Final Report:
Control of grape powdery mildew with synthetic, biological and organic fungicides: 2014 field trials

W. Douglas Gubler, Trang T. Nguyen, and Nicholas S. Morris

Department of Plant Pathology, University of California, Davis, CA, 95616

University of California Cooperative Extension,
Department of Plant Pathology,
University of California, Davis, October 2014

Published 2014 at: http://plantpathology.ucdavis.edu/Cooperative_Extension/

Report Summary

Powdery mildew is an economically important disease of grapes worldwide. This report details the findings of our annual powdery mildew fungicide trials on grapevine (*Vitis vinifera*, Cultivar Chardonnay). Trials were conducted at Herzog Ranch, near Courtland, California in 2014. Treatments were placed in four adjacent trials in the vineyard in a complete randomized design. Spraying commenced in April 14. Powdery mildew pressure increased slowly, held in check by cool temperatures after disease onset, but quickly built to very high disease pressure levels as temperatures warmed. Spraying was completed at veraison on July 11 and treatments were evaluated for disease incidence and severity on July 21.

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. Some applications were based on the Gubler-Thomas Risk Index, with application intervals based on the index.

Temperatures were mild and humidity was low during much of the 2014 growing season, providing optimal conditions for the asexual reproduction and dispersal of powdery mildew. Overall disease pressure was relatively high. By early June, heavy mildew coverage was evident on untreated clusters. By the time of disease evaluation, disease severity in untreated plots in all trials reached 98-100%.

Materials and Methods

A. Experimental design

Experimental desig	Complete randomized design with 5 replicates.		
Experimental unit	2 adjacent vines = 1 plot		
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 125 gallons (certain products), = 2.2 gallons/5 replicates 150 gallons (pre-bloom to pea-sized berries, late April – early June) = 2.7 gallons/5 reps 200 gallons (late season), = 3.5 gallons/5 reps 250 gallons (late season),= 4.4 gallons/5 reps		
Application metho	Handgun sprayers (attached to Nifty Fifty brand 25 or 50 gallon 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.

Trial 1 (Row 9-10)
4 reps: 0.01416 acre

No.	Flag	Treatment	Frequency (days)	Application rate (per acre)	FP/ 4 replicates
1	W	Untreated Control	None	None	None
2	G	Microthiol disperss alt Serenade Optimum + Kinetic	7-14 (RI)	5lb alt 1 lb + 0.05% (v/v)	32.1 g alt 6.4 g + 2.6 ml at 100 gal or 4.0 ml at 150 gal or 5.3 ml at 200 gal or 6.6 ml at 250 gal
3	BD	Microthiol disperss alt Regalia + Kinetic	7-14 (RI)	5 lb alt 2 qt + 0.05% (v/v)	32.1 g alt 26.8 ml + 2.6 ml at 100 gal or 4.0 ml at 150 gal or 5.3 ml at 200 gal or 6.6 ml at 250 gal
4	KC	Microthiol disperss alt Taegro + Kinetic	7-14 (RI)	5 lb alt 2.6 oz + 0.05% (v/v)	32.1 g alt 1.0 g + 2.6 ml at 100 gal or 4.0 ml at 150 gal or 5.3 ml at 200 gal or 6.6 ml at 250 gal
5	GD	Microthiol disperss alt Taegro + Kinetic	7-14 (RI)	5 lb alt 5.2 oz + 0.05% v/v)	32.1 g alt 2.1 g + 2.6 ml at 100 gal or 4.0 ml at 150 gal or 5.3 ml at 200 gal or 6.6 ml at 250 gal
6	PKS	OR 114	7-10 (RI)	0.5 gal	26.8 ml
7	GKS	OR 114 + OR 009	7-10 (RI)	0.5 gal + 1 qt	26.8 ml + 13.4 ml
8	RKS	SSS 6	7-10 (RI)	0.5 gal	26.8 ml
9	YS	SSS 6 + OR 009	7-10 (RI)	0.5 gal + 1 qt	26.8 ml + 13.4 ml
10	RS	PureSpray Green + Serenade Optimum	10	1% (v/v) + 8 oz	79.5 ml at 150 gal or 106.0 ml at 200 gal or 132.5 ml at 250 gal + 3.2 g
11	RKC	PureSpray Green	10	1% (v/v)	79.5 ml at 150 gal or 106.0 ml at 200 gal or 132.5 ml at 250 gal
12	RC	Serenade Optimum	10	14 oz	5.6 g
13	PKC	Timorex Gold	10	0.86 qt	11.5 ml
14	GS	Timorex Gold alt Quintec	10 alt 14	0.86 qt alt 4 fl oz	11.5 ml alt 1.7 ml

Note: Treatment 13 and 14 were sprayed with Luna Experience 6 fl oz and JMS Stylet Oil 0.5% (v/v) on April 25 and May 9.

