Final Report:
Control of grape powdery mildew with synthetic, biological and organic fungicides: 2012 field trials

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Report Summary

Powdery mildew is an economically-important pathogen of grapes worldwide. This report details the findings of our annual powdery mildew fungicide trials on grapevine (Cultivar Chardonnay) (*Vitis vinifera*). The trials were conducted at Herzog Ranch, near Courtland, California in 2012. Treatments were placed in four adjacent trials in the vineyard. Spraying commenced in mid April, amidst significant rainfall events that likely promoted the release of powdery mildew (*Erysiphe necator*) ascospores from overwintering chasmothecia. Powdery mildew pressure increased slowly, held in check by cool temperatures early on, but quickly built to very high disease pressure levels as temperatures warmed. Spraying was completed on July 23 and treatments were evaluated for disease incidence and severity.

The trials consisted of soft chemistry products, including biologicals, sulfurs, nutrient applications, oils, and other materials, as well as synthetics. Spray frequencies varied from weekly applications to 21 day intervals. Many applications were based on the Gubler-Thomas Risk Index, with application intervals based on the index.

Temperatures were mild during much of the 2012 growing season, providing optimal conditions for the asexual reproduction and dispersal of powdery mildew. Overall disease pressure was high. By late June, heavy mildew coverage was evident on untreated clusters. By the time of disease evaluation, disease severity in untreated plots in all three trials reached 95-100%.

Materials and Methods

A1. Experimental design

Trials II-V: Synthetic and organic treatments

Experimental design	Complete randomized design with 5 replicates.		
Experimental unit	2 adjacent vines = 1 plot (Trial 3A is 1 vine= 1plot		
Plot area	154 ft^2 (row spacing = 11 ft, vine spacing = 7 ft)		
Area/treatment	770 ft^2 (5 reps x 2 vines = 1 treatment)	Area/treatment	0.0177 acre/treatment
Volume water/acre	100 gallons (pre-bloom in mid-April), = 1.8 gallons/5 replicates 150 gallons (pre-bloom to pea-sized berries, late April – late May), = 2.7 gallons/5 reps 200 gallons (late season), = 3.5 gallons/5 reps 250 gallons (late season),= 4.4 gallons/5 reps		

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 I

No.	Flag.	Treatment	Frequency (days)	Application rate (per acre)	FP/5 replicates
1	W	Untreated	none	none	none
2	K	Quintec	21	6.6 fl oz	3.5 ml
3	G	Rally + Silwet L-77 alt Quintec + Silwet L-77	14	(5 oz + alt 4 fl oz) + 0.125% (v/v)	2.5 g alt 2.1 ml + 8.5 ml (at 100 gal), 12.8 ml(at 150 gal), 16.6 ml (at 200 gal), 20.8 ml (at 250 gal)
4	YKS	Luna Exp + Silwet L-77 alt Quintec + Silwet L-77	21	(6 fl oz alt 6.6 fl oz) + 0.125% (v/v)	3.1 ml alt 3.5 ml + 8.5 ml (at 100 gal), 12.8 ml(at 150 gal), 16.6 ml (at 200 gal), 20.8 ml (at 250 gal)
5	Y	Pristine + Silwet L-77 alt Quintec + Silwet L-77	21	(10.5 oz + alt 6.6 fl oz) + 0.125% (v/v)	5.3 g + alt 3.5 ml + 8.5 ml (at 100 gal), 12.8 ml(at 150 gal), 16.6 ml (at 200 gal), 20.8 ml (at 250 gal)
6	YKD	Torino + Silwet L-77 alt Quintec + Silwet L-77	14	3.4 fl oz+ alt 4 fl oz + 0.125% (v/v)	1.8 ml alt 2.9 ml + 8.5 ml (at 100 gal), 12.8 ml(at 150 gal), 16.6 ml (at 200 gal), 20.8 ml (at 250 gal)
7	BS	Luna Tranquility alt Flint	21 alt 14	12.0 fl oz alt 2 oz	6.2 ml + 1 g
8	KS	Luna Exp alt Flint	14	6 fl oz alt 2 oz	3.1 ml + 1 g
9	O	Sovran then Topguard 1.04 then Quintec then Topguard (then repeat protocol)	14	4.8 oz then 10 fl oz then 4 fl oz then 10 fl oz (then repeat- 4.8 oz etc.)	2.4 g then 5.2 ml then 2.1 ml then 5.2 ml then repeat protocol)
10	OKS	Kumulus (at budbreak) then Problad Plus + Silwet L-77 alt Abound + Silwet L-77	budbreak (until shoots 8-12") then 14 then 14-21(RI)	5 lb/100 gal then 30 fl oz + O.125% (v/v) alt 15.4 fl oz + 0.125% (v/v)	29 g then (15.7 ml alt 8.1 ml) + 8.5 ml (at 100 gal), 12.8 ml(at 150 gal), 16.6 ml (at 200 gal), 20.8 ml (at 250 gal)
11	BC	Kumulus (at budbreak) then Problad Plus + Abound + Silwet L-77 alt Elite + Silwet L-77	budbreak (until shoots 8-12") then 14 then 14-21 (RI)	5 lb/100 gal then 21 fl oz + 10 fl oz + 0.125% (v/v) alt 4 oz + 0.125% (v/v)	29 g then (11 ml + 5.2 ml alt 2 g) + 8.5 ml (at 100 gal), 12.8 ml(at 150 gal), 16.6 ml (at 200 gal), 20.8 ml (at 250 gal)
12	GD	Kumulus (at budbreak) then Elite + Silwet L-77 alt Abound + Silwet L-77	budbreak (until shoots 8-12") then 14 then 14-21 (RI)	5 lb/100 gal then 4 oz + 0.125%(v/v) alt 15.4 fl oz + Silwett L-77 0.125%(v/v)	29 g then (2 g alt 8.1 ml) + 8.5 ml (at 100 gal), 12.8 ml(at 150 gal), 16.6 ml (at 200 gal), 20.8 ml (at 250 gal)
13	B	Problad Plus + Silwet L-77 (2x) then Sonata + Silwet L-77	7-10	30 fl oz + 0.125% (v/v) (2x) then 2 qt + 0.125%(v/v)	(15.7 ml then (2x) 33.5 ml) + 8.5 ml (at 100 gal), 12.8 ml(at 150 gal), 16.6 ml (at 200 gal), 20.8 ml (at 250 gal)
14	Pu	Sonata + Silwet L-77	7-10	2 qt + 0.125% (v/v)	33.5 ml + 8.5 ml (at 100 gal), 12.8 ml(at 150 gal), 16.6 ml (at 200 gal), 20.8 ml (at 250 gal)

