
Control of grape powdery mildew with synthetic, biological and organic fungicides: 2020 field trials

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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 on 5C – 30- yrs-old). Along with Muscat blanc, Roussanne and Carignan, Chardonnay is one of the highly susceptible wine varieties (2).

This trial was conducted at Trincherro Family Estates Vineyards, Elk Grove (38°19'14.2"N, -121°30'25.7"W) from April to July 2020. Treatments were placed in a complete randomized block design. Spraying commenced on April 15th. Spraying was completed at veraison on July 24th, and treatments were evaluated for disease incidence and severity on August 4th 2020.

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

Table 1. Experimental design

Experimental design	Randomized complete block design with 5 replicates		
Experimental unit	2 adjacent vines = 1 plot		
Row and tree spacing	15 ft (row) and 6 ft (vine)	Plot unit area	90 ft ²
Area/treatment	450 ft ² or 0.01033 acre/treatment (5 replicates = 1 treatment)		
Volume water/Acre	50 gallons (pre-bloom to pea-sized berries) = 1.0352 gal/5 reps 100 gallons (late April,) = 2.0704 gal/5 reps, 150 gallons (late May) = 3.1056 gal/5 reps		
Equipment	Stihl SR 450 Backpack Sprayers		

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.

Treat ement No	Flag	Treatment	Application rate (100 gaper acre)	Frequency
1	W	Untreated Control	None	None
2	K	Luna Experience	8.6 fl oz	
3	KD	Rally	5 oz	14 days
		Quintec	5 fl oz	
		Mettel	4 fl oz	
		Pristine	18.5 fl oz	
		Inspire Super	20 fl oz	
		Luna Experience	8.6 fl oz	
		Vivando	15 fl oz	
		Merivon	4 fl oz	
4	KS	LifeGard WG	4.5 oz	14 days
		Quintec	5 fl oz	
		Mettel	4 fl oz	
		LifeGard WG	4.5 oz	
		Inspire Super	20 fl oz	
		Luna Experience	8.6 fl oz	
		Vivando	15 fl oz	
		Merivon	4 fl oz	
5	KC	Double Nickel LC	1 qt	14 days
		Quintec	5 fl oz	
		Mettel	4 fl oz	
		Double Nickel LC	1 qt	
		Inspire Super	20 fl oz	
		Luna Experience	8.6 fl oz	
		Vivando	15 fl oz	
		Merivon	4 fl oz	
6	O	Skip treatment	None	14 days
		Quintec	5 fl oz	
		Mettel	4 fl oz	
		Skip treatment	None	
		Inspire Super	20 fl oz	
		Luna Experience	8.6 fl oz	
		Vivando	15 fl oz	
		Merivon	4 fl oz	
7	OS + O	Flint Extra + Sylcoat	3.5 fl oz + 4 fl oz	14 days
		Prolivo + Sylcoat	5 fl oz + 4 fl oz	
		Luna Experince + Sylcoat	6.4 fl oz + 4 fl oz	
		Quintec + Sylcoat	4 fl oz + 4 fl oz	
		Torino + Sylcoat	3.4 fl oz + 4 fl oz	
		Luna Tranquility + Sylcoat	14 fl oz + 4 fl oz	
		Vivando + Sylcoat	15.4 fl oz + 4 fl oz	
		Serenade ASO + Sylcoat	4 qts + 4 fl oz	

8	OC + O	Sulfur 1 st app	5 lb	14 days
		Kocide-3000 + NS1	1.5 lb + 1% (v/v)	
		Kocide-3000 + NS2	1.5 lb + 1% (v/v)	
9	OKD	Rango	160 fl oz	7 days
		Rango	160 fl oz	
		Oxidate	128 fl oz	
		Rango	160 fl oz	
		Oxidate	128 fl oz	
		Rango	160 fl oz	
		Oxidate	128 fl oz	
10	OKS	Rango	160 fl oz	14 days
		Rango	160 fl oz	
		Terramera Biological + Nu-film	0.8 % + 16 fl oz	
		Rango	160 fl oz	
		Terramera Biological + Nu-film	0.8 % + 16 fl oz	
		Rango	160 fl oz	
		Terramera Biological + Nu-film	0.8 % + 16 fl oz	
11	ONS	EMP	1 % (v/v)	7 days
12	Y	Gemm Experimental	24 gal	7 days
13	YD	EMP + GemmExperimental	1 % (v/v) + 24 gal	7 days
18	YKC	CLP_UCD + Serenade ASO	5.5 oz + 32 fl oz	14 days
19	YRD	Merivon 5.5 fl oz /	5.5 fl oz	14 days
		Vivando + Serifel + DyneAmic	15 fl oz + 4 oz + 0.125 % (v/v)	
		Pristine 23 oz + DyneAmic	23 oz + 0.125 % (v/v)	
		Cevya + DyneAmic	5 fl oz + 0.125 % (v/v)	
		Vivando + Serifel + DyneAmic	15 fl oz + 4 oz + 0.125 % (v/v)	
		Merivon 5.5 fl oz /	5.5 fl oz	
20	YRS	Cevya + DyneAmic	5 fl oz + 0.125 % (v/v)	14 days
21	R	Sulfur Dry-Flowable (1st and 2nd app)	5 lb	14 days
		Stargus + JMS Stylet Oil	64 fl oz + 1% (v/v)	
22	RD	Sulfur Dry-Flowable (1st and 2nd app)	5 lb	14 days
		Stargus + Inspire Super + JMS Stylet Oil	32 fl oz + 10.5 fl oz + 1% (v/v)	
		Stargus + Luna Experience	32 fl oz + 6 fl oz	
23	RS + R	EXP14	1272.57 gr	14 days
24	RC + R	EXP14	1908.86 gr	14 days
25	RKD	OxiDate 5.0 + Kinetic	0.39 % (v/v) + 0.125% (v/v)	7 days

