GCM, 12 fl oz + Syl-Coat, 4 fl oz, 14d	G	11.7	DEFGH	77.3 BCDEFG
Terramera (Exp B), 0.8% v/v + Nu Film P, 8 fl oz, 10-14d	RS	13.1	DEFGH	73.3 DEFGH
Lalitha21 (Foliar), 6 fl oz, 14d	OC	14.6	CDEFGH	89.3 ABCDE
Terramera (Exp A), 1.2% v/v, 10-14d	BKS	14.6	CDEFGH	78.7 ABCDEFG
Lalitha22 (Drip), 6 fl oz, 14d	KS	15.0	CDEFGH	84.0 ABCDEF
Terramera (Exp B), 0.4 % v/v, 10-14d	PKS	16.1	CDEFGH	89.3 ABCDE
GCM, 12 fl oz, 14d	P&Pu	17.8	BCDEFGH	82.7 ABCDEFG
Circadian Sunrise PM Plus, 3.3 lbs, 7d	PKC	18.0	BCDEFGH	97.3 ABC
Terramera (Exp A), 0.6 % v/v + Terramera (Exp B), 0.4% v/v + Nu Film P, 8 fl oz, 21d	GS	20.9	BCDEFGH	76.0 CDEFG
EMP Barrier (Polymer), 1% (v/v), 7-10d	OKS	21.3	BCDEFGH	90.7 ABCD
NS1, 1L, 10-14d	YC	22.3	BCDEFGH	92.0 ABCD
Terramera (Exp A), 0.6 % v/v + EMP Barrier (Polymer), 1% v/v, 10-14d	GKS	22.3	BCDEFGH	73.3 DEFGH
HML Silco, 540ml, 10-14d	BS	24.1	BCDEFG	76.0 CDEFG
HML32, 1.25L, 10-14d	GD	27.2	BCDEF	98.7 AB
Terramera (Exp B), 0.4% v/v + Nu Film P, 8 fl oz + Microthiol Disperse 5 lb, 10-14d	YKD	27.7	BCDE	77.3 BCDEFG
NS2 (Protector), 1L, 10-14d	BD	30.5	BCD	92.0 ABCD
Circadian Sunrise PM Plus, 8.8. lbs, 14d	GKD	32.7	BC	89.3 ABCDE
All Phase, 4.7 lbs, 14d	P	33.3	ABC	97.3 ABC
All Phase, 1.8lb + Circadian Sunrise PM Plus, 6.6 lbs, 14-21d	YKS	33.7	ABC	94.7 ABCD
Serifel, 16 fl oz + Syl-Coat, 4 fl oz, 14d	RC	37.0	AB	98.7 AB
Untreated Control	W	52.5	A	100.0 A

Table 3. Disease incidence and severity in trial 3. Product names are followed by rate (per acre) and the frequency of application. Treatment means followed by the same letter are not significantly different according to Tukeys Kramer at $\alpha=0.05$; alt = alternated with; fb = followed by.