Trial 2 (Row 11)

No.	Flag	Treatment	Frequency (days)	Application rate (per acre)	FP/5 replicates
1	W	Untreated Control	None	None	None
2	OD	Pyriofenone	14	4 fl oz	2.1 ml
3	OS	Pyriofenone	14	5 fl oz	2.6 ml
4	GKD	Pyriofenone alt Quintec	14	4 fl oz alt 4 fl oz	2.1 ml alt 2.1 ml
5	RKC	Pyriofenone alt Abound	14	4 fl oz alt 11 fl oz	2.1 ml alt 5.8 ml
6	B	Pyriofenone alt Elite	14	4 fl oz alt 4 oz	2.1 ml alt 2.0 g
7	GS	MCW-710 SC + Dyneamic	10-14 (RI)	6 fl oz + 0.125% (v/v)	3.1 ml + 8.5 ml at 100 gal 12.8 ml at 150 gal 16.6 ml at 200 gal 21.3 ml at 250 gal
8	KD	MCW-710 SC + Dyneamic	10-14 (RI)	8.6 fl oz + 0.0125% (v/v)	4.5 ml + 8.5 ml at 100 gal 12.8 ml at 150 gal 16.6 ml at 200 gal 21.3 ml at 250 gal
9	GD	(MCW-710 SC alt Quintec) + Dyneamic	10-14 (RI)	(8.6 fl oz alt 4 fl oz) + 0.125% (v/v)	(4.5 ml alt 2.1 ml) + 8.5 ml at 100 gal 12.8 ml at 150 gal 16.6 ml at 200 gal 21.3 ml at 250 gal

Trial 3 (Row 12)

This trial is funded by the IR-4 Biopesticide Research Project

No.	Flag	Treatment	Frequency (days)	Application rate (per acre)	FP/5 replicates
1	YKC	Stylet alt Regalia	7	0.5% (v/v) alt 2 qt	34.1 ml at 100 gal or 51.1 ml at 150 gal or 66.2 ml at 200 gal or 83..3 ml at 250 gal alt 33.5 ml
2	BC	Stylet then Regalia (2x) then Stylet then Luna Experience	7 then 7 (2x) then 7 then 21	0.5% (v/v) then 2 qt then 0.5% (v/v) then 6 fl oz	34.1 ml at 100 gal or 51.1 ml at 150 gal or 66.2 ml at 200 gal or 83..3 ml at 250 gal or then 33.5 ml then 34.1 ml at 100 gal or 51.1 ml at 150 gal or 66.2 ml at 200 gal or 83..3 ml at 250 gal or then 3.1 ml
3	Y	Regalia (2x) then Luna Experience then Pristine then Flint	7 (2x) then 21 then 14 then 14	2 qt (2x) then 6 fl oz then 8 oz then 2 oz	33.5 ml (2x) then 3.1 ml then 4.0 g then 1.0 g
4	PKS	Rally alt Regalia	14 alt 7	5 oz alt 2 qt	2.5 g alt 33.5 ml
5	BS	JMS Stylet-oil then Luna Experience then Regalia (2x) then Flint	7 then 21 then 7 (2x) then 14	0.5% (v/v) then 6 fl oz then 2 qt (2x) then 2 oz	34.1 ml at 100 gal or 51.1 ml at 150 gal or 66.2 ml at 200 gal or 83..3 ml at 250 gal or then 3.1 ml then 33.5 ml (2x) then 1.0 g
6	YC	Rally	14	5 oz	2.5 g
7	BD	Rally + Regalia	14	5 oz + 2 qt	2.5 g + 33.5 ml

Trial 4 (Row 14-15)

No.	Flag.	Treatment	Frequency (days)	Application rate (per acre)	FP/5 replicates
1	W	Untreated Control	None	None	None
2	OD	Double Nikel 55 WDG	10-14 (RI)	20 oz	10.0 g
3	OS	Double Nikel LC	10-14 (RI)	2 qt	33.5 ml
4	GKD	Tavano 5% SC	18	6.5 fl oz	3.4 ml
5	KD	K-PHITE 7LP +Tactic	14	3 qt + 6 oz/100 gal	50.2 ml + 1.6 ml at 50 gal or 3.2 ml at 100 gal or 4.8 ml at 150 gal
6	GD	K-PHITE 7LP + Latron B-1956	14	3 qt + 6 oz/100 gal	50.2 ml + 1.6 ml at 50 gal or 3.2 ml at 100 gal or 4.8 ml at 150 gal
7	YKC	QSE-40	10	1.35 oz/25.4 gal	2.8 ml at 100 gal or 4.2 ml at 150 gal or 5.6 ml at 200 gal or 7.0 ml at 250 gal
8	BC	QSE-60	10	2.03 oz/25.4 gal	4.3 ml at 100 gal or 6.4 ml at 150 gal or 8.6 ml at 200 gal or 10.7 ml at 250 gal
9	BS	Cinnerate	7-10 (RI)	25 fl oz	13.1 ml
10	YC	Serenade Optimum	10	20 oz	10.0 g
11	BD	Vigor Cal	14	1 qt	16.7 ml
12	GKS	Vigor Cal	14	2 qt	33.5 ml
13	YD	Sysstem Cal	14	1 qt	16.7 ml
14	K	Sysstem Cal	14	2 qt	33.5 ml
15	YKS	Sysstem SeaCal	14	1 qt	16.7 ml
16	YS	Sysstem SeaCal	14	2 qt	33.5 ml
17	GS	GOP-1 Bran + GOP-1 Oil	7	7 oz/ 25 gal + 32 oz/ 25 gal	21.4 g + 102.2 ml (at 150 gal) or 27.8 g + 132.5 ml (at 200 gal) or 34.9 g + 166.5 ml (at 250 gal)
18	Y	Golden Pest Spray Oil (2x) then Quintec alt Rally	7 (2x) then 21 alt 14	1% (v/v) (2x) then 6.6 fl oz alt 5 oz	68.1 ml at 100 gal or 102.2 ml at 150 gal or 132.5 ml at 200 gal or 166.5 ml at 250 gal (2x) then 3.5 ml alt 2.5 g
19	PKS	Golden Pest Spray Oil (2x) then Quintec alt Rally	7 (2x) then 21 alt 14	2% (v/v) (2x) then 6.6 fl oz alt 5 oz	136.3 ml at 100 gal or 204.4 ml at 150 gal or 265.0 ml at 200 gal or 333.0 ml at 250 gal (2x) then 3.5 ml alt 2.5 g