26	RKS	PureSpray Green	1 gal	7 days
28	G	Oxidate 2.0 + PureSpray Green	1 % (v/v) + 1% (v/v)	7 days
29	GD	Regalia 5%	0.5 gal	7 days
30	GS	Regalia 5% + PureSpray Green	0.5 gal + 1 gal	7 days
31	GKD	Regalia 5%	0.5 gal	7 days
		PureSpray Green	1 gal	
32	GKS	SP2480 + Nu-film	25 fl oz + 16 fl oz	14 days
33	GKC	Rally	5 oz	14 days
		SP2480 + Nu-film	25 fl oz + 16 fl oz	
		Pristine	18.5 fl oz	
		SP2480 + Nu-film	25 fl oz + 16 fl oz	
		Luna Experience	8.6 fl oz	
		SP2480 + Nu-film	25 fl oz + 16 fl oz	
		Vivando	15 fl oz	
34	B	SP2480 + Nu-film	25 fl oz + 16 fl oz	14 days
		Rhyme	5 fl oz	
35	BD	PureSpray green	1 gal	14 days
36	BS	86PM	1 gal	7 days
37	BC	Sulfur Dry-Flowable	5 lb	14 days
38	BKD	Gatten + Dyne-Amic	6.4 fl oz	21 days
39	BKS	Parade + Dyne-Amic	3.1 fl oz	7 days
40	BKC	Circadian Sunrise Hotricultural	2 oz/gal	14 days
41	Pu	Sulfur 1st app	5 lb	14 days
		Kocide-3000 + HML32	1.5 lb + 1.25% (v/v)	
		Rhyme + Sonata + Sylcoat	5 fl oz + 64 fl oz + 4 fl oz	
		Provilo + Sonata + Sylcoat	5 fl oz + 64 fl oz + 4 fl oz	
		Inspire super + Sonata + Sylcoat	20 fl oz + 64 fl oz + 4 fl oz	
		Quintec + Sonata + Sylcoat	5 fl oz + 64 fl oz + 4 fl oz	
		Luna Experience + Sonata + Sylcoat	6 fl oz + 64 fl oz + 4 fl oz	
42	P	Torino + Sonata + Sylcoat	3.4 fl oz + 64 fl oz + 4 fl oz	14 days
		Sonata + Sylcoat/	96 fl oz + 4 fl oz	
		Rhyme + Sulfur DF + Syl-Tac	5 fl oz + 5 lb + 12.8 fl oz	
		Provilo Sulfur DF + Syl-Tac	5 fl oz + 5 lb + 12.8 fl oz	
		Inspire Super + Sulfur DF + Syl-Tac	20 fl oz + 5 lb + 12.8 fl oz	
		Quintec + Sulfur DF + Syl-Tac	5 fl oz + 5 lb + 12.8 fl oz	
		Luna Experience + Sulfur DF + Syl-Tac	6 fl oz + 5 lb + 12.8 fl oz	
		Torino + Sulfur DF + Syl-Tac	3.4 fl oz + 5 lb + 12.8 fl oz	
		Sonata + Syl-Tac	96 fl oz + 12.8 fl oz	

43	PWD	Sonata + Sulfur dry flowable + Sylcoat /	96 fl oz + 5 lb + 4 fl oz	7 days
		Sonata + Sulfur dry flowable + Sylcoat /	96 fl oz + 5 lb + 4 fl oz	
		Sonata + Sulfur dry flowable + Sylcoat /	96 fl oz + 5 lb + 4 fl oz	
		Sonata + PureSpray green + Sylcoat /	96 fl oz + 1 ga + 4 fl oz	
		Sonata + PureSpray green + Sylcoat /	96 fl oz + 1 ga + 4 fl oz	
		Sonata + PureSpray green + Sylcoat /	96 fl oz + 1 ga + 4 fl oz	
		WE1891-1 + Sylcoat	2.5 lb + 4 fl oz	
		WE1891-1 + Sylcoat	2.5 lb + 4 fl oz	
44	PWS	Sonata + WE1819-1 + Sulfur dry flowable + Sylcoat /	64 fl oz + 0.23 lb + 5 lb + 4 fl oz	7 days
		Sonata + WE1819-1 + Sulfur dry flowable + Sylcoat /	64 fl oz + 0.23 lb + 5 lb + 4 fl oz	
		Sonata + WE1819-1 + Sulfur dry flowable + Sylcoat /	64 fl oz + 0.23 lb + 5 lb + 4 fl oz	
		Sonata + WE1819-1 + PureSpray green + Sylcoat /	64 fl oz + 0.23 lb + 1 ga + 4 fl oz	
		Sonata + WE1819-1 + PureSpray green + Sylcoat /	64 fl oz + 0.23 lb + 1 ga + 4 fl oz	
		Sonata + WE1819-1 + PureSpray green + Sylcoat /	64 fl oz + 0.23 lb + 1 ga + 4 fl oz	
		WE1819-1 + Sylcoat	2.5 lb + 4 fl oz	
		WE1819-1 + Sylcoat	2.5 lb + 4 fl oz	
45	PWC	Aprovia + NuFilm /	13.3 fl oz + 0.125 % (v/v)	14 days
		Quintec + NuFilm /	6.6 fl oz + 0.125 % (v/v)	
		Inspire super + NuFilm /	20 fl oz + 0.125 % (v/v)	
		Miravis prime + NuFilm	13.4 fl oz + 0.125 % (v/v)	
		Inspire super + NuFilm /	20 fl oz + 0.125 % (v/v)	
		Miravis prime + NuFilm	13.4 fl oz + 0.125 % (v/v)	
46	PKD	Aprovia + NuFilm	13.3 fl oz + 0.125 % (v/v)	14 days
		Inspire super + NuFilm	20 fl oz + 0.125 % (v/v)	
		Miravis prime + NuFilm	13.4 fl oz + 0.125 % (v/v)	