Treatment	Flag	Mean Severity (%)		Mean Incidence (%)	
Rhyme, 5 fl oz + Sonata, 64 fl oz + Syl-Coat, 4 fl oz fb Prolivo, 5 fl oz + Sonata, 64 fl oz + Syl-Coat 4 fl oz fb, Laguna, 5 fl oz + Sonata, 64 fl oz + Syl-Coat, 4 fl oz fb Luna Experience, 8.6 fl oz + Sonata, 64 fl oz + Syl-Coat, 4 fl oz fb, Torino, 3.4 fl oz + Sonata, 64 fl oz + Syl-Coat, 4 fl oz fb, Sonata, 64 fl oz + Syl-Coat, 4 fl oz, 14 d	RKD	3.4	B	50.7	AB
Pyraziflumid SC, 3.1 fl oz + DYNE-AMIC, 0.25% v/v, 21 d	Y	3.5	B	42.6	AB
OxiDate, 1.28 fl oz + Luna Experience, 6.4 fl oz fb PerCarb, 3lbs + Kinetic, 0.125 % v/v fb Oxidate, 1.28 fl oz + Luna Experience, 6.4 fl oz, 7 d	OKS	3.5	B	42.7	AB
Gatten, 6.4 fl oz + DYNE-AMIC, 0.25% v/v, 14 d	BS	3.6	B	49.3	AB
Rhyme, 5 fl oz fb Rhyme, 5 fl oz fb, Quintec, 5 fl oz fb Pristine, 18.5 oz fb VJR84-R002, 5 fl oz + NIS 0.25% v/v, 0.25% v/v fb Luna Experience, 8.6 fl oz fb VJR84-R002, 5 fl oz + NIS 0.25% V/V fb, Inspire Super, 20 fl oz fb, Vivando, 15 fl oz, 14 d	OKD	3.7	B	48.0	AB
Luna Experience, 6.4 fl oz, 14 d	KS	3.9	B	52.0	AB
Luna Tranquility, 14 fl oz, 14 d	GS	4.4	B	58.7	AB
Rhyme, 5 fl oz + Sulfur Dry-Flowable, 5 lbs +Syl-Tac, 12.8 fl oz fb, Prolivo, 5 fl oz + Sulfur Dry-Flowable, 5 lbs + Syl-Tac, 12.8 fl oz fb Laguna, 5 fl oz + Sulfur Dry-Flowable, 5 lbs + Syl-Tac, 12.8 fl oz fb Quintec 2.08 F, 5 fl oz + Sulfur Dry-Flowable, 5 lbs + Syl-Tac, 12.8 fl oz fb Luna Experience, 6 fl oz + Sulfur Dry-Flowable, 5 lbs + Syl-Tac, 12.8 fl oz fb Torino, 3.4 fl oz + Sulfur Dry-Flowable, 5 lbs + Syl-Tac, 12.8 fl oz fb Sonata, 96 fl oz + Syl-Tac, 12.8 fl oz, 14 d	GKD	4.7	B	56.0	AB
BAS 750 07F, 5 oz + Syl-Coat, 4 fl oz, 14 d	YS	5.3	B	50.7	AB
Merivon 5.5 fl oz fb Sulfur/oil fb Sulfur/oil fb Merivon, 5.5 fl oz fb Vivando, 15 fl oz + Serfiel, 4 fl oz + DYNE-AMIC, 0.125% v/v fb, Pristine, 23 oz + DYNE-AMIC, 0.125% v/v fb	YC	6.0	B	68.0	AB
BAS 750 07F, 5 fl oz + DYNE-AMIC, 0.125% v/v, 14 d			B		