15	PKD	Quadris Top + Dyneamic alt Quintec + Dyneamic	14	14 fl oz + 0.125% (v/v) alt 4 fl oz + 0.125% (v/v)	(7.3 ml alt 2.1 ml) + 8.5 ml (at 100 gal), 12.8 ml(at 150 gal), 16.6 ml (at 200 gal), 20.8 ml (at 250 gal)
16	KD	Inspire Super + Dyneamic alt Quintec + Dyneamic	14	20 fl oz + 0.125% (v/v) alt 4 fl oz + 0.125% (v/v)	(10.5 ml alt 2.1 ml) + 8.5 ml (at 100 gal), 12.8 ml(at 150 gal), 16.6 ml (at 200 gal), 20.8 ml (at 250 gal)
17	P	Exp 3 + Dyneamic alt Quintec + Dyneamic	14	13 fl oz + 0.125% (v/v) alt 4 fl oz + 0.125% (v/v)	(6.8 ml alt 2.1 mL) + 8.5 ml (at 100 gal), 12.8 ml (at 150 gal), 16.6 ml (at 200 gal), 20.8 ml (at 250 gal)
18	GS	Exp 3 + Dyneamic	14	13 fl oz + 0.125% (v/v)	6.8 ml + 8.5 ml (at 100 gal), 12.8 ml(at 150 gal), 16.6 ml (at 200 gal), 20.8 ml (at 250 gal)
19	YKC	Quintec alt Flint (standard)	(14-21)	6.6 fl oz alt 2 oz	3.5 ml alt 1 g
20	BD	Topguard 1.04	14	10 fl oz	5.2 ml
21	KC	NUP 12033 30 WDG (Flint when disease pressure high)	14-21 (14 for Flint when dis press. High)	1.75 lb or 2 oz	14 g or 1 g
22	PKS	Kocide	14	1.75 lb	14 g
23	OKD	Pristine + Sylgard 309	21	12 oz + 3 fl oz/100 gal	6 g + 1.6 ml (at 100 gal/A) 2.4 ml (at 150 gal/A) 3.1 ml (at 200 gal/A) 3.9 ml (at 250 gal/A)
24	YS	Pristine + Sylgard 309 alt Vivando + Sylgard 309	21	12 oz + 3 fl oz/100 gal alt 15.4 fl oz + 3 fl oz/100 gal	(6 g alt alt 8 mL) + 1.6 ml (at 100 gal/A) 2.4 ml (at 150 gal/A) 3.1 ml (at 200 gal/A) 3.9 ml (at 250 gal/A)
25	OS	Merivon+ Sylgard 309 alt Vivando + Sylgard 309	21	5 oz + 3 fl oz/100 gal alt 15.4 fl oz + 3 fl oz/100 gal	(2.6 ml alt 8 mL) + 1.6 ml (at 100 gal/A) 2.4 ml (at 150 gal/A) 3.1 ml (at 200 gal/A) 3.9 ml (at 250 gal/A)
26	PKC	Merivon + Sylgard 309	21	5 oz + 3 fl oz/100 gal	2.6 ml + 1.6 ml (at 100 gal/A) 2.4 ml (at 150 gal/A) 3.1 ml (at 200 gal/A) 3.9 ml (at 250 gal/A)
27	BKS	Merivon + Sylgard 309	28	8 oz + 3 fl oz/100 gal	4.2 ml + 1.6 ml (at 100 gal/A) 2.4 ml (at 150 gal/A) 3.1 ml (at 200 gal/A) 3.9 ml (at 250 gal/A)

*All treatments (except control) received 2 applications of 0.5% (v/v) Stylet-oil at 7 day intervals during first two weeks after bloom.

Trial II

No.	Flag	Treatment	Frequency (days)	Application rate (per acre)	FP/5 replicates
1	W	Untreated Control	None	None	none
2	K	Viticure alt Pristine	14-21 (RI)	8 fl oz alt 8.5 oz	4.2 mL alt 4.3 g
3	G	Viticure alt Kumulus alt Quadris Top	14	8 fl oz alt 5 lb/100 gal alt 14 fl oz	4.2 mL alt (29g at 100 gal/A) (41g at 150 gal/A) (58g at 200 gal/A) (70g at 250 gal/A) alt 7.3 mL

4	KS	Exp 4 alt Flint	7 alt 14	0.25% (v/v) alt 2 oz	17 ml (at 100 gal), 25.6 ml(at 150 gal), 33.2 ml (at 200 gal), 41.6 ml (at 250 gal) alt 1.0g
5	O	Exp 4 + Flint	14	0.25% + 1 oz	17 ml (at 100 gal), 25.6 ml(at 150 gal), 33.2 ml (at 200 gal), 41.6 ml (at 250 gal) + 0.5g
6	YKS	Flint	14	2 oz	1.0 g
7	Y	IKF-309	14	4 fl oz	2.1 ml
8	YKD	IKF-309	14	5 fl oz	2.6 ml
9	BS	IKF-309 alt Rally	14	4 fl oz alt 4 oz	2.1 ml alt 2 g
10	OS	IKF-309 alt Elite	14	4 fl oz alt 4 oz	2.1 ml alt 2 g
11	BC	Vivando	14	10.3 fl oz	5.4 ml
12	GD	Quintec alt Flint, then Leaf Removal alone	(14-21)	6.6 fl oz alt 2.0 oz	3.5 ml alt 1.0 g
13	B	Stylet-oil	14	2% (v/v)	134.0 ml (at 100 gal/A) 201.0 ml (at 150 gal/A) 268.0 ml (at 200 gal/A) 333.1 ml (at 250 gal/A)
14	Pu	Stylet-oil alone (before bloom) then Stylet-oil + Procure	14	1% (v/v) (before bloom) then 1% (v/v) + 6 oz	67.0 ml (at 100 gal/A) 100.5 ml (at 150 gal/A) 134.0 ml (at 200 gal/A) 167 ml (at 250 gal/A) then (see above) + 3.1 ml
15	PKD	Stylet-oil (before bloom) then Stylet-oil + Flint	14	1% (v/v) (before bloom) then 1% (v/v) + 2 oz	67.0 ml (at 100 gal/A) 100.5 ml (at 150 gal/A) 134.0 ml (at 200 gal/A) 167 ml (at 250 gal/A) then (see above) + 1.0 g
16	KD	Tri-Tek	10-21(RI)	1% (v/v)	67.0 ml (at 100 gal/A) 100.5 ml (at 150 gal/A) 134.0 ml (at 200 gal/A) 167 ml (at 250 gal/A)
17	P	Tri-Tek	10-21(RI)	2%(v/v)	134.0 ml (at 100 gal/A) 201.0 ml (at 150 gal/A) 268.0 ml (at 200 gal/A) 333.1 ml (at 250 gal/A)
18	GS	Eco 4000 (change rate on1st week of June)	14	.05% (v/v) then 0.075% (v/v)	3.4 then 5.1 ml(at 100 gal) 5.1 then 7.7 ml(at 150gal) 6.6 then 9.9 ml (at 200gal) 8.3 then12.5 ml(at 250gal)
19	YKC	Acadian + Rally	14	0.5 gal + 4 oz	33.5 ml + 2 g
20	BD	Rally	14	4 oz	2 g
21	KC	Exp 1	10		
22	PKS	Exp 2	10		
23	OKD	Kumulus	10-14	5 lb	40 g
24	YS	Kumulus + Exp A	10-14	5 lb + 0.25% (v/v)	40 g + 17 ml (at 100 gal) 25.6 ml(at 150 gal) 33.2 ml (at 200 gal) 41.6 ml (at 250 gal)
25	OKS	CX-10440 5% SC	7-14 (RI)	6.5 fl oz	3.4 ml

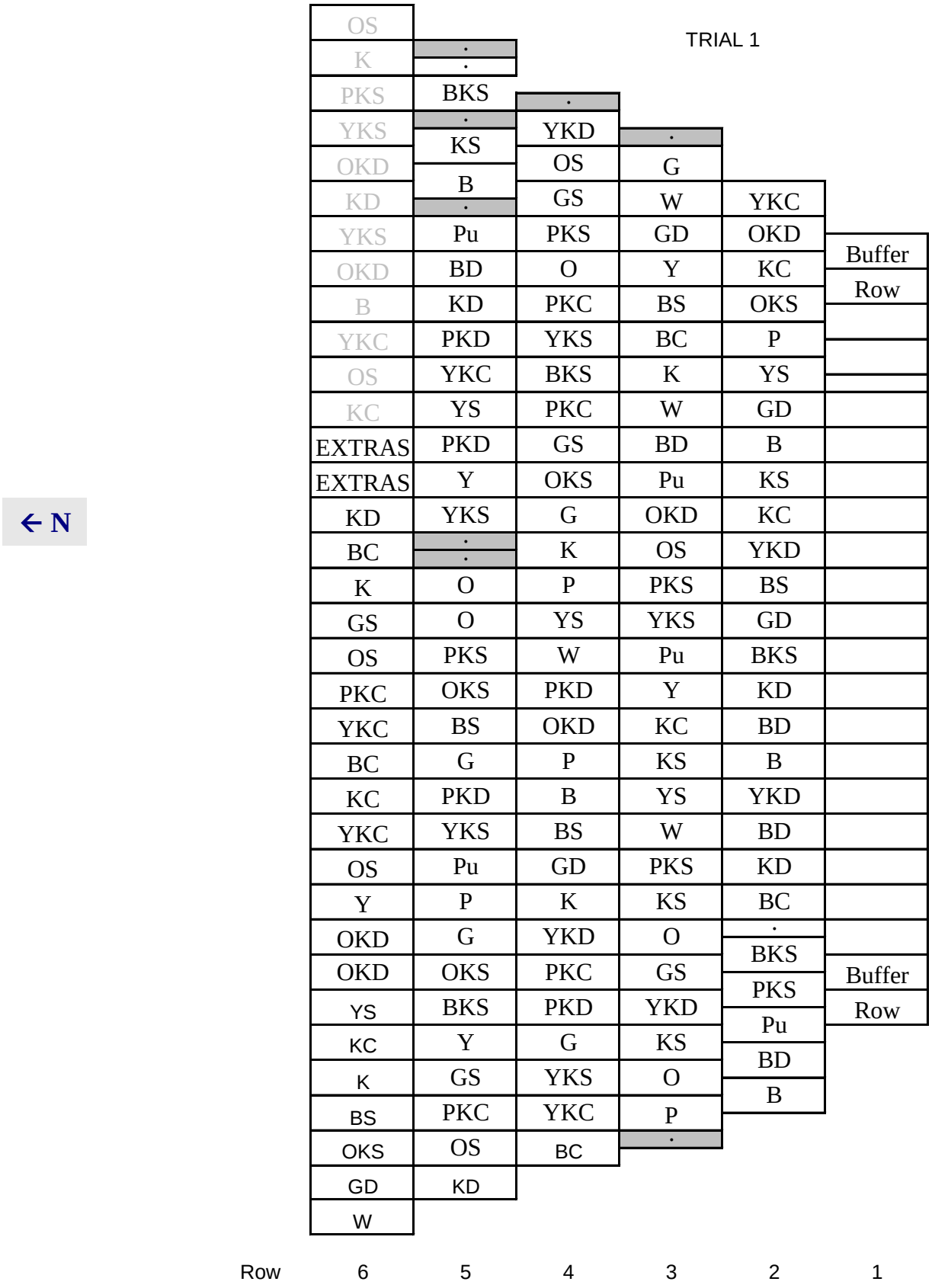
*All treatments (except control) received 2 applications of 0.5% (v/v) Stylet-oil at 7 day intervals during first two weeks after bloom.