47	PKS	Sulfur + Mastercop	5 lb + 3 pt	14 days
		Sulfur + Mastercop	5 lb + 3 pt	
		Luna Experience	8.6 fl oz	
		Captan Gold	2 qt	
		Incognito 85 WDG	1.2 lb	
		Luna Experience	8.6 fl oz	
		Incognito 85 WDG	1.2 lb	
		Merivon	4 fl oz	
48	PKC	Provilo	4 fl oz	14 days
49	W+K	Provilo	5 fl oz	14 days
50	W+Y	OxiDate 5.0 + PureSpray Green/	0.39 % (v/v) + 1 % (v/v)	7 days
51	W+G	OxiDate 5.0 + PureSpray Green/	0.39 % (v/v) + 1 % (v/v)	7 days
		PerCarb + Kinetic	3 lb + 0.125% (v/v)	
52	W+B	PerCarb + Kinetic	3 lb + 0.125% (v/v)	7 days
		OxiDate 5.0 + Kinetic	0.39 % (v/v) + 0.125% (v/v)	
53	W+Pu	Sulfur DF	3 lb	7 days
		PerCarb + Kinetic	3 lb + 0.125% (v/v)	
		OxiDate 5.0 + Kinetic	0.39 % (v/v) + 0.125% (v/v)	
54	W+P	PerCarb + Sulfur DF/	3 lb + 3 lb	7 days
		OxiDate 5.0 + Sulfur DF	0.39 % (v/v) + 3 lb	

C. Map



Row	6	5	4	3	2	1	Vine
-106	X	X	X	X	X	X	-106
-105	X	X	X	X	X	X	-105
-104	X	X	X	X	X	X	-104
-103	X	X	55-P+R	X	X	55-P+R	-103
-102	X	X	42-P	X	X	X	-102
-101	X	55-P+R	48-PKC	X	X	X	-101
-100	52-W+B	2-K	14-YS	40-BKC	55-P+R	20-YRS	-100
-99	4-KS	7-OS+O	27-RKC	1-W	X	10-OKS	-99
-98	26-RKS	16-YKD	6-O	29-GD	28-G	47-PKS	-98
-97	X	X	15-YC	44-PWS	X	54-W+P	-97
-96	X	X	38-BKD	35-BD	39-BKS	13-YD	-96
-95	22-RD	5-KC	31-GKD	12-Y	8-OC+O	30-GS	-95
-94	41-Pu	9-OKD	X	50-W+Y	19-YRD	3-KD	-94
-93	49-W+K	24-RC+R	11-ONS	25-RKD	45-PWC	18-YKC	-93
-92	17-YKS	46-PKD	37-BC	X	21-R	X	-92
-91	X	53-W+Pu	32-GKS	51-W+G	12-Y	4-KS	-91
-90	X	34-B	36-BS	43-PWD	10-OKS	X	-90
-89	21-R	17-YKS	48-PKC	47-PKS	53-W+Pu	25-RKD	-89
-88	X	44-PWS	28-G	40-BKC	42-P	37-BC	-88
-87	13-YD	15-YC	14-YS	16-YKD	41-Pu	39-BKS	-87
-86	6-O	X	2-K	11-ONS	X	45-PWC	-86
-85	52-W+B	3-KD	27-RKC	51-W+G	12-Y	26-RKS	-85
-84	5-KC	32-GKS	7-OS+O	35-BD	X	31-GKD	-84
-83	36-BS	22-RD	30-GS	9-OKD	20-YRS	43-PWD	-83
-82	38-BKD	54-W+P	19-YRD	23-RS+R	29-GD	51-W+G	-82
-81	18-YKC	X	1-W	46-PKD	33-GKC	X	-81
-80	8-OC+O	49-W+K	50-W+Y	9-OKD	X	31-GKD	-80
-79	X	20-YRS	52-W+B	39-BKS	X	25-RKD	-79
-78	34-B	26-RKS	24-RC+R	25-RKD	51-W+G	47-PKS	-78
-77	46-PKD	43-PWD	50-W+Y	49-W+K	16-YKD	53-W+Pu	-77
-76	1-W	5-KC	22-RD	47-PKS	X	19-YRD	-76
-75	7-OS+O	31-GKD	13-YD	32-GKS	X	21-R	-75
-74	27-RKC	17-YKS	10-OKS	36-BS	30-GS	54-W+P	-74
-73	4-KS	38-BKD	48-PKC	18-YKC	42-P	41-Pu	-73
-72	8-OC+O	X	29-GD	6-O	35-BD	14-YS	-72
-71	44-PWS	37-BC	3-KD	40-BKC	X	23-RS+R	-71
-70	15-YC	28-G	40-BKC	X	11-ONS	50-W+Y	-70
-69	30-GS	52-W+B	13-YD	34-B	19-YRD	53-W+Pu	-69
-68	20-YRS	X	46-PKD	39-BKS	29-GD	45-PWC	-68
-67	39-BKS	43-PWD	18-YKC	18-YKC	42-P	41-Pu	-67