Mastercop, 3 pt + Luna Experience, 6 fl oz + Incognito 85 WDG, 1.2 lbs + Mastercop, 3 pt + Luna Experience, 6 fl oz + Incognito, 1.2 lbs, 14d	B&G	6.5	B	66.7	AB
Luna Sensation, 5 fl oz, 14 d	OS	7.0	B	56.0	AB
Rhyme, 5 fl oz fb Quintec, 5 fl oz fb Rhyme, 5 fl oz fb Pristine, 18.5 oz fb R84-R002, 6 oz + NIS 0.25% v/v fb Inspire Super, 20 fl oz fb R84-R002, 6 oz + NIS 0.25% v/v fb Luna Experience, 8.6 fl oz fb Vivando, 15 fl oz, 14 d	BKS	8.7	B	64.0	AB
Rally, 5 fl oz fb Quintec, 5 fl oz fb, Mettel, 4 fl oz fb Pristine, 18.5 oz fb Inspire Super, 20 fl oz fb Luna Experience, 8.6 fl oz fb Vivando, 15 fl oz fb Merivon, 4 fl oz, 14 d	P&Pu	9.1	B	77.3	AB
Sonata, 96 fl oz + Sulfur Dry-Flowable, 5lbs + Syl-Coat, 4 fl oz fb Sonata, 96 fl oz + Sulfur Dry-Flowable, 5lbs + Syl-Coat, 4 fl oz fb, Sonata, 96 fl oz + Sulfur Dry-Flowable, 5lbs + Syl-Coat, 4 fl oz, fb Sonata, 96 fl oz + Purespray oil, 5lbs + Syl-Coat, 4 fl oz fb Sonata, 96 fl oz + Purespray oil, 5lbs + SylCoat, 4 fl oz fb Sonata, 96 fl oz + Purespray oil, 5lbs + Syl-Coat, 4 fl oz fb, 14 d	BC	10.5	B	61.3	AB
Sonata, 96 fl oz + WE1819-1, 0.23 lbs+ Sulfur Dry-Flowable, 5 lbs + Syl-Coat, 4 fl oz fb Sonata, 96 fl oz + WE1819-1, 0.23 lbs+ Sulfur Dry-Flowable, 5 lbs + Syl-Coat, 4 fl oz fb Sonata, 96 fl oz + WE1819-1, 0.23 lbs+ Sulfur Dry-Flowable, 14 d	KC	11.1	B	68.0	AB
Rally, 5 fl oz fb Quintec, 5 fl oz fb Mettel, 4 fl oz fb Pristine, 18.5 oz fb VJR84-R002, 6 fl oz + NIS 0.25% V/V fb Inspire Super, 20 fl oz fb VJR84-R002, 6 fl oz + NIS 0.25% V/V fb Luna Experience, 8.6 fl oz fb Vivando, 15 fl oz, 14 d	GKS	12.1	B	64.0	AB
Quintec, 4 fl oz, 14 d	K	14.0	B	73.3	AB
Flint Extra, 3.5 oz fb, Serenade ASO 3 qt fb, Quintec 4 fl oz fb, Flint Extra, 3.4 oz fb, Serenade ASO, 3 qt fb Flint extra, 3.4 oz fb Scala, 18 fl oz, 14 d	RS	20.5	B	65.3	AB
Quintec, 4 fl oz alt Flint, 2 oz, 14 d	B	27.8	AB	73.3	AB
OxiDate T&V, (0.39% v/v); 0.5 fl oz + Luna Experience, 6.4 fl oz, 14 d	P	32.6	AB	60.0	AB
Untreated Control	W	61.2	A	97.3	A