Trial 5 (Row 16-17)

No.	Flag	Treatment	Frequency (days)	Application rate (per acre)	FP/5 replicates
1	W	Untreated Control	None	None	none
2	OKD	Mettle + Dyneamic	14-17 (RI)	5 fl oz + 0.125% (v/v)	2.6 ml + 8.5 ml at 100 gal 12.8 ml at 150 gal 16.6 ml at 200 gal 21.3 ml at 250 gal
3	OS	Torino SC +Dyneamic	14-17 (RI)	3.4 fl oz + 0.125% (v/v)	1.8 ml + 8.5 ml at 100 gal 12.8 ml at 150 gal 16.6 ml at 200 gal 21.3 ml at 250 gal
4	GKD	(Mettle then Pristine then Torino SC then Mettle then Quintec then Torino SC) + Dyneamic	14-17 (RI)	(5 fl oz then 10.5 oz then 3.4 fl oz then 5 fl oz then 6 fl oz then 3.4 fl oz) + 0.125% (v/v)	(2.6 ml then 5.3 g then 1.8 ml then 2.6 ml then 3.1 ml then 1.8 ml) + 8.5 ml at 100 gal 12.8 ml at 150 gal 16.6 ml at 200 gal 21.3 ml at 250 gal
5	GS	(Mettle then Pristine then Mettle then Torino SC then Quintec then Torino SC) + Dyneamic	14-17 (RI)	(5 fl oz then 10.5 oz then 5 fl oz then 3.4 fl oz then 6 fl oz then 3.4 oz) + 0.125% (v/v)	(2.6 ml then 5.3 g then 2.6 ml then 1.8 ml then 3.1 ml then 1.8 ml) + 8.5 ml at 100 gal 12.8 ml at 150 gal 16.6 ml at 200 gal 21.3 ml at 250 gal
6	KD	Luna Experience + Syl-Coat (from bloom)	21	8 fl oz + 4 fl oz/100 gal	4.2 ml + 2.1 ml at 100 gal or 3.2 ml at 150 gal or 4.2 ml at 200 gal or 5.3 ml at 250 gal
7	GD	Luna Tranquility + Syl-Coat (from bloom)	14	16 fl oz + 4 fl oz/100 gal	8.4 ml + 2.1 ml at 100 gal or 3.2 ml at 150 gal or 4.2 ml at 200 gal or 5.3 ml at 250 gal
8	YKC	(Luna Exp then Quintec then Luna Tranquility then Sonata ASO then Flint then Torino) + Syl-Coat (from bloom)	14	(6 fl oz then 4 fl oz then 16 fl oz then 3 qts then 2 oz then 3.4 fl oz) + 4 fl oz/100 gal	(4.2 ml then 2.6 ml then 8.4 ml then 50.2 ml then 1.5 g then 1.8 ml) + 2.1 ml at 100 gal or 3.2 ml at 150 gal or 4.2 ml at 200 gal or 5.3 ml at 250 gal
9	BC	(Inspire Super alt Quintec) + Dynaemic	14	(20 fl oz 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 21.3 ml at 250 gal
10	Y	(Inspire Super then Quintec then Inspire Super then Taegro (4x)) + Dyneamic	14	(20 fl oz then 4 fl oz then 20 fl oz then 5.2 fl oz (4x)) + 0.125% (v/v)	(10.5 ml then 2.1 ml then 10.5 ml then 2.7 ml (4x)) + 8.5 ml at 100 gal 12.8 ml at 150 gal 16.6 ml at 200 gal 21.3 ml at 250 gal
11	PKS	Pristine	21	14.5 oz	7.3 g
12	BS	Viticure alt Quintec	14	6 fl oz alt 4 fl oz	3.1 ml alt 2.1 ml
13	YC	Viticure alt Pristine	14	6 fl oz alt 8 oz	3.1 ml alt 4.0 g
14	BD	Rhyme	14	2.5 fl oz	1.3 ml
15	GKS	Rhyme	14	5 fl oz	2.6 ml

16	YD	Sovran then Rhyme alt Quintec	14	4 oz then 5 fl oz alt 4 fl oz	2.0 g then 2.6 ml alt 2.1 ml
17	YKS	(Rally alt Quintec) + Dyneamic	14	(5 oz alt 4 fl oz) + 0.25% (v/v)	(2.5 g alt 2.1 ml) + 17 ml at 100 gal 25.5 ml at 150 gal 34 ml at 200 gal 42.5 ml at 250 gal
18	K	(Torino alt Quintec) + Dyneamic	14	(3.4 fl oz alt 4 fl oz) + 0.25% (v/v)	(1.8 ml alt 2.1 ml) + 17 ml at 100 gal 25.5 ml at 150 gal 34 ml at 200 gal 42.5 ml at 250 gal
19	YS	Quintec + Dyneamic	21	6.6 fl oz + 0.25% (v/v)	3.5 ml + 17 ml at 100 gal 25.5 ml at 150 gal 34 ml at 200 gal 42.5 ml at 250 gal
20	RKC	(Luna Experience alt Quintec) + Dyneamic	21	(8 fl oz alt 6.6 fl oz) + 0.25% (v/v)	(4.2 ml alt 3.5 ml) + 17 ml at 100 gal 25.5 ml at 150 gal 34 ml at 200 gal 42.5 ml at 250 gal
21	KS	(Pristine alt Quintec) + Dyneamic	21	(10.5 oz alt 6.6 fl oz) + 0.25% (v/v)	(5.3 g alt 3.5 ml) + 17 ml at 100 gal 25.5 ml at 150 gal 34 ml at 200 gal 42.5 ml at 250 gal