-66	5-KC	26-RKS	9-OKD	42-P	35-BD	14-YS	-66
-65	32-GKS	40-BKC	44-PWS	33-GKC	41-Pu	23-RS+R	-65
-64	35-BD	49-W+K	21-R	27-RKC	12-Y	36-BS	-64
-63	54-W+P	28-G	7-OS+O	22-RD	47-PKS	37-BC	-63
-62	X	17-YKS	8-OC+O	31-GKD	14-YS	23-RS+R	-62
-61	16-YKD	38-BKD	10-OKS	23-RS+R	42-P	3-KD	-61
-60	15-YC	51-W+G	31-GKD	52-W+B	18-YKC	26-RKS	-60
-59	45-PWC	14-YS	20-YRS	54-W+P	28-G	51-W+G	-59
-58	24-RC+R	48-PKC	36-BS	28-G	19-YRD	50-W+Y	-58
-57	13-YD	37-BC	40-BKC	16-YKD	30-GS	53-W+Pu	-57
-56	34-B	49-W+K	5-KC	9-OKD	44-PWS	2-K	-56
-55	35-BD	6-O	47-PKS	7-OS+O	25-RKD	32-GKS	-55
-54	X	4-KS	33-GKC	21-R	46-PKD	1-W	-54
-53	X	8-OC+O	25-RKD	41-Pu	32-GKS	11-ONS	-53
-52	43-PWD	8-OC+O	33-GKC	1-W	25-RKD	36-BS	-52
-51	12-Y	17-YKS	21-R	46-PKD	1-W	11-ONS	-51
-50	10-OKS	15-YC	27-RKC	X	11-ONS	50-W+Y	-50
-49	27-RKC	29-GD	X	X	19-YRD	53-W+Pu	-49
-48	X	29-GD	X	X	45-PWC	47-PKS	-48
-47	X	29-GD	X	X	45-PWC	47-PKS	-47
-46	X	29-GD	X	X	45-PWC	47-PKS	-46
-45	X	29-GD	X	X	45-PWC	47-PKS	-45
-44	X	29-GD	X	X	45-PWC	47-PKS	-44
-43	X	29-GD	X	X	45-PWC	47-PKS	-43
-42	X	29-GD	X	X	45-PWC	47-PKS	-42
-41	X	29-GD	X	X	45-PWC	47-PKS	-41
-40	X	29-GD	X	X	45-PWC	47-PKS	-40
-39	X	29-GD	X	X	45-PWC	47-PKS	-39
-38	X	29-GD	X	X	45-PWC	47-PKS	-38
-37	X	29-GD	X	X	45-PWC	47-PKS	-37
-36	X	29-GD	X	X	45-PWC	47-PKS	-36
-35	X	29-GD	X	X	45-PWC	47-PKS	-35
-34	X	29-GD	X	X	45-PWC	47-PKS	-34
-33	X	29-GD	X	X	45-PWC	47-PKS	-33
-32	X	29-GD	X	X	45-PWC	47-PKS	-32
-31	X	29-GD	X	X	45-PWC	47-PKS	-31
-30	X	29-GD	X	X	45-PWC	47-PKS	-30
-29	X	29-GD	X	X	45-PWC	47-PKS	-29
-28	X	29-GD	X	X	45-PWC	47-PKS	-28
-27	X	29-GD	X	X	45-PWC	47-PKS	-27
-26	X	29-GD	X	X	45-PWC	47-PKS	-26
-25	X	29-GD	X	X	45-PWC	47-PKS	-25
-24	X	29-GD	X	X	45-PWC	47-PKS	-24
-23	X	29-GD	X	X	45-PWC	47-PKS	-23
-22	X	29-GD	X	X	45-PWC	47-PKS	-22
-21	X	29-GD	X	X	45-PWC	47-PKS	-21
-20	X	29-GD	X	X	45-PWC	47-PKS	-20
-19	X	29-GD	X	X	45-PWC	47-PKS	-19
-18	X	29-GD	X	X	45-PWC	47-PKS	-18
-17	X	29-GD	X	X	45-PWC	47-PKS	-17
-16	X	29-GD	X	X	45-PWC	47-PKS	-16
-15	X	29-GD	X	X	45-PWC	47-PKS	-15
-14	X	29-GD	X	X	45-PWC	47-PKS	-14
-13	X	29-GD	X	X	45-PWC	47-PKS	-13
-12	X	29-GD	X	X	45-PWC	47-PKS	-12
-11	X	29-GD	X	X	45-PWC	47-PKS	-11
-10	X	29-GD	X	X	45-PWC	47-PKS	-10
-9	X	29-GD	X	X	45-PWC	47-PKS	-9
-8	X	29-GD	X	X	45-PWC	47-PKS	-8
-7	X	29-GD	X	X	45-PWC	47-PKS	-7
-6	X	29-GD	X	X	45-PWC	47-PKS	-6
-5	X	29-GD	X	X	45-PWC	47-PKS	-5
-4	X	29-GD	X	X	45-PWC	47-PKS	-4
-3	X	29-GD	X	X	45-PWC	47-PKS	-3
-2	X	29-GD	X	X	45-PWC	47-PKS	-2
-1	X	29-GD	X	X	45-PWC	47-PKS	-1
Row	6	5	4	3	2	1	Vine