Fig 3. Powdery Mildew infested berries from Untreated Control (A). Berries treated with Luna Experience (B). White labelled vine represents Untreated Control, blue labelled vine represents Luna Experience treatment (C).

Acknowledgements

Thanks to the various industry donors for providing testing materials. Thanks to Trinchero Family Estates for providing vines for the trials.

Appendix

Product	Active Ingredient(s)	Manufacturer or distributor	Chemical class (after Adaskaveg et al. 2008)
All Phase	Potassium sorbate (19%), Sodium lauryl Sulfate (2%)	Circadian Crop Sciences	N/A
Aprovia TOP	Difenoconazole (10.95%), Benzovindiflupyr (7.30%)	Syngenta	SDHI (7)
BAS 750 07F	Proprietary	N/A	Proprietary
Circadian Sunrise PM Plus	Corn Oil (8%), Sodium Lauryl Sulfate (2%)	Circadian Crop Sciences	N/A
CX-10252	Bacillus mycoides	Certis	N/A
DYNE-AMIC	Methyl esters of C16-C18 fatty acids, Alkylphenol ethoxylate, Polyalkyleneoxide modified polydimethylsiloxane	BASF	N/A
EMP Barrier (Polymer)	Co-polymer emulsion	Gemm Ag Solutions	AP (9)
Flint 50 WDG	Trifloxystrobin (50%)	Bayer CropScience	Qol (11)
Gatten	Flutianil	Nichino America	U13
GCM	Bacillus velezensis	N/A	N/A
HML Silco	Potassium silicate	Henry Manufacturing	N/A
HML32	Potassium Bicarbonate (26.4%)	Henry Manufacturing	N/A
Incognito	Thiophanate methyl (85%)	ADAMA essentials	N/A
Inspire Super	Difenoconazole (8.4%), Cuprodimil (24.1%)	Syngenta Crop Protection Inc.	DMI (3)/anilinopyrimidine (9)
JMS Stylet-Oil	Paraffinic oil (97.1%)	JMS Flower Farms Inc.	Oil
Kinetic (Adjuvant)	Proprietary blend of polyalkyleneoxide modified polymethylsiloxane and nonionic surfactant (99.00%)	Helena Chemical Co.	Adjuvant
Laguna	Difenoconazole (23.2%)	Wilbur-Ellis	DMI-triazole (3)
Lalitha22 (Drip)	Azospirillum brasilense, Bacillus subtilis, Pseudomonas fluorescens, Trichoderma harzianum, Trichoderma virens, Trichoderma viride	Acela Biotech	N/A
Lalitha21 (Foliar)	Azospirillum brasilense, Bacillus subtilis, Pseudomonas fluorescens, Trichoderma harzianum, Trichoderma virens, Trichoderma viride	Acela Biotech	N/A
Lifegard WG	Bacillus mycoides (40%)	CERTIS	Biological
Luna Experience	Fluopyram (17.54%), Tebuconazole (17.54%)	Bayer CropScience	SDHI (7)/DMI-triazole (3)
Luna Tranquility	Pyrimethanil (32.61%), Fluopyram (10.87%)	Bayer CropScience	SDHI (7)/API (9)
Mastercop	Copper Sulfate Pentahydrate (21.46%)	ADAMA	Inorganic (M01)
Merivon	Pyraclostrobin (21.26%)/Fluxapyroxad (21.26%)	BASF	SDHI (7)/Qol (11)
Mettel	Tetraconazole (11.6%)	ISAGRO USA	N/A
Microthiol Dispers	Silfur (80%)	UPL NA INC	M2
Miravis Prime	Fludioxonil (21.4%), Pydiflumetofen	Syngenta	SDHI (7)
NIS (+Prolivo)	Pyriofenone (27.3%)	Summit Agro USA	Aooessoria formation inhibitor
NS1	Potassium soap	Henry Manufacturing	N/A
NS2 (Protector)	Pure base soap	Henry Manufacturing	N/A
Nu Film P	Pinene Polymers, petrolatum, alkyl amine ethoxylate	Miller	N/A
Oxidate T & V	Hydrogen Peroxide (27%), Peroxyacetic acid (5%)	Biosafe systems	N/A
PerCarb	Sodium Carbonate Peroxyhydrate (85%)	Biosafe Systems	N/A
Pristine	Pyraclostrobin (12.8%), boscalid (25.2%)	BASF	SDHI (7)/Qol (11)
Pristine 38 WG	Pyraclostrobin (12.8%), boscalid (25.2%)	BASF	SDHI (7)/Qol (11)
Prolivo 3005C	Pyriofenone	Summit Agro USA	benzophenone (U8)
PureSpray Green	Mineral oil (98%)	Petro-Canada	Oil
Pyraziflumid SC	N/A	Nichino America	SDHI
Quintec	Quinoxifen (22.6%)	DOW AgroSciences LLP	Quinoline (13)
Rally	Myclobutanil (40%)	DOW AgroSciences LLC	DMI-triazole (3)
Rhyme	Flutiafol (22.7%)	Chemnova Inc.	DMI-triazole (3)
Seranade	Bacillus subtilis QST 713 (26%)	Bayer CropScience	Biological
Serifel	Bacillus amyloliquefaciens MBI 600 (11%)	Bayer CropScience	Biological
Sonata	Bacillus pumilus QST 2808 (1.38%)	Bayer CropScience	Biological
Sulfur Dry-Flowable	Sulfur (80%)	Wilbur-Ellis	Inorganic (M2)
Switch	Cyprodinil (37.5%), Fludioxonil (25%)	Syngenta Crop Protection	anilinopyrimidine (9)/phenylpyrrol (12)
Syl-Coat	Polyether-polymethylsiloxanecopolymer and Polyether (100%)	Wilbur-Ellis	Adjuvant
Syl-Tac	Ethylated Seed Oil	Wilbur-Ellis	Adjuvant
Terramera (Exp A)	Cold Pressed Neem Oil (70%)	Terramera Inc	N/A
Terramera (Exp B)	Cold Pressed Neem Oil (52%) Octanoid acid (25%)	Terramera Inc	N/A
Torino	Cyflufenamid (10%)	Gowan Co.	Phenyl-acetamide (U6)
Vivando	Metrafenone (25.2%)	BASF	benzophenone (U8)
VJR84-R002	N/A	FMC Corporation	N/A
WE1819-1	N/A	Wilbur-Ellis	N/A
86 PM (Organic Oil)	Lemongrass Oil (5.3%), Cinnamon Oil (2.6%), Peppermint Oil (1.3%)	NorCal Nutrients	N/A

Literature Cited

- 1- Wilcox, Wayne Frank, et al. Compendium of Grape Diseases, Disorders, and Pests. Second Edition. APS Press, The American Phytopathological Society, 2015.
- 2- Vasquez, Stephen. "Grape Cultivar Susceptibility to Grapevine Powdery Mildew." UC Cooperative Extnsion.