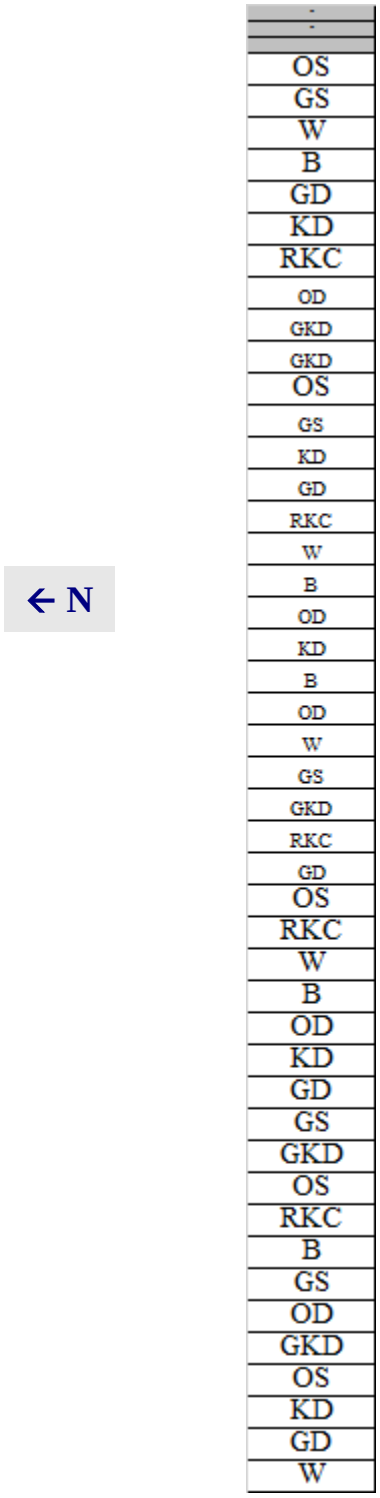
C. Maps

Trial 1

	BD	
	GKS	
	RKC	
	RKS	
	W	
	YS	
	RC	
	GD	
	KC	
	RS	
	PKS	
	G	
	W	
	BD	GS
	YS	PKC
	RS	GS
	RKC	PKC
	GKS	GS
	RC	PKC
	G	GS
	KC	PKC
	GD	
	PKS	G
	RKS	GD
	RC	YS
	RKC	RS
	RS	PKS
	YS	KC
	RKS	RKC
	GKS	W
	PKS	BD
	W	GKS
	GD	RC
	KC	RKS
	BD	
	G	
Row	10	9

← N

Trial 2



Row 11

Trial 3

BD
BS
BC
YKC
PKS
YC
BS
Y
PKS
BC
YKC
Y
BD
YC
PKS
BS
YKC
BD
Y
YC
BC
Y
YKC
BC
YC
BS
BS
PKS
BD
PKS
BS
BD
YC
Y
YKC
BC

← N

Row 12

Trial 4

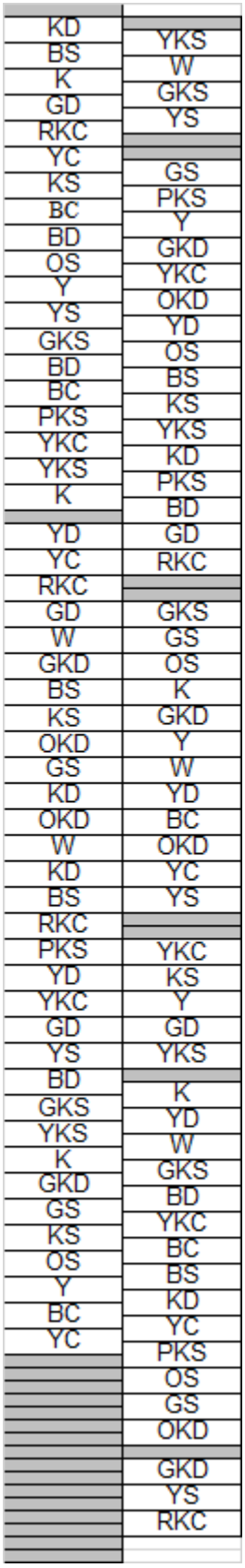
← N

YC	
OD	
GS	Y
	YKC
BC	
GKD	K
GKS	GD
PKS	BD
GS	KD
OS	BS
KD	YS
YS	OS
K	W
GKS	PKS
YD	YD
BD	YKS
Y	BC
W	YC
GKD	YS
GD	K
OD	GS
BC	GKS
YKS	W
YKC	OD
BS	OS
YC	
OD	PKS
K	Y
GD	GD
	GKD
PKS	YD
OS	BS
YS	YKS
BD	BD
YKC	KD
BC	YKC
GKS	
YC	YS
YKS	YKS
KD	K
W	YD
YD	GKS
	BD
BS	YC
GS	BS
GKD	PKS
	Y
Y	BC
	YKC
	GD
	KD
	GS
	GKD
	OS
	OD
	W