Block 1
Block 2
Block 3
Block 4
Block 5

Color
B Blue
G Green
K Black
O Orange
P Pink
Pu Purple
R Red
Y Yellow
W White
N Gray
Pattern
C Checker
D Dot
S Stripe

n	Flag
1	W
2	K
3	KD
4	KS
5	KC
6	O
7	OS+O
8	OC+O
9	OKD
10	OKS
11	ONS
12	Y
13	YD
14	YS
15	YC
16	YKD
17	YKS
18	YKC
19	YRD
20	YRS
21	R
22	RD
23	RS+R
24	RC+R
25	RKD
26	RKS
27	RKC
28	G
29	GD
30	GS
31	GKD
32	GKS
33	GKC
34	B
35	BD
36	BS
37	BC
38	BKD
39	BKS
40	BKC
41	Pu
42	P
43	PWD
44	PWS
45	PWC
46	PKD
47	PKS
48	PKC
49	W+K
50	W+Y
51	W+G
52	W+B
53	W+Pu
54	W+P
55	P+R

D. Application History

[illegible]

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 relative humidity were obtained from the trial site in Elk Grove (Figure 1). Powdery mildew incidence and severity were assessed in each treatment by evaluating twenty-five 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 with $\alpha=0.05$.

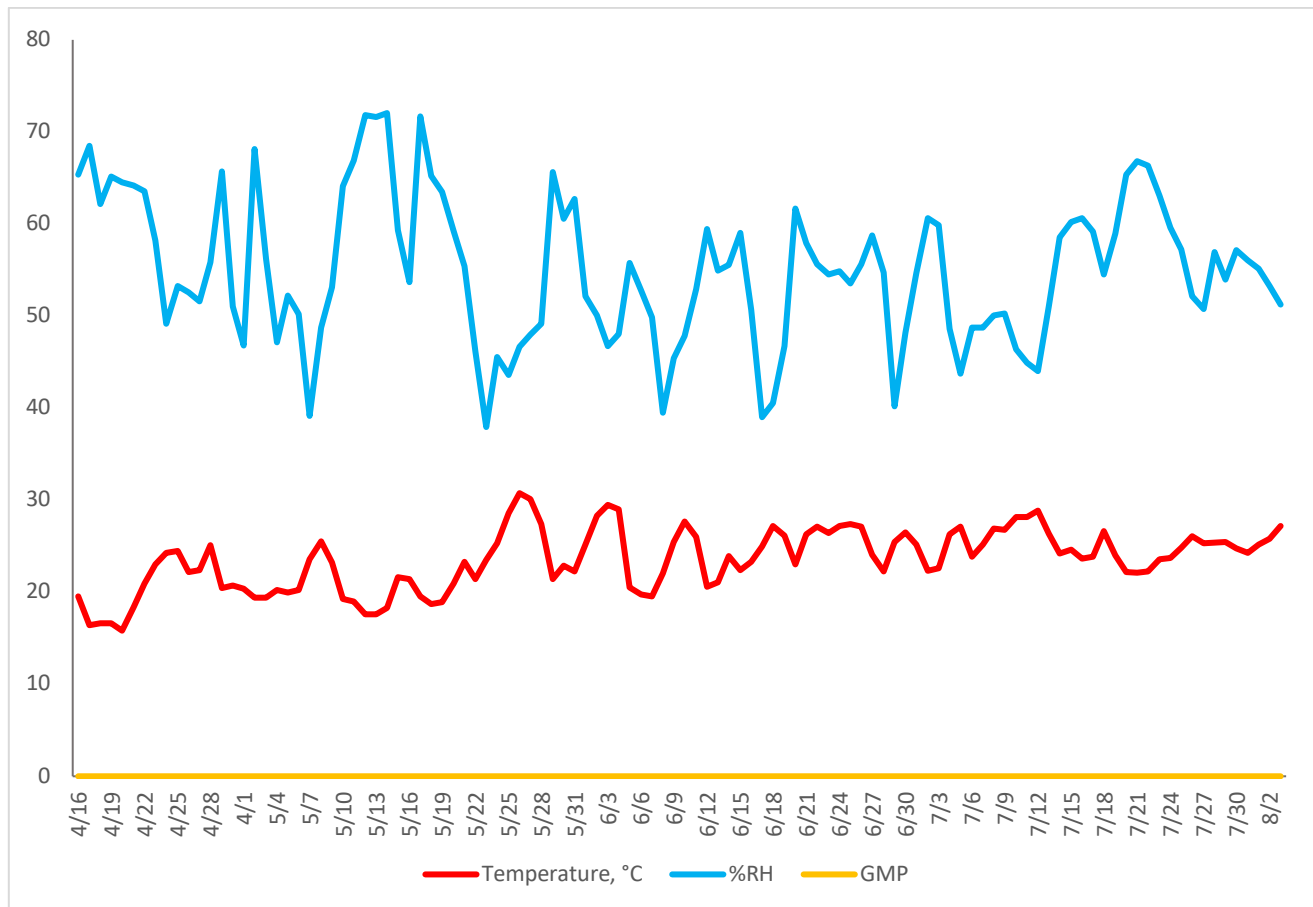


Figure 1. Average daily relative humidity (%RH), average daily temperature (°C) and number of grape powdery mildew spore counts were recorded from April 2020 to August 2020.

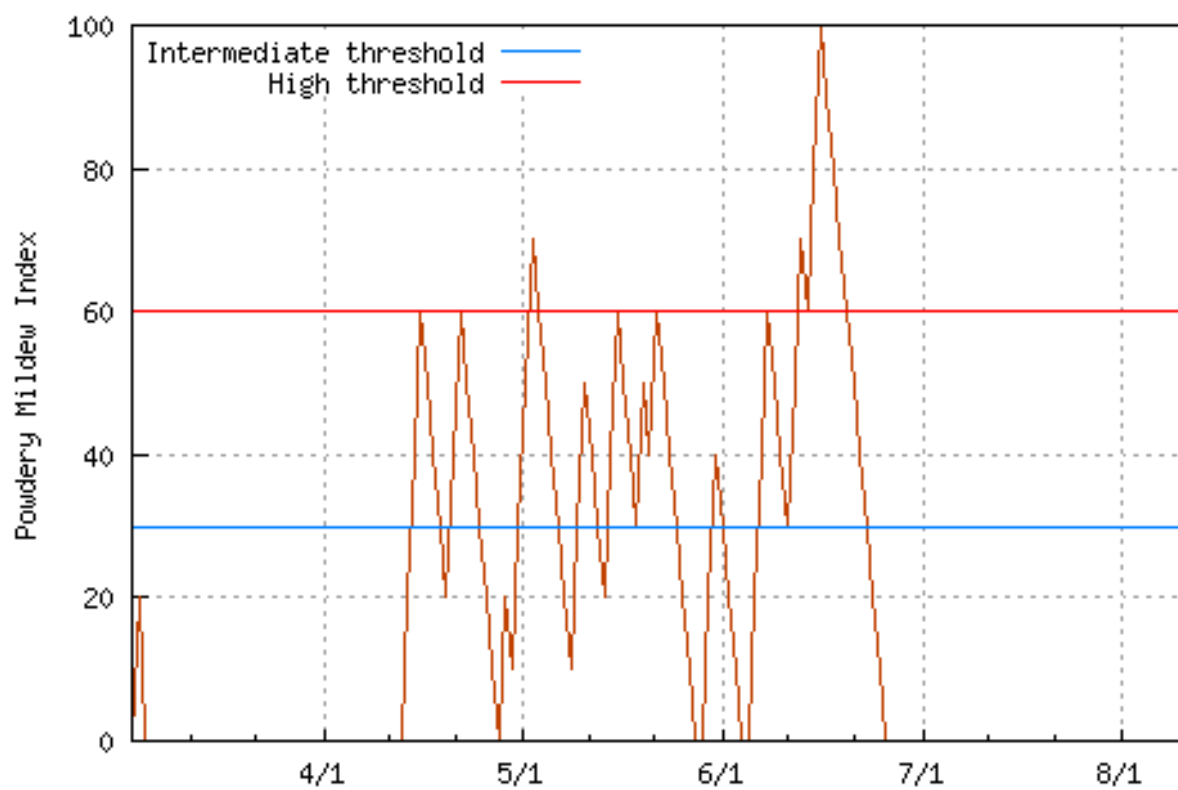


Figure 2. Thomas-Gubler Risk Index data from March to August. The Red line data points indicate risk index > 60 , between blue and red data points indicate risk index data between 30 and 60 and blue data points are values below 30.