Trial 3

No.	Flag	Treatment	Frequency (days)	Application rate (per acre)	FP/5 replicates
1	W	Untreated Control	None	None	none
2	Pu	Stylet Oil + Luna Exp then Quintec alt Flint	21 then14-21 (RI)	0.5% (v/v) + 2 oz then 6.6 fl oz alt 2.0 oz	84 ml + 2 oz then 3.5 ml alt 1.0 g
3	R	Stylet Oil + Luna Exp then Pristine alt Sonata alt Quintec alt Sonata alt Flint alt Sonata	21 then14	0.5% (v/v) + 2 oz then 8 oz alt 1 gal alt 4 fl oz alt 1 gal alt 1.5 oz alt 1 gal	84 ml + 2 oz then 4.0 g alt 67 ml alt 2.1 ml alt 67 ml alt 0.75 g a;t 67 ml
4	B	Stylet oil + Luna Exp then Pristine alt Rally alt Quintec alt Rally alt Flint alt Rally	21 then 14	0.5% (v/v) + 2 oz then 8 oz alt 4 oz alt 4 fl oz alt 4 oz alt 1.5 oz alt 4 oz	84 ml + 2 oz then 4.0 g alt 2.0 g alt 2.1 ml alt 2.0g alt 0.75 g alt 2.0 g
5	OKS	Stylet oil + Luna Exp then Phyton 27 AG + HiWett	21 then10-14 (RI)	0.5% (v/v) + 2 oz then 40 fl oz + 0.1% (v/v)	84 ml + 2 oz then 21 ml + 10.2 ml (at 150 gal) 13.2 ml (at 200 gal) 16.7 ml (at 250 gal)
6	GD	Stylet oil + Luna Exp then Viticure alt Pristine	21 then14-21 (RI)	0.5% (v/v) + 2 oz then 8 fl oz alt 8.5 oz	84 ml + 2 oz then 4.2 ml alt 4.3 g
7	KD	Stylet oil + Luna Exp then Viticure alt Kumulus alt Quadris Top	21 then14-21 (RI) alt 10-14 (RI) alt 14-21 (RI)	0.5% (v/v) + 2 oz then 8 oz alt 5 lb alt 14 oz	84 ml + 2 oz then 4.2 alt 40.1 g alt 7.3 ml
8	KS	Stylet oil + Luna Exp then MARXP-1 + NuFilm P	21 then 7	0.5% (v/v) + 2 oz then 0.4% (v/v) + 6 oz	84 ml + 2 oz then 53 ml (at 200 gal) 66.6 ml (at 250 gal) + 3.1 ml
9	YKD	Stylet oil + Luna Exp then MARXP-2 + NuFilm P	21 then 7	0.5% (v/v) + 2 oz then 0.4% (v/v) + 6 oz	84 ml + 2 oz then 53 ml (at 200 gal) 66.6 ml (at 250 gal) + 3.1 ml
10	OKD	Stylet oil + Luna Experience then Stylet oil + Flint then Regalia	21 then 14 then 7	0.5% (v/v) + 2 oz then 2 qt	33.6 ml
11	B	Stylet oil + Luna Experience then Stylet oil + Flint then Luna Exp then Flint then Regalia	21 then 14 then 21 then 14 then 7	0.5% (v/v) + 2 oz then 6 fl oz then 2 oz then 2 qt	3.1 ml then 1 g then 33.3 ml

*All treatments (except control) received 2 applications of 0.5% (v/v) Stylet-oil at 7 day intervals during first two weeks after bloom. Trial 3 received application of Luna Experience, 6 fl oz and 0.5% (v/v) Stylet oil on 5/9. Treatments OKD and B received application of Flint, 2 oz and 0.5% (v/v) Stylet-oil on 5/30.

TRIAL 1



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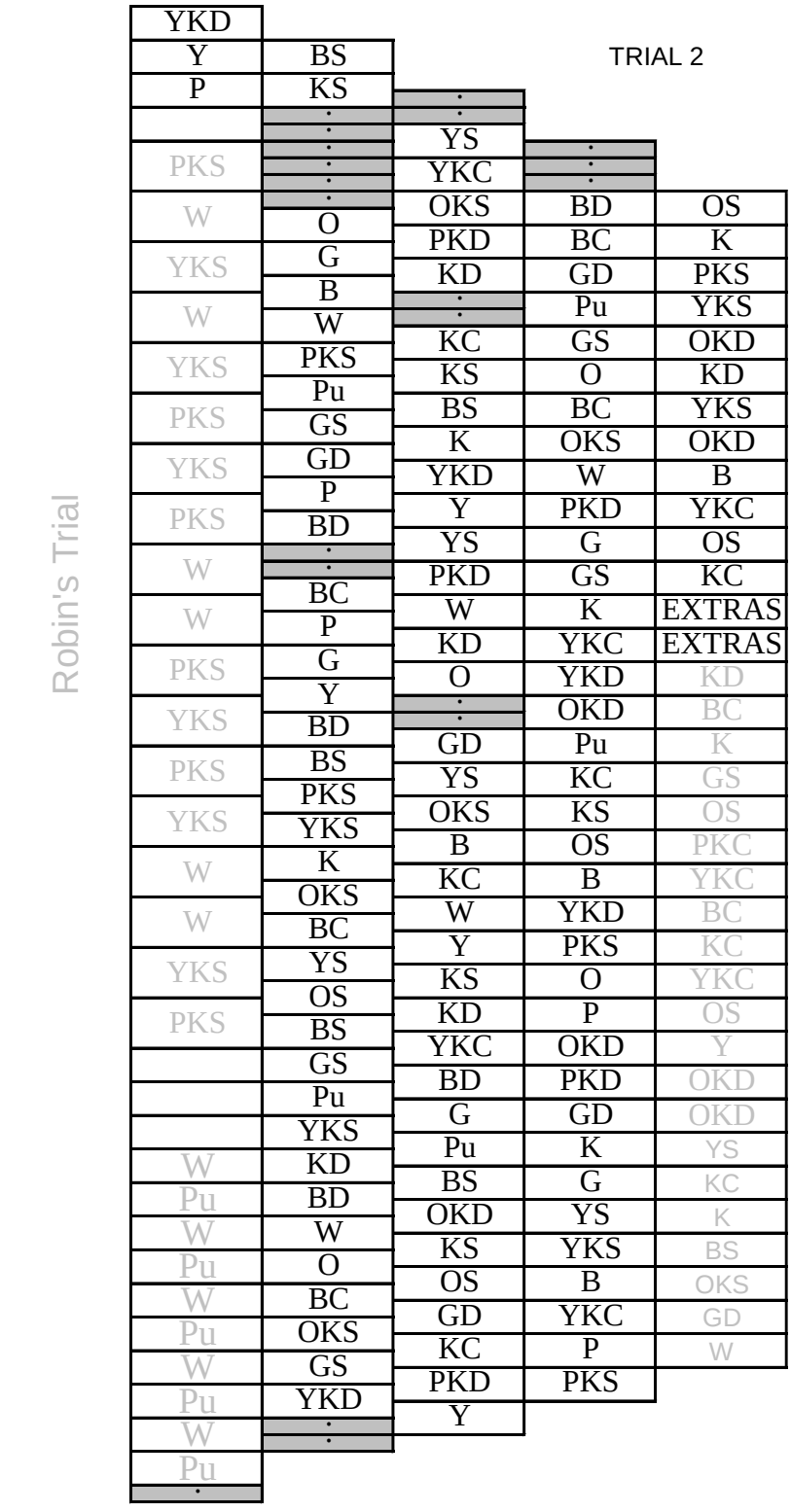
TRIAL 2