Row 15 14

Trial 5

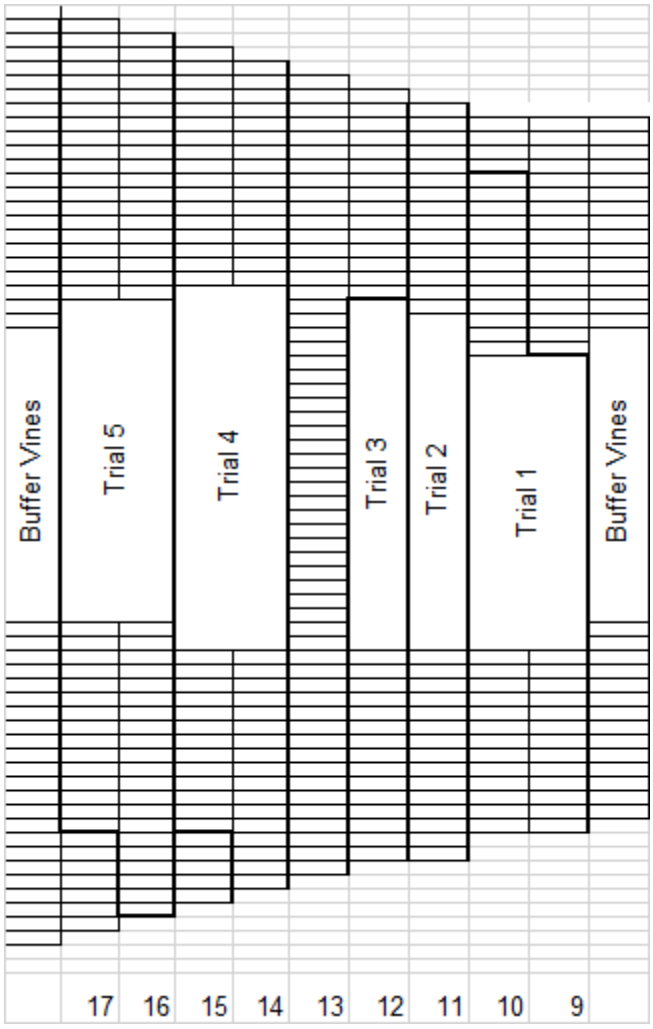
← N



Row 17 16

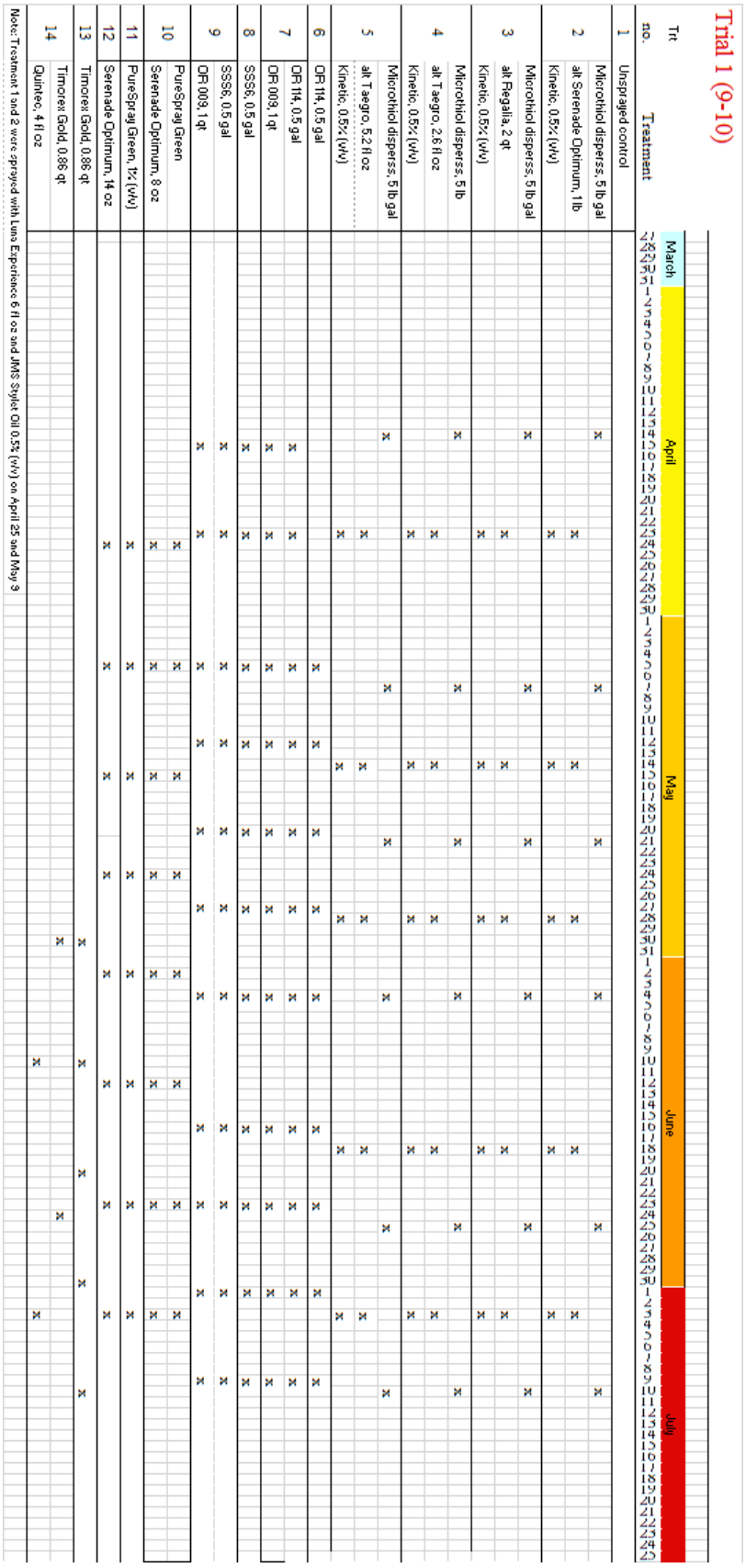
Overview map

← N

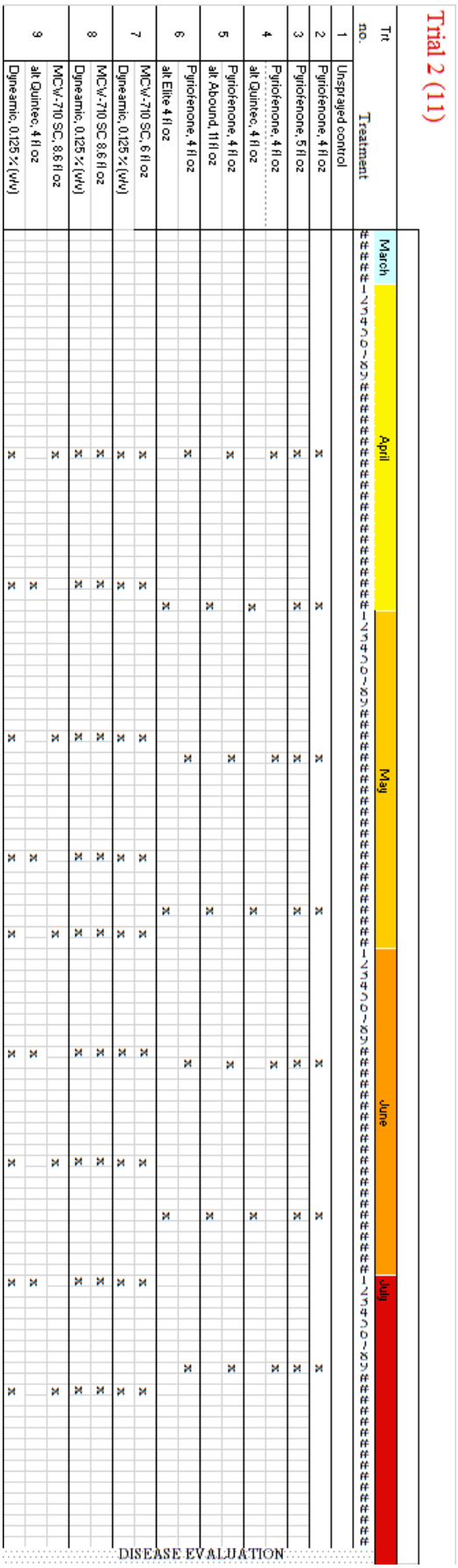


D. Application history

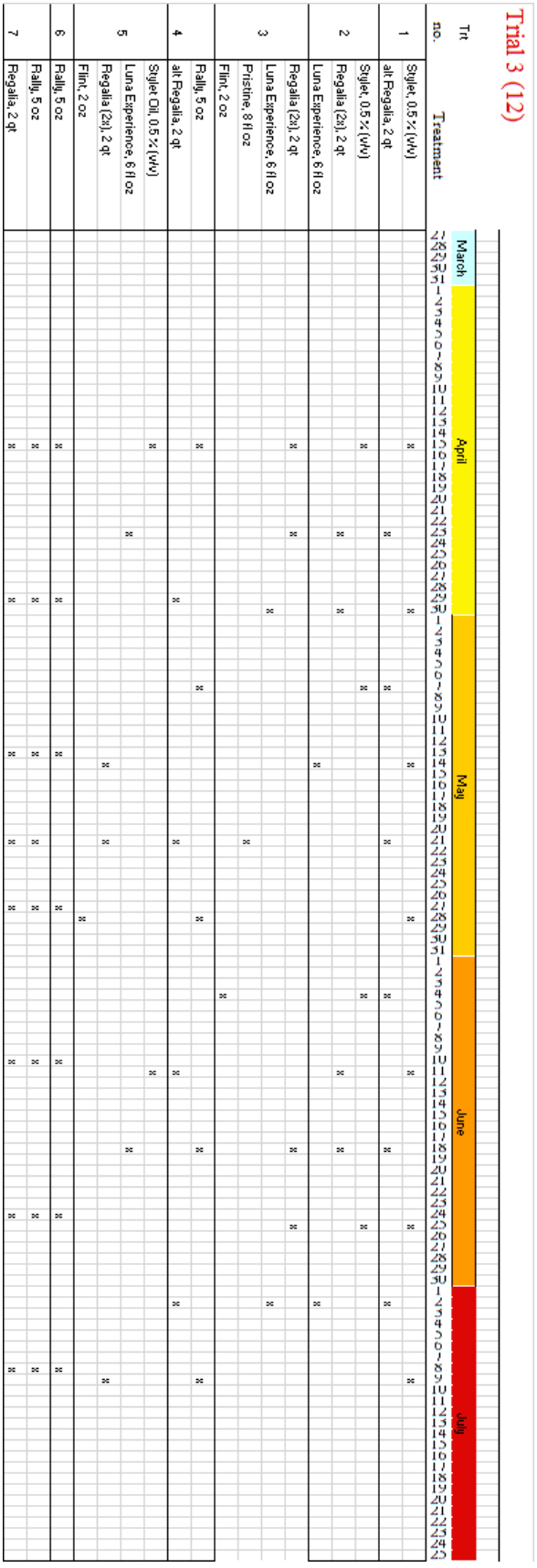