Results

Table 1. Disease incidence and severity. 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 $\alpha=0.05$; /= followed by.

	Treatments	Flag	Mean Incidence (%)	Mean Severity (%)
Pictures	Luna Experience 8.6 fl oz, 14d	K	0.00 a	0.00 a
Pictures	Rally 5 fl oz / Quintec 5 fl oz / Mettel 4 fl oz / Pristine 18.5 fl oz / Inspire Super 20 fl oz / Luna Experience 8.6 fl oz / Vivando 15 fl oz / Merivon 4 fl oz, 14d	KD	0.00 a	0.00 a
Pictures	Double Nickel LC 1 qt / Quintec 5 fl oz / Mettel 4 fl oz / Double Nickel LC 1 qt, / Inspire Super 20 fl oz / Luna Experience 8.6 fl oz / Vivando 15 fl oz / Merivon 4 fl oz, 14d	KC	0.00 a	0.00 a
Pictures	Skip Treatment / Quintec 5 fl oz / Mettel 4 fl oz / Skip Treatment / Inspire Super 20 fl oz / Luna Experience 8.6 fl oz / Vivando 15 fl oz / Merivon 4 fl oz, 14d	O	0.00 a	0.00 a
Pictures	Kocide-3000 5 lb + NS1 1%v/v / Kocide-3000 5 lb + NS2 1% (v/v), 14d	OC+O	0.00 a	0.00 a
Pictures	Rango 160 fl oz / Rango 160 fl oz / Oxidate 128 fl oz / Rango 160 fl oz / Oxidate 128 fl oz / Rango 160 fl oz / Oxidate 128 fl oz / Rango 160 fl oz , 7d	OKD	0.00 a	0.00 a
Pictures	Rango 160 fl oz / Rango 160 fl oz / Terramera Biological 0.8 % v/v + Nu-film 16 oz / Rango 160 lf oz / Terramera Biological 0.8 % v/v + Nu-film 16 oz / Rango 160 lf oz / Terramera Biological 0.8 % v/v + Nu-film 16 oz / Rango 160 lf oz , 14d	OKS	0.00 a	0.00 a
Pictures	EMP 1% (v/v), 7d	ONS	0.00 a	0.00 a
Pictures	Gemm Experimental 24 gal, 7d	Y	0.00 a	0.00 a
Pictures	EMP 1% (v/v) + GemmExperimental 24 gal, 7d	YD	0.00 a	0.00 a
Pictures	CLP_UCD 5.5 oz + Serenade ASO 32 oz, 14d	YKC	0.00 a	0.00 a
Pictures	Merivon 5.5 fl oz / Vivando 15 oz + Serifel 4 oz + DyneAmic 0.125% / Pristine 23 oz + DyneAmic 0.125% / Cevya 5 oz + DyneAmic 0.125% / Vivando 15 oz + Serifel 4 oz + DyneAmic 0.125% / Merivon 5.5 oz, 14d	YRD	0.00 a	0.00 a
Pictures	Sulfur Dry-Flowable 1st and 2nd appl. / Stargus 32 oz + Inspire Super 10.5 fl oz+ JMS Stylet Oil 1% (v/v) / Stargus 32 oz+ Luna Experience 6 fl oz, 14d	RD	0.00 a	0.00 a
	EXP 14 1272.57 g, 14d	RS+R	0.00 a	0.00 a
Pictures	EXP 14 1908.86 g, 14d	RC+R	0.00 a	0.00 a
Pictures	OxiDate 5.0 0.39% (v/v) + Kinetic 0.12% (v/v), 7d	RKD	0.00 a	0.00 a
Pictures	PureSpray Green 1 gal, 7d	RKS	0.00 a	0.00 a
Pictures	OxiDate 5.0 0.39% (v/v) + PureSpray Green 1 gal, 7d	G	0.00 a	0.00 a