Robin's Trial



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		G	·	OKD	BC
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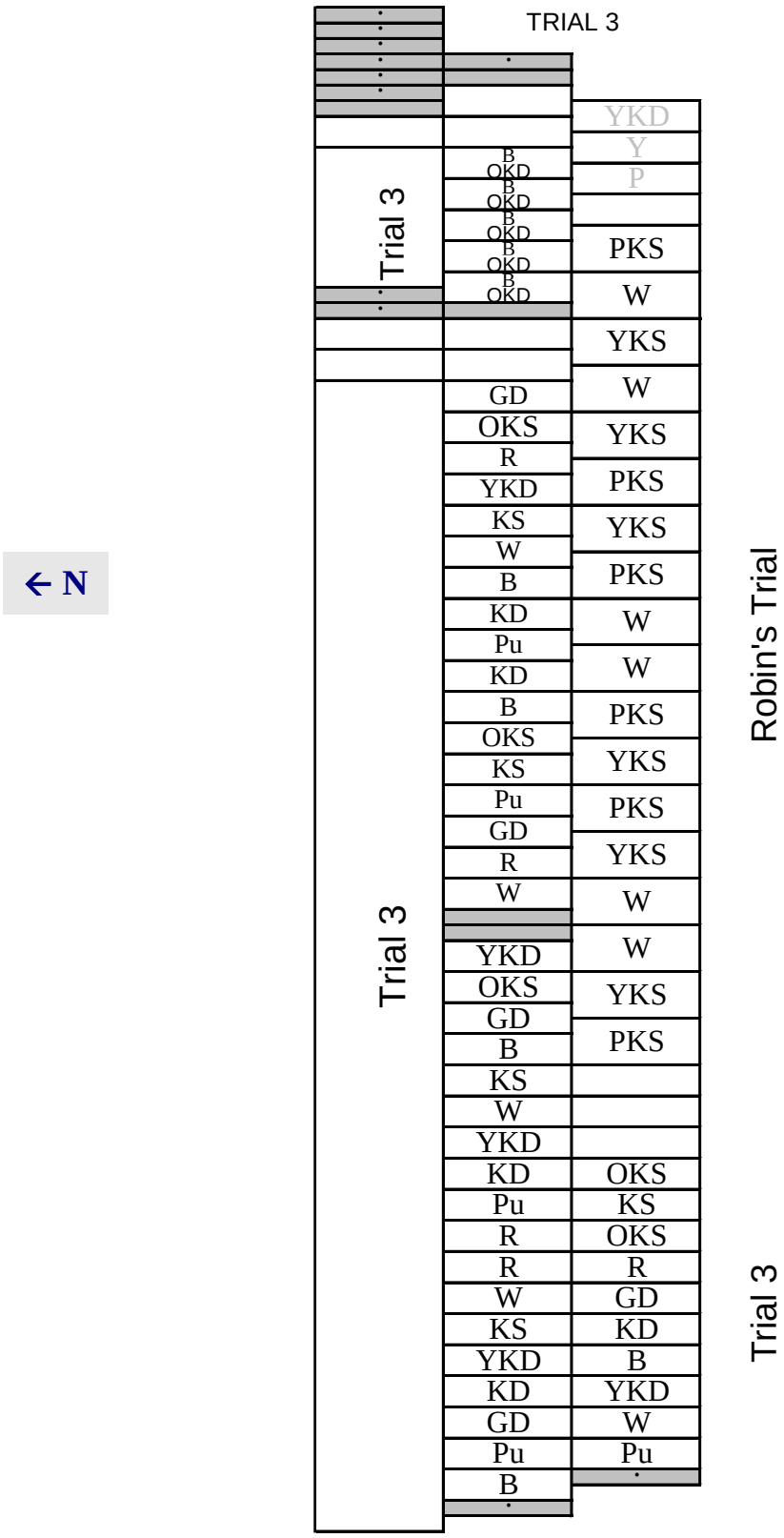
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Trial 3
Robin's Trial
Trial 3
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Overview map

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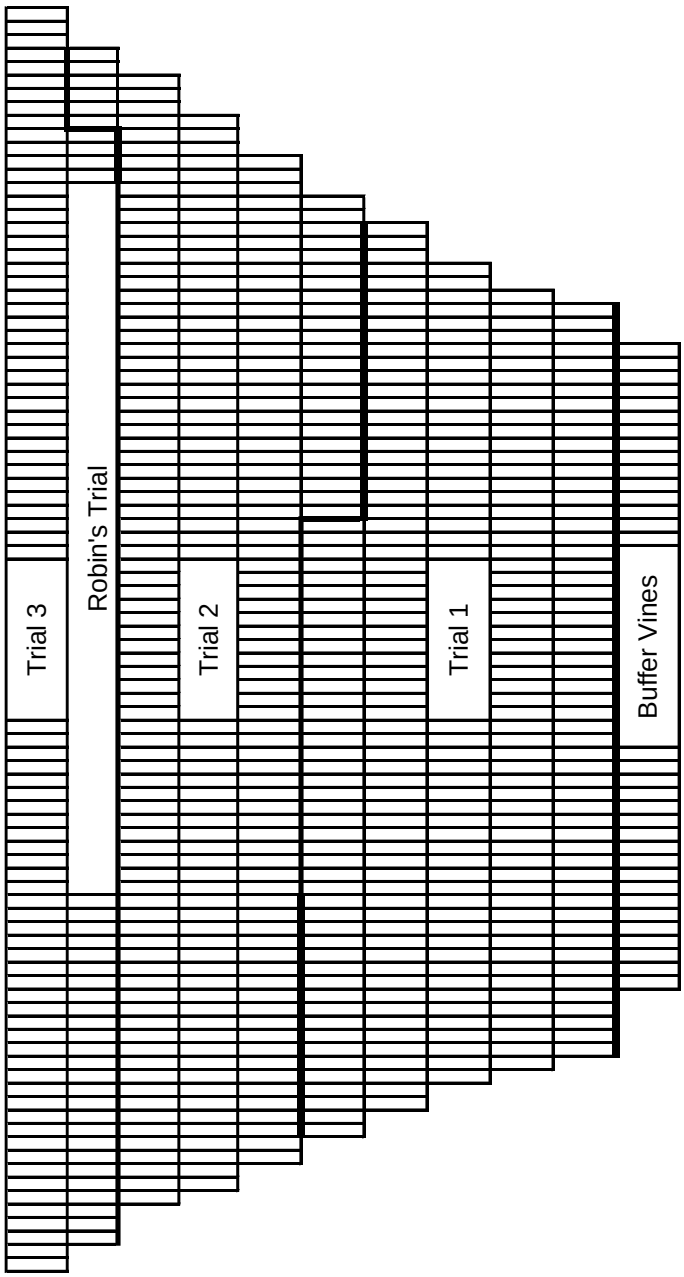