TRIAL 1



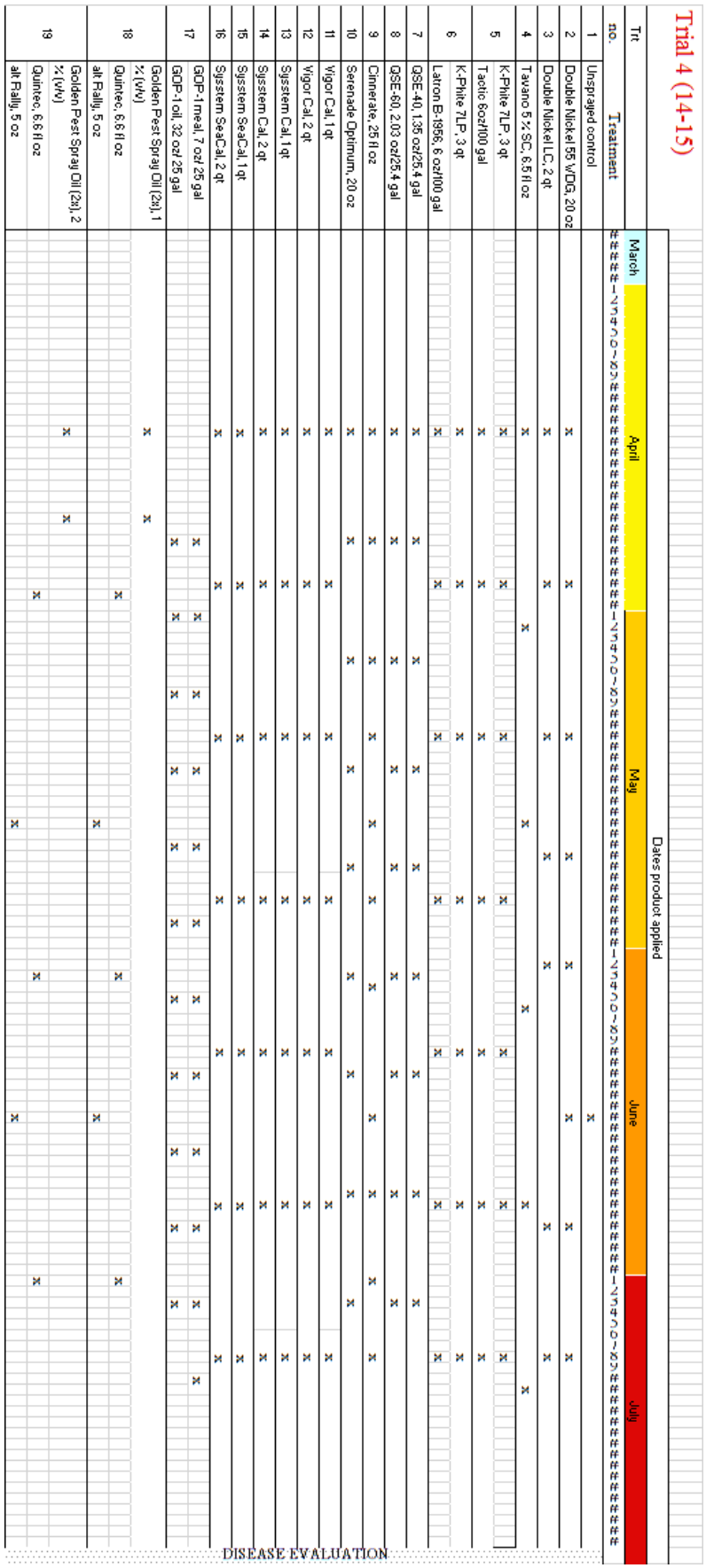
TRIAL 2


Trial 2 (11)
Trt no.
Treatment
March
April
May
June
July
1 Unsprayed control
2 Pyriofenone, 4 fl oz
3 Pyriofenone, 5 fl oz
4 Pyriofenone, 4 fl oz
alt Quintec, 4 fl oz
5 Pyriofenone, 4 fl oz
alt Abound, 11fl oz
6 Pyriofenone, 4 fl oz
alt Elite 4 fl oz
7 MCW-710 SC, 6 fl oz
Dyneamic, 0.125 % (v/v)
8 MCW-710 SC, 8.6 fl oz
Dyneamic, 0.125 % (v/v)
9 MCW-710 SC, 8.6 fl oz
alt Quintec, 4 fl oz
Dyneamic, 0.125 % (v/v)
DISEASE EVALUATION