Pictures	Regalia 5% (3 tbsp), 7d	GD	0.00 a	0.00 a
Pictures	Regalia 5% (3 tbsp) + PureSpray Green 1 gal, 7d	GS	0.00 a	0.00 a
Pictures	Regalia 5% (3 tbsp) / PureSpray Green 1 gal, 7d	GKD	0.00 a	0.00 a
Pictures	SP2480 25 fl oz + NuFilm 16 fl oz/100 gal, 14d	GKS	0.00 a	0.00 a
Pictures	86PM 1 gal, 14d	BD	0.00 a	0.00 a
Pictures	86PM 1 gal / Sulfur Dry-Flowable 5 lb, 7d	BS	0.00 a	0.00 a
Pictures	Gatten 6.4 fl oz + Dyne-Amic 0.25% v/v, 14d	BC	0.00 a	0.00 a
Pictures	Circadian Sunrise Hotricultural 2 oz/ gal, 7d	BKS	0.00 a	0.00 a
Pictures	Sulfur 1st app 5 lb / Kocide-3000 5 lb + HML32 1.25% (v/v), 14d	BKC	0.00 a	0.00 a
Pictures	Rhyme 5 fl oz + Sonata 64 fl oz + Sylcoat 4 fl oz / Provilo 5 fl oz + Sonata 64 fl oz + Sylcoat 4 fl oz / Inspire super 20 fl oz + Sonata 64 fl oz + Sylcoat 4 fl oz / Quintec 2.08 F 5 fl oz + Sonata 64 fl oz + Sylcoat 4 fl oz / Luna Experience 6 fl oz + Sonata 64 fl oz + Sylcoat 4 fl oz / Torino 3.4 fl oz + Sonata 64 fl oz + Sylcoat 4 fl oz / Sonata 96 fl oz + Sylcoat 4 fl oz, 14d	Pu	0.00 a	0.00 a
Pictures	Rhyme 5 fl oz + Sulfur dry flowable 5 lb + Syl-Tac 12.8 oz / Provilo 5 fl oz + Sulfur dry flowable 5 lb + Syl-Tac 12.8 oz / Inspire Super 20 fl oz + Sulfur dry flowable 5 lb + Syl-Tac 12.8 fl oz / Quintec 2.08F + Sulfur dry flowable 5 lb + Syl-Tac 12.8 fl oz / Luna Experience 6 fl oz + Sulfur dry flowable 5 lb + Syl-Tac 12.8 fl oz / Torino 3.4 fl oz + Sulfur dry flowable 5 lb + Syl-Tac 12.8 fl oz / Sonata 96 fl oz + Syl-Tac 12.8 fl oz, 14d	P	0.00 a	0.00 a
Pictures	Aprovia 13.3 fl oz + NuFilm 0.125% (v/v) / Quintec 6.6 fl oz + NuFilm 0.125% / Inspire super 20 fl oz + NuFilm 0.125% (v/v) / Miravis prime 13.4 fl oz + NuFilm 0.125% (v/v) / Inspire super 20 fl oz + NuFilm 0.125% (v/v) / Miravis prime 13.4 fl oz + NuFilm 0.125% (v/v) , 14d	PWC	0.00 a	0.00 a
Pictures	Aprovia 13.3 fl oz + NuFilm 0.125% (v/v) / Inspire super 20 fl oz + NuFilm 0.125% (v/v) / Miravis prime 13.4 fl oz + NuFilm 0.125% / Aprovia 13.3 fl oz + NuFilm 0.125% (v/v) / Inspire super 20 fl oz + NuFilm 0.125% (v/v) / Miravis prime 13.4 fl oz + NuFilm 0.125 % (v/v), 14d	PKD	0.00 a	0.00 a
Pictures	Sulfur 5 lbs + Mastercop 3 pt/A / *Sulfur (5 lbs/A) + Mastercop 3 pt / Luna Experience (8.6 fl oz) / Captan Gold 4L 2 qt / Incognito 85 WDG 1.2 lb / Luna Experience 8.6 fl oz / Incognito 85 WDG 1.2 lb / Merivon 4 fl oz, 14d	PKS	0.00 a	0.00 a
Pictures	Provilo 4 fl oz, 14d	PKC	0.00 a	0.00 a
Pictures	Provilo 5 fl oz, 14d	W+K	0.00 a	0.00 a
Pictures	OxiDate 5.0 0.39% (v/v) + PureSpray Green 1.0% (v/v), 7d	W+Y	0.00 a	0.00 a
Pictures	OxiDate 5.0 0.39% (v/v) + PureSpray Green 1.0% (v/v) / PerCarb 3 lbs (100 gal) + Kinetic 0.125% (v/v), 7d	W+G	0.00 a	0.00 a
Pictures	Sulfur DF 3 Lb /PerCarb 3 lbs/100 gal + Kinetic 0.125% (v/v)/ OxiDate 5.0 0.39% (v/v) + Kinetic 0.125% (v/v), 7d	W+Pu	0.00 a	0.00 a

Pictures	PerCarb 3 lbs/100 gal + Sulfur DF 3 Lbs/ OxiDate 5.0 0.39% (v/v) + Sulfur DF 3 Lbs, 7d	W+P	0.00 a	0.00 a
Pictures	Cevya 5 oz + DyneAmic 0.125% (v/v), 14d	YRS	0.80 ab	0.01 a
Pictures	Rally 5 fl oz / SP2480 25 fl oz+NuFilm 16 fl oz/100 gal / Pristine 18.5 / SP2480 25 fl oz+NuFilm 16 fl oz/100 gal / Luna Experience 8.6 oz / SP2480 25 fl oz+NuFilm 16 fl oz/100 gal / Vivando 15 fl oz / SP2480 25 fl oz+NuFilm 16 fl oz/100 gal, 14d	GKC	0.80 ab	0.01 a
Pictures	Parade (Pyraziflumid) 3.1 fl oz + Dyne-Amic 0.25% v/v, 21d	BKD	0.80 ab	0.01 a
	Rhyme 5 fl oz / PureSpray green 1 ga, 14d	B	0.80 ab	0.02 a
Pictures	PerCarb (3 lbs/100 Gallons) + Kinetic 0.125% (v/v)/ OxiDate 5.0 (0.39%) + Kinetic 0.125% (v/v), 7d	W+B	0.80 ab	0.01 a
Pictures	Flint Extra 3.5 oz +Sylcoat 4 oz / Prolivo 5 oz + Sylcoat 4 oz / Luna Experince 6.4 oz+Sylcoat 4 oz / Quintec 4 oz+Sylcoat 4 oz / Torino 3.4 oz+Sylcoat 4 oz / Luna Tranquility 14 oz+Sylcoat 4 oz / Vivando 15.4 oz+Sylcoat 4 oz / Serenade ASO 4 qts +Sylcoat 4 oz , 14d	OS+O	0.80 ab	0.01 a
Pictures	Sulfur Dry-Flowable 1st and 2nd appl. / Stargus 64 oz+JMS Stylet Oil 1% (v/v), 14d	R	1.60 ab	0.03 a
Pictures	Sonata 64 fl oz + WE1819-1 0.23 lb Sulfur dry flowable 5 lb + Sylcoat 4 oz / Sonata 64 fl oz + WE1819-1 0.23 lb + Sulfur dry flowable 5 lb + Sylcoat 4 oz / Sonata 64 fl oz + WE1819-1 0.23 lb + Sulfur dry flowable 5 lb + Sylcoat 4 oz / Sonata 64 fl oz + WE1819-1 0.23 lb + PureSpray green 1 ga + Sylcoat 4 oz / Sonata 64 fl oz + WE1819-1 0.23 lb + PureSpray green 1 ga + Sylcoat 4 oz / Sonata 64 fl oz + WE1819-1 0.23 lb + PureSpray green 1 ga + Sylcoat 4 oz / WE1819-1 2.5 lb + Sylcoat 4 oz / WE1819-1 2.5 lb + Sylcoat 4 oz, 7d	PWS	2.40 ab	0.15 a
Pictures	Sonata 96 fl oz + Sulfur dry flowable 5 lb + Sylcoat 4 oz / Sonata 96 fl oz + Sulfur dry flowable 5 lb + Sylcoat 4 oz / Sonata 96 fl oz + Sulfur dry flowable 5 lb + Sylcoat 4 oz / Sonata 96 fl oz + PureSpray green 1 ga + Sylcoat 4 oz / Sonata 96 fl oz + PureSpray green 1 ga + Sylcoat 4 oz / Sonata 96 fl oz + PureSpray green 1 ga + Sylcoat 4 oz / WE1891-1 2.5 lb + Sylcoat 4 oz / WE1891-1 2.5 lb + Sylcoat 4 oz, 7d	PWD	2.40 ab	0.52 ab
Pictures	LifeGard WG 4.5 oz / Quintec 5 fl oz / Mettel 4 fl oz / LifeGard WG 4.5 oz / Inspire Super 20 fl oz / Luna Experience 8.6 fl oz / Vivando 15 fl oz / Merivon 4 fl oz, 14d	KS	6.40 b	1.62 c
Pictures	Untreated Control	W	18.40 c	1.11 bc