Vineyard Row 11 10 9 8 7 6 5 4 3 2 1

D. Application history

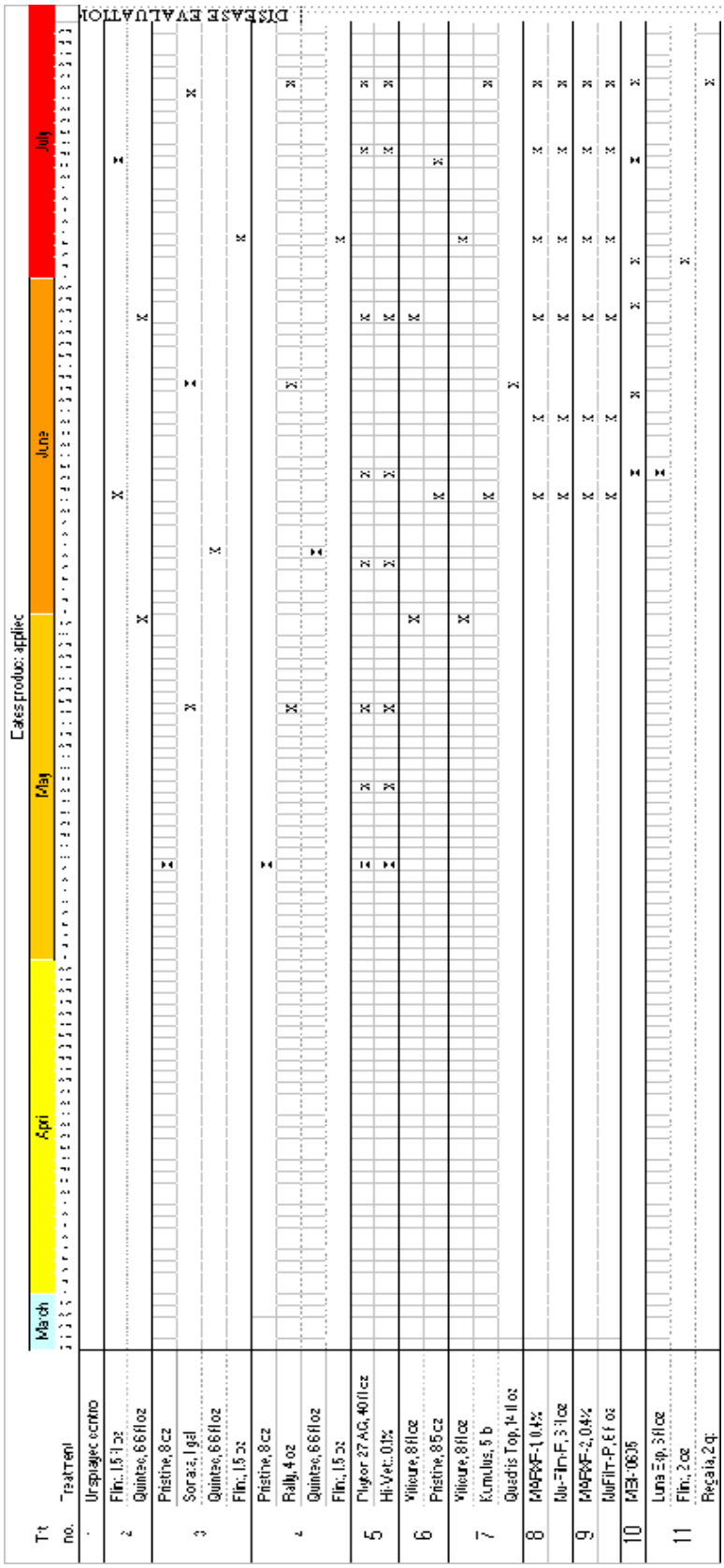
TRIAL 1

Trt no.	Treatment
1	Unsprayed control
2	Quintec, 6.6 fl oz
3	Rally, 5 oz
	Silwet L-77, 0.125%
	Quintec, 4 fl oz
4	Luna Exp, 6 fl oz
	Quintec, 6.6 fl oz
	Silwet L-77, 0.125%
5	Pristine, 10.5 oz
	Quintec, 6.6 fl oz
	Silwet L-77, 0.125%
6	Torino, 3.4 fl oz
	Quintec, 4 fl oz
	Silwet L-77, 0.125%
7	Tranquility, 12 fl oz
	Flint, 2 oz
8	Luna Exp, 6 fl oz
	Flint, 2 oz
9	Sovran, 4.8 oz
	Topguard 1.04, 10 fl oz
	Quintec, 4 fl oz
10	Kumulus, 5lbf100 gal
	Probald Plus, 30 fl oz
	Abound, 15.4 fl oz
	Silwet L-77, 0.125%
11	Kumulus, 5lbf100 gal
	Probald Plus, 21 fl oz
	Abound, 10 fl oz
	Silwet L-77, 0.125%
	Elite, 4 oz
12	Kumulus, 5lbf100 gal
	Elite, 4 oz
	Silwet L-77, 0.125%
	Abound, 15.4 fl oz
13	Probald Plus, 30 fl oz
	Silwet L-77, 0.125%
	Sonata, 2 qt
14	Sonata, 2 qt
	Silwet L-77, 0.125%
15	Quadris Top, 14 fl oz
	Dyneamic, 0.125%
	Quintec, 4 fl oz
16	Inspire Super, 20 fl oz
	Dyneamic, 0.125%
	Quintec, 4 fl oz
17	Exp 3, 13 fl oz
	Dyneamic, 0.125%
	Quintec, 4 fl oz
18	Dyneamic, 0.125%
	Exp 3, 13 fl oz
19	Quintec, 6.6 fl oz
	Flint, 2 oz
20	Topguard 1.04, 10 fl oz
21	NUP 120033, 1.75 lb
	Flint, 2 oz
22	Kocide, 1.75 lb
23	Pristine, 12 oz
	Sylgard 309, 3 fl oz/ 100 gal
24	Pristine, 12 oz
	Sylgard 309, 3 fl oz/ 100 gal
	Vivando, 15.4 fl oz
25	Merivon, 5 oz
	Sylgard 309, 3 fl oz/ 100 gal
	Vivando, 15.4 fl oz
26	Merivon, 5 oz
	Sylgard 309, 3 fl oz/ 100 gal
27	Merivon, 8 oz
	Sylgard 309, 3 fl oz/ 100 gal

TRIAL 2

Trt no.	Treatment	March	April	May	June	July	DISEASE EVALUATION
1	Unsprayed control						
2	Viticure, 8 fl oz			X	X	X	
	Pristine, 8.5 oz			X	X	X	
3	Viticure, 8 fl oz			X	X		
	Kumulus, 5 lb/100 gal			X		X	
	Quadris Top, 14 fl oz				X	X	
4	Exp 4, 0.25%			X	X	X	
	Flint, 2 oz			X	X	X	
5	Exp 4, 0.25%			X	X	X	
	Flint, 1 oz			X	X	X	
6	Flint, 2 oz			X	X	X	
7	IKF-309, 4 fl oz			X	X	X	
8	IKF-309, 5 fl oz			X	X	X	
9	IKF-3094 fl oz			X	X	X	
	Rally, 4 oz			X	X		
10	IKF-309, 4 fl oz			X	X	X	
	Elite, 4 oz			X	X	X	
11	Vivando, 10.3 fl oz			X	X	X	
12	Flint, 2 oz			X			
	Quintec, 6.6 fl oz		X				
13	Stylet-oil, 2%			X	X	X	
14	Stylet-oil alone, 1%		X				
	Procure, 6 oz			X	X	X	
	Stylet-oil, 1%			X	X	X	
15	Stylet-oil(before bloom), 1%		X				
	Flint, 2 oz			X	X	X	
	Stylet-oil, 1%			X	X	X	
16	Tri-Trek, 1%			X	X	X	
17	Tri-Tek, 2%			X	X	X	
18	Eco 4000, .05%			X	X	X	
19	Acadian, .5 gal			X	X	X	
	Rally, 4 oz			X	X	X	
20	Rally, 4 oz			X	X	X	
21	Exp 1			X	X	X	
22	Exp 2			X	X	X	
23	Kumulus, 5lb			X	X	X	
24	Exp A, 0.25%			X	X	X	
	Kumulus, 5 lb			X	X	X	
25	CX-10440 5% SC, 6.5 fl oz			X	X	X	