Acknowledgements

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Appendix: Materials

Product	Active ingredient(s) and concentration	Manufacturer or distributor	Chemical class (Frac Code)
86PM	proprietary	NorCal Nutrients	oil
Aprovia	Benzovindiflupy	Syngenta	SDHI (7)
Captan Gold	captan	Adama	Phthalimides (M04)
Cevya	mefentrifluconazole	BASF	DMI
Circadian Sunrise Horticultural	corn oil + peppermint oil	Circadian Crop Sciences	N/A
CLP_UCD	proprietary	UC Davis	N/A
Double Nickel LC	<i>Bacillus amyloliquefaciens</i> strain d747	CERTIS	biological
Dyne-Amic	polyalkyleneoxide modified polydimethylsiloxane, nonionic emulsifiers, methyl ester of c16-c18 fatty acids (99%)	Helena Chemical Co.	adjuvant
EMP Barrier	co-polymer emulsion	Gemm Ag Solutions	N/A
EXP14	proprietary	Biotallys	N/A
Gemm Experimental	proprietary	Gemm Ag Solutions	N/A
Flint Extra	trifloxystrobin (50%)	Bayer CropScience	QoI (11)
Gatten	flutianil	Nichino America	thiazolidine (U13)
Incognito 85 WDG	thiophanate methyl (85%)	ADAMA	MBC(1)
Inspire Super	difenoconazole (8.4%), cyprodinil (24.1%)	Syngenta Crop Protection, Inc.	DMI-triazole (3)/AP(9)
JMS Stylet-Oil	paraffinic oil (97.1%)	JMS Flower Farms, Inc.	Oil
Kocide 3000	copper (30%)	Dupont	minerals
LifeGard WG	<i>Bacillus mycoides</i> (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	AP(9)/ SDHI (7)
Mastercop	copper sulfate pentahydrate (21.46%)	ADAMA	inorganic (M01)
Merivon	pyraclostrobin (21.26%), fluxapyroxad (21.26%)	BASF	QoI(11)/SDHI (7)
Mettler 125 ME	tetraconazole (11.6%)	Gowan Co.	DMI-triazole (3)
Miravis Prime	fludioxonil (21.4%), pydiflumetofen 12.8%)	Syngenta	Phenylpyrroles (12)/ SDHI (7)
NS1	proprietary	Henry Manufacturing	N/A
NS2	proprietary	Henry Manufacturing	N/A
HML32	proprietary	Henry Manufacturing	N/A
Oxidate 2.0	hydrogen peroxide 27.1 + peroxyacetic acid 2%	Biosafe systems	N/A
OxiDate 5.0	hydrogen peroxide 27.1 + peroxyacetic acid 5%	Biosafe systems	N/A
Parade (Pyraziflumid)	pyraziflumid	Nichino America	SDHI(7)
PerCarb	sodium carbonate peroxyhydrate (85%)	Biosafe systems	N/A
Pristine	pyraclostrobin (12.8%), boscalid (25.2%)	BASF	QoI(11)/SDHI (7)
Prolivo	pyriofenone	Summit Agro USA	benzoylpyridine (50)
PureSpray Green	mineral oil (98%)	Petro-Canada	oil
Quintec	quinoxifen (22.6%)	Dow AgroSciences LLC	aryloxyquinoline (13)
Rally 40 WSP	myclobutanil (40%)	Dow AgroSciences LLC	DMI-triazole (3)
Rango	proprietary	Terramera Inc.	N/A
Regalia	extract of <i>Reynoutria sachalinensis</i> (5%)	Marrone Bio Innovations	Plant extract
Rhyme	flutriafol (22.7 %)	FMC	DMI-triazole (3)

Serenade ASO	<i>Bacillus subtilis</i> qst 713 (26%)	Bayer CropScience	biological
Serifel	<i>Bacillus amyloliquefacines</i> mbi 600 (11%)	Bayer CropScience	biological
Sonata	<i>Bacillus pumilus</i> qst 2808 (1.38%)	Bayer CropScience	biological
SP2480	proprietary	SePRO Corporation,	proprietary
Stargus	<i>Bacillus amyloliquefaciens</i> strain f72	Marrone Bio Innovations	biological
Sulfur Dry-Flowable	sulfur (80%)	Wilbur-Ellis	Inorganic (M2)
Syl-Coat	polyether-polymethylsiloxane-copolymer and polyether-100%	Wilbur-Ellis	adjuvant
Syl-Tac	ethylated seed oil	Wilbur-Ellis	adjuvant
Terramera Biological	cold pressed neem oil (52%) octanoid acid (25%)	Terramera Inc.	N/A
Torino SC	cyflufenamid (10%)	Gowan Co.	phenyl-acetamide (U06)
Vivando	metrafenone (25.2%)	BASF	benzophenone (50)
WE1819-1	proprietary	Wilbur Ellis	N/A
WE1891-1	proprietary	Wilbur Ellis	N/A

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