TRIAL 3


Trt no.
Treatment
Untreated control
Flint, 1.5 oz
Quintec, 6.6 fl oz
Pristine, 8 oz
Sonata, 1 gal
Quintec, 6.6 fl oz
Flint, 1.5 oz
Pristine, 8 oz
Rally, 4 oz
Quintec, 6.6 fl oz
Flint, 1.5 oz
Rubigan 27 AG, 40 fl oz
Hi-Yield, 0.1%
Vibrance, 8 fl oz
Pristine, 8.5 oz
Vibrance, 8 fl oz
Kumulus, 5 lb
Quadris Top, 14 fl oz
MARXF-1, 0.4%
Nu-Film-F, 3 fl oz
MARXF-2, 0.4%
NuFilm-P, 6 fl oz
M34-0636
Luna Exp, 3 fl oz
Flint, 2 oz
Regalia, 2 qt
March
April
May
June
July
Cases produc. applic
DISEASE EVALUATION

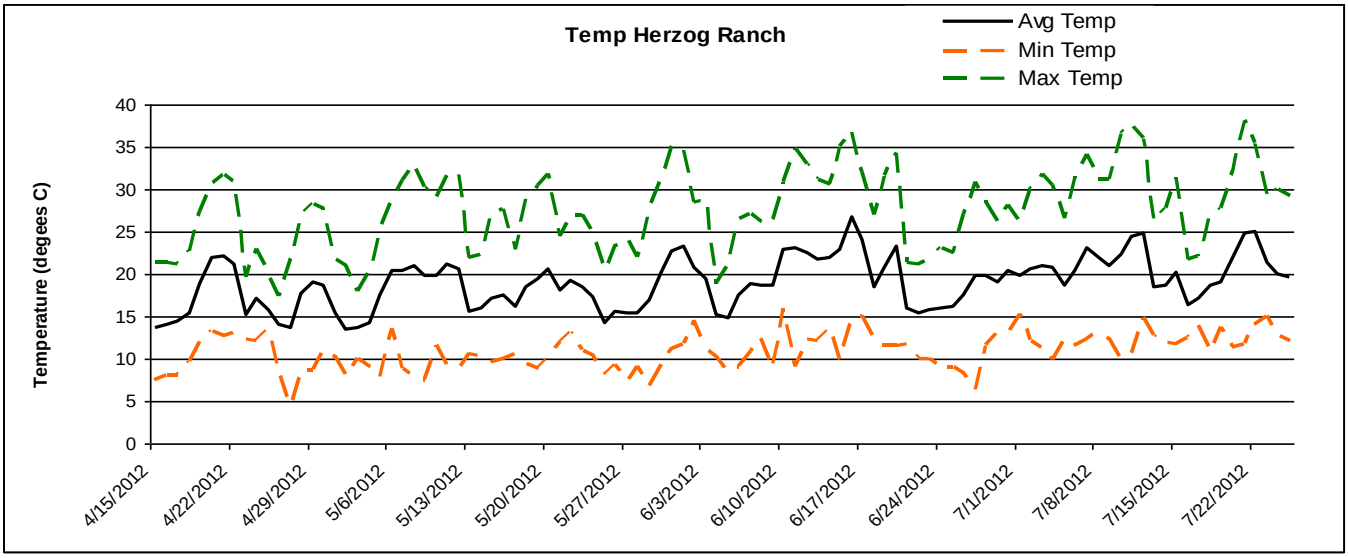
E. Vine management

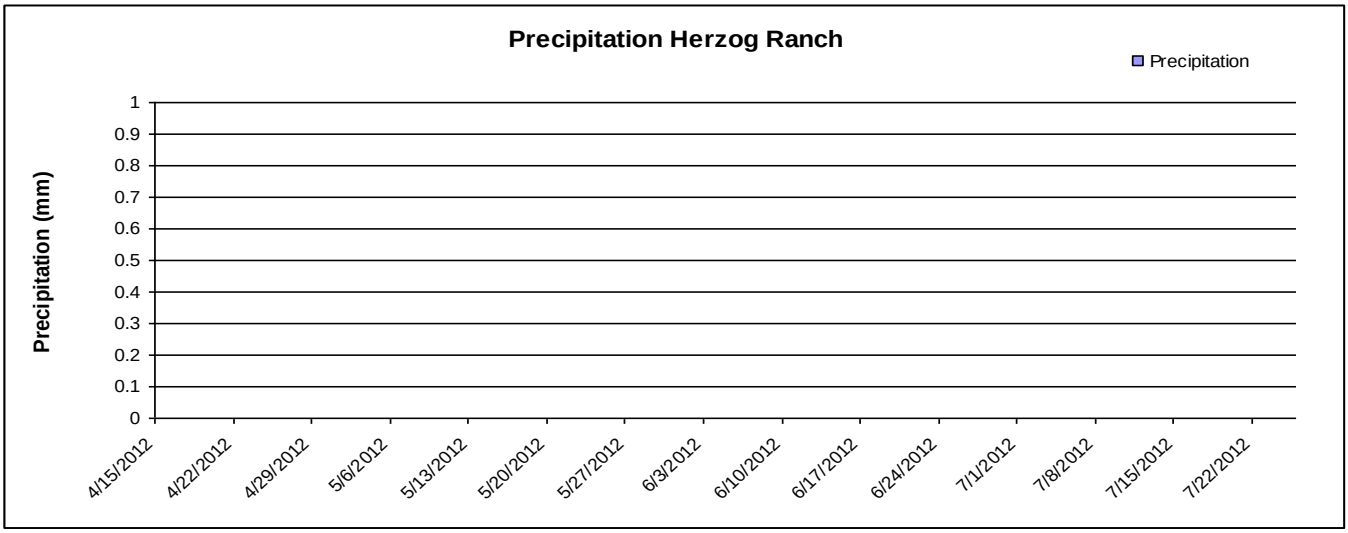
During the application period (mid April to late July), vines were irrigated two times by flooding. Sucker shoots were removed by local field personnel during the second week of May 2012. Leaf removal around the clusters was conducted by our research group on May 31 and June 7 2012. Sucker and leaf removal were done on all trials. Overhanging shoots were hedged on June 4, 5, and 6 2012 using electric hedgers. Additional small-scale removal of leaves was also conducted at various times.

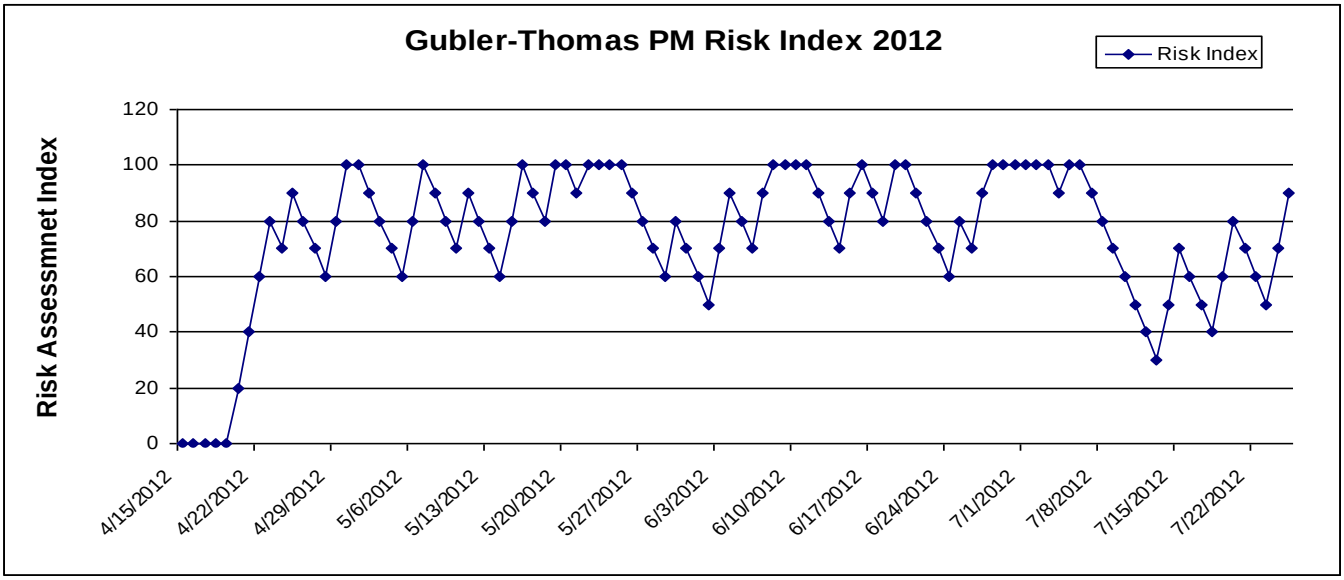
F. Data collection and statistics

Daily temperature, precipitation data and Gubler-Thomas Risk Index values were computed and obtained from a Metos weather station (Pessl Instruments Gmbh, Weksweg 107, 8160 Weiz, Austria) located at the site. Effect of plot position on plot mean severity was based on data values for all plots from all trials. Disease was assessed on 23 July. Powdery mildew incidence and severity were assessed in each plot by evaluating twenty five random clusters. Incidence was defined as the proportion of clusters in a plot hosting at least some living powdery mildew. Severity was determined by estimating the percentage of berries in a cluster that were infected; the severity value of all clusters was then averaged to give a plot-wide estimate of disease severity. Visual estimates of severity were made for more heavily infected clusters. Mean incidence and severity values for each treatment along with standard error were computed. Trial models were analyzed using the ANOVA Tests for data; P-values for trials 1, 2, 3, and 3A were all $P<0.0001$. Means comparisons were made using Fisher's LSD with $\alpha=0.05$.

Figure 1. Weather data, powdery mildew risk index values, and disease progression in the trials from April to until disease evaluation on 26 July. (A-B) daily records of precipitation and temperatures from the Powdery Mildew index website, http://www.fieldclimate.com. (C) Powdery mildew risk index, calculated by an on site Metos weather station







Results and discussion

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 α=0.05; alt =alternated with.

Treatment	Disease Severity %		Disease Incidence %	
Merivon, 8 fl oz + Sylgard 309, 3 fl oz/100 gal, 28 d	0.00	d	0.80	h
Merivon, 5 fl oz Sylgard 309, 3 fl oz/100 gal alt Vivando, 15.4 fl oz + Sylgard 309, 0125%, 21 d	0.05	d	3.20	gh
Rally, 5 oz + Silwet L-77, 0.125%(v/v) alt Quintec, 6.6 fl oz + Silwet L-77, 0.125% (v/v), 14 d	0.10	d	8.00	efgh
Merivon, 5 fl oz + Sylgard 309, 3 fl oz/100 gal, 21 d	0.10	d	7.20	efgh
Topguard, 10 fl oz, 14 d	0.14	d	6.40	fgh
Torino, 3.4 fl oz + Silwet L-77, 0.125% (v/v) alt Quintec, 4 fl oz + Silwet L-77, 0.125%(v/v), 14 d	0.21	d	6.40	fgh
Inspire Super, 20 fl oz + Dyneamic, 0.125%(v/v) alt Quintec, 4 fl oz + Dyneamic, 0.125% (v/v), 14 d	0.21	d	7.20	efgh
Luna Exp, 6 fl oz + Silwet L-77, 0.125% (v/v) alt Quintec, 6.6 fl oz + Silwet L-77, 0.125% (v/v), 21 d	0.24	d	10.40	edfgh
Pristine, 10.5 oz + Silwet L-77, 0.125% alt Quintec, 6.6 fl oz + Silwet L-77, 0.125% 21 d	0.27	d	6.40	fgh
Pristine, 12 oz + Sylgard 309, 3 fl oz/100 gal, 21 d	0.40	d	16.00	defgh
Kumulus, 5 lb/100 gal (at budbreak) then Problad Plus, 30 fl oz+ Silwet L-77, 0.125% (v/v), 14d alt Abound, 15.4 fl oz + Silwet L-77, 0.125% (v/v), 14-21 d (RI)	0.40	d	21.60	def
Quadris Top, 2 qt + Dyneamic, 0.125% (v/v) alt Quintec, 4 fl oz + Dyneamic, + 0.125% (v/v), 14 d	0.41	d	15.20	defgh
Pristine, 12 oz + Sylgard 309, 3 fl oz/100 gal alt Vivando, 15.4 fl oz + Sylgard 309, 3 fl oz/100 gal, 21 d	0.43	d	11.20	defgh
Sovran, 4.8 oz then Topguard, 10 fl oz then Quintec, 4 fl oz then Topguard, 10 fl oz, 14 d	0.45	d	12.80	defgh
Exp 3, 13 fl oz + Dyneamic, 0.125% (v/v), 14 d	0.52	d	22.40	def
Exp 3, 13 fl oz + Dyneamic, 0.125%(v/v) alt Quintec, 4 fl oz + Dyneamic, 0.125% (v/v), 14 d	0.55	d	19.20	defg
Problad Plus, 30 fl oz + Silwet L-77, 0.125% (v/v) (2x) then Sonata, 2 qt + Silwett-L-77, 0.125% (v/v), 7-10 d	0.58	d	12.80	defgh
Luna Exp, 6 fl oz alt Flint, 2 oz, 14 d	0.61	d	6.40	fgh
Kumulus (at budbreak), 5lb/100 gal, then Problad Plus, 21 fl oz + Abound, 10 fl oz, 14d + Silwet L-77, 0.0125% alt Elite, 4 oz + Silwet L-77, 0.125% (v/v), 14-21d (RI)	1.12	d	24.80	cde
Quintec 6.6 fl oz alt Flint, 2 oz, 14-21 (RI)	1.74	d	42.40	bc
Kumulus (at budbreak), 5lb/100 gal, then Elite, 4 oz + Silwet L-77, 0.125% (v/v), 14 d alt Abound, 15.4 fl oz + Silwet L-77, 0.125% (v/v), 14-21 (RI)	1.75	d	22.40	def
Quintec, 6.6 fl oz, 21 d	2.10	d	54.00	b
Sonata, 2 qt + Silwet L-77, 0.125%(v.v), 7-10 d (RI)	2.49	d	28.00	cd
Tranquility, 12.0 fl oz, 21 d alt Flint, 2 oz, 14 d	21.87	c	83.20	a
Kocide, 1.75 lb, 14d	41.52	b	95.20	a
NUP 12033 30 WDG (Flint when disease pressure high)14-21d (RI), 14 d (Flint)	46.30	b	98.40	a
Untreated Control	99.00	a	100.00	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 α=0.05; alt =alternated with.

Treatment	Disease Severity %		Disease Incidence %	
Vivando, 10.3 fl oz, 14d	0.00	f	0.00	i
IKF-309, 4 fl oz alt Elite, 4 oz, 14d	0.17	f	4.80	hi
IKF-309, 4 fl oz alt Rally, 4 oz, 14d	0.26	f	8.00	hi
Tri-Tek, 2 % (v/v), 10-21d (RI)	0.34	f	10.40	hi
Viticure, 8 fl oz alt Kumulus, 5 lb/100 gal alt Quadris Top, 14 fl oz, 14d	0.36	f	6.40	hi
IKF-309, 5 fl oz, 14d	0.40	f	11.20	hi
IKF-309, 4 fl oz, 14d	0.49	f	12.80	hi
Stylet-oil, 2% (v/v), 14d	1.03	f	16.00	ghi
Viticure, 8 fl oz alt Pristine, 8.5 oz, 14-21d (RI)	1.07	f	22.40	fghi
Tri-Tek, 1 % (v/v), 10-21d (RI)	1.15	f	15.20	hi
Stylet-oil (before bloom), 1% (v/v) then Stylet-oil, 1% (v/v) + Flint, 2 oz, 14d	1.36	f	25.60	fgh
Kumulus, 5 lb + Exp A, 0.25% (v/v), 10-14d (RI)	1.55	f	23.20	fgh
Stylet-oil (before bloom), 1% (v/v) then Stylet-oil, 1% (v/v) + Procure, 6 oz, 14d	1.62	f	14.40	hi
Acadian, 0.5 gal + Rally, 4 oz, 14d	3.31	f	40.00	ef
Kumulus, 5lb, 10-14 (RI)	3.52	f	53.60	de
Rally, 4 oz, 14d	3.89	ef	38.40	efg
Exp. 4, 0.25% (v/v), 7d alt Flint, 2 oz, 14d	5.11	def	60.00	cde
Exp. 4, 0.25% (v/v) + Flint, 1 oz, 14d	5.76	def	68.80	bcd
Eco 4000, 0.05% (v/v) until June then 0.075% (v/v), 14d	7.06	def	64.00	bcd
Quintec, 6.6 fl oz alt Flint, 2 oz, 14-21d (RI) then Leaf Removal alone	8.37	def	83.20	ab
CX-10440 5% SC, 6.5 fl oz. 7-14 (RI)	12.48	cde	64.00	bcd
Flint, 2 oz, 14d	13.69	cd	81.60	abc
Exp. 1, 10d	20.93	c	94.40	a
Exp. 2, 10d	40.01	b	98.40	a
Untreated Control	95.96	a	100.00	a

Table 3. Disease severity in trial 3 treatments. 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 α=0.05; alt =alternated with.

Treatment	Disease Severity %		Disease Incidence %	
Stylet Oil, 0.5% (v/v) + Luna Exp, 6 fl oz, 21d then Stylet Oil, 0.5% (v/v) + Flint, 2oz, 14d then Luna Exp., 6 fl oz, 21 d then Flint, 2 oz, 14d then Regalia, 2 qt, 7d	0.04	d	2.40	e
Stylet Oil 0.5% (v/v) Luna Exp, 6 fl oz, 21 d then Stylet Oil 0.5% (v/v) + Flint, 2 oz, 14d then Regalia,	0.05	d	4.00	de
Stylet Oil, 0.5% (v/v) + Luna Exp, 6 fl oz, 21d then Viticure, 8 oz, 14-21d (RI) alt Kumulus, 5 lb, 10-14d (RI)alt Quadris Top, 14 oz, 14-21d (RI)	0.40	d	16.00	cde
Phyton 27 AG, 40 fl oz + HiWett, 0.1% (v/v), 10-14d (v/v)	0.54	d	16.80	cde
Stylet Oil, 0.5% (v/v) + Luna Exp 6 fl oz, 21d then Viticure, 8 fl oz alt Pristine, 8.5 oz, 14-21d (RI)	0.63	d	15.20	cde
Stylet Oil, 0.5% (v/v) + Luna Exp, 6 fl oz, 21d then MARXP-2, 0.4% (v/v) + NulFilm P, 6 fl oz, 7d	1.30	cd	28.80	cd
Sonata, 1 gal alt Quintec, 4 fl oz alt Sonata, 1 gal alt Flint, 1.5 oz alt Sonata, 1 gal, 14d	1.47	cd	36.80	c
Stylet Oil, 0.5% (v/v) + Luna Exp, 6 fl oz, 21d then MARXP-1, 0.4% (v/v) + NulFilm P, 6 fl oz, 7d	3.94	bc	73.60	b
Pristine, 8 oz alt Rally, 4 oz alt Quintec, 4 fl oz alt Rally, 4 oz alt Flint, 1.5 oz alt Rally, 4 oz, 14d	4.52	b	70.40	b
Stylet Oil, 0.5% (v/v) + Luna Exp, 6 fl oz, 21d then Quintec, 6.6 fl oz alt Flint, 2 oz, 14-21d (RI)	5.66	b	73.60	b
Untreated Control	97.30	a	100.00	a

Acknowledgements

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Appendix: Materials

Product	Active ingredient(s) and concentration	Manufacturer or distributor	Chemical class (after Adaskaveg et al. 2008)
Acadian	soluble potash (5%)	Acadian Agritech	N/A
Abound	azoxystrobin (22.9%)	Syngenta	QoI
CX-10440 5% SC	proprietary	Certis	N/A
Dyneamic	polyalkyleneoxide modified polydimethylsiloxane, nonionic emulsifiers, methyl ester of C16-C18 fatty acids (99%)	Helena Chemical Co.	adjuvant
Eco 4000	Proprietary	Nature Chem	oil
Elite 45 WP	tebuconazole (45%)	Bayer	DMI-triazole
Exp A	N/A	proprietary	N/A
Exp 1	N/A	proprietary	N/A
Exp 2	N/A	proprietary	N/A
Exp 3	N/A	proprietary	N/A
Exp 4	proprietary	proprietary	N/A
Flint 50WG	trifloxystrobin (50%)	Bayer	QoI
Hi Wett	polysiloxane polyether copolymer, polyoxyethylene-polyoxypropylene copolymer & alcohol ethoxylate (100%)	First Choice	adjuvant
IKF-309	proprietary	ISK Biosciences	N/A
Inspire Super 2.82	difenoconazole (8.4%), cyprodinil (24%)	Syngenta Crop Protection, Inc.	DMI + anilinopyrimidine
JMS Stylet-Oil	paraffinic oil (97.1%)	JMS Flower Farms, Inc.	oil
Kocide 3000	copper hydroxide (46.1%)	DuPont	copper
Kumulus DF	sulfur (80%)	BASF	sulfur
Luna Experience	fluopyram (17.54%), tebuconazole (17.54%)	Bayer	DMI-triazole/ N/A
Luna Tranquility	fluopyram (11.3%) pyrimethanil (33.8%)	Bayer	SDHI/AP
MARXP-1	potassium hypochlorite	Enviro Tech Chemical Services Inc.	Bleach
MARXP-2	peroxyacetic Acid (14-17%) hydrogen Peroxide (21-23%) acetic Acid (14-20%)	Enviro Tech Chemical Services Inc.	N/A

Merivon	fluxabyroxad (21.26%) pyraclostrobin (21.26%)	BASF	N/A + QoI
NUP-12033	copper hydroxide (46.1%)	Nufarm Americas Inc.	N/A
Phyton-27 AG	copper sulfate pentahydrate (21.27%)	Phyton Corporation	other
Pristine	pyraclostrobin (12.8%) boscalid (25.2%)	BASF	QoI + carboxamide
Problad Plus	protein extracted from the plant of the genus Lupinus, 20%	FMC Corporation	N/A
Procure 480SC	triflumizole (42.14%)	Crompton Manufacturing Company (Chemtura Corp.)	DMI
Quadris Top 2.71	azoxystrobin (18.2%), difenoconazole (11.9%)	Syngenta Crop Protection, Inc	DMI-triazole/QoI
Quintec	quinoxyfen (22.6%)	Dow AgroSciences LLP	quinoline
Rally 40 WSP	myclobutanil (40%)	Dow AgroSciences LLP	DMI-triazole
Regalia	*Reynoutria sachilinensis* extract	Marrone BioInnovations	biological
Silwet L-77	allyloxypolyethyleneglycol methyl ether heptamethyltrisiloxane polyalkyleneoxide	Helena Chemical Co.	unknown
Sonata	*Bacillus pumilus* QST 2808 (1.38%)	Agraquest	biological
Sovran	kresoxim-methyl (50%)	Chaminova, Inc	QoI
Sylgard 309	polysiloxane (80%)	Dow Corning Corp	adjuvant
Topguard	flutriafol (12%)	Cheminova	DMI
Torino	N/A	Gowan Co.	N/A
Tranquility	fluopyram (11.3%) pyrimethanil (33.8%)	Bayer	N/A
Tri-Tek	petroleum oil (80%)	Brandt, Inc.	oil
Viticure 4 SC	triflumizole (42.14%)	Crompton Manufacturing Company (Chemtura Corp.)	DMI
Vivando	metrafenone (300g/L)	BASF	N/A

Appendix sources: (1) Adaskaveg, et al. 2012. Efficacy and timing of fungicides, bactericides and biologicals for deciduous tree fruit, nut, strawberry, and vine crops 2012, available at http://ucanr.edu/sites/plp/files/146650.pdf. (2) Janousek et al. 2008. Grape powdery mildew trials, available at http://ucanr.edu/sites/plp/Cooperative_Extension/gubler/fungtrials2008/, (3) Bay, et al, 2011, Grape powdery mildew Trials available at: http://ucanr.edu/sites/plp/Cooperative_Extension/gubler/fungtrials2011/ , (4) product-specific MSDS and/or labels.