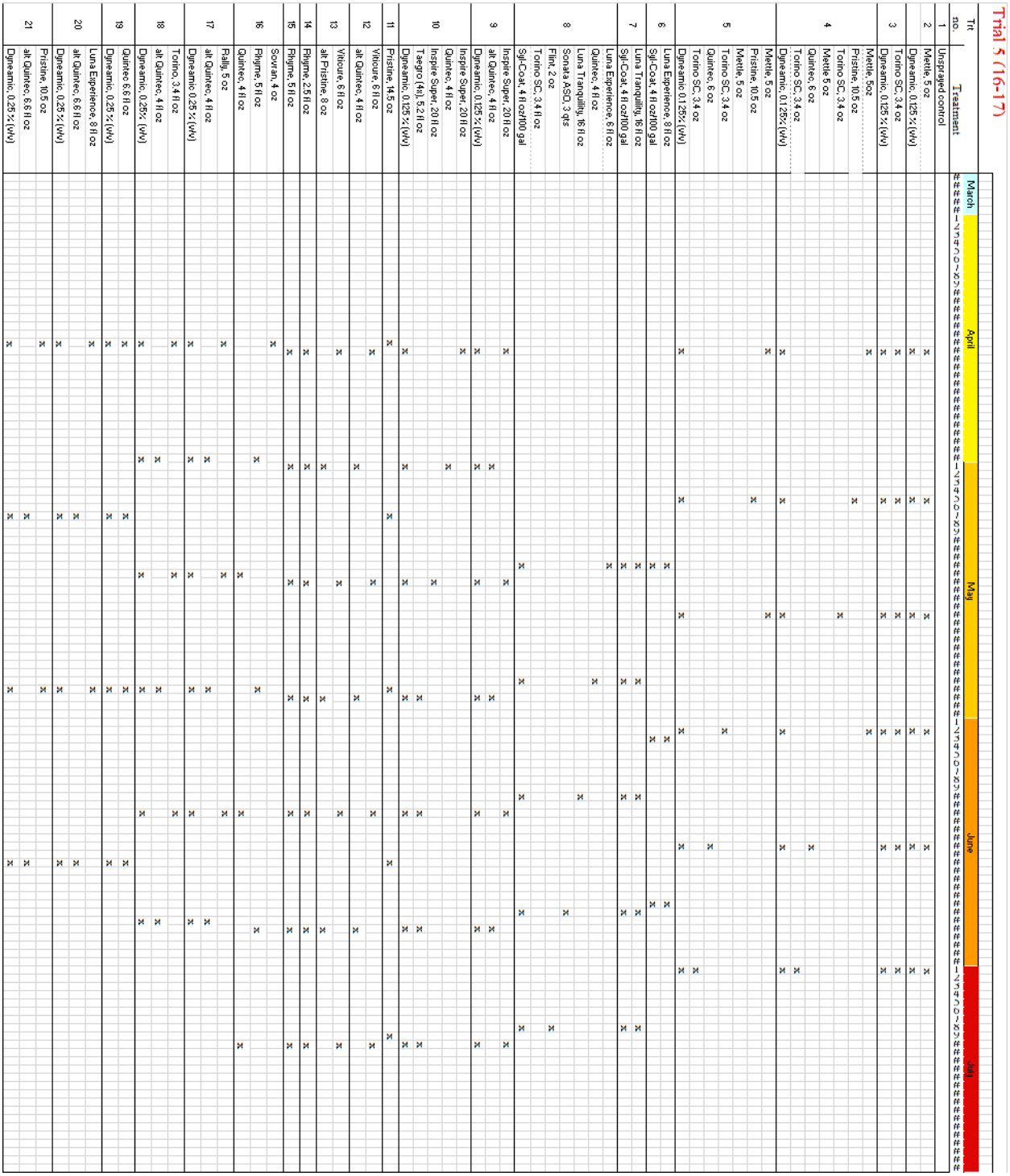
TRIAL 3


Trial 3 (12)
Trt no.
Treatment
March
April
May
June
July
1
Stylet, 0.5 % (v/v) alt Regalia, 2 qt
2
Stylet, 0.5 % (v/v) Regalia (2x), 2 qt
Luna Experience, 6 fl oz
3
Regalia (2x), 2 qt
Luna Experience, 6 fl oz
Pristine, 8 fl oz
Flint, 2 oz
4
Rally, 5 oz alt Regalia, 2 qt
Stylet Oil, 0.5 % (v/v)
5
Luna Experience, 6 fl oz
Regalia (2x), 2 qt
Flint, 2 oz
6
Rally, 5 oz
7
Rally, 5 oz
Regalia, 2 qt

Trial 4


Trial 4 (14-15)
Trt no.
Treatment
Dates product applied
March
April
May
June
July
DISEASE EVALUATION
1 Unsprayed control
2 Double Nickel 55 WDG, 20 oz
3 Double Nickel LC, 2 qt
4 Tavano 5% SC, 6.5 fl oz
5 K-Phite 7LP, 3 qt
Tactic 6oz/100 gal
6 K-Phite 7LP, 3 qt
Latron B-1956, 6 oz/100 gal
7 QSE-40, 1.35 oz/25.4 gal
8 QSE-60, 2.03 oz/25.4 gal
9 Cinnerate, 25 fl oz
10 Serenade Optimum, 20 oz
11 Vigor Cal, 1 qt
12 Vigor Cal, 2 qt
13 System Cal, 1 qt
14 System Cal, 2 qt
15 System SeaCal, 1 qt
16 System SeaCal, 2 qt
17 GDP-1 meal, 7 oz/ 25 gal
GDP-1 oil, 32 oz/ 25 gal
Golden Pest Spray Oil (2x), 1 % (v/v)
Quintec, 6.6 fl oz
alt Rally, 5 oz
18
Golden Pest Spray Oil (2x), 2 % (v/v)
Quintec, 6.6 fl oz
alt Rally, 5 oz
19

Trial 5



E. Vine management

During the application period (Apr 14 to Jul 11), vines were irrigated 3 times by flooding. Sucker shoots were removed the second week of May 2014. Leaf removal around the clusters was conducted on May 21 and Jun 3 2014. Sucker and leaf removal were done in all trials.

F. Data collection and statistics

Daily temperature, precipitation and Gubler-Thomas Risk Index values were computed and obtained from an Adcon weather station. Overall temperature were mild throughout the season (Table 1), three precipitation events were recorded on Apr 24, 25 and 27 as 0.1, 5.8 and 0.7, respectively (Table 2). 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 having some living powdery mildew. Severity was determined by estimating the percentage of area of a cluster that were 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 along with standard error were computed. Trial models were analyzed using the ANOVA Tests for data. Means comparisons were made using Fisher's LSD with α=0.05.

Figure 1. Daily temperature data from Apr 1 to Jul 23 2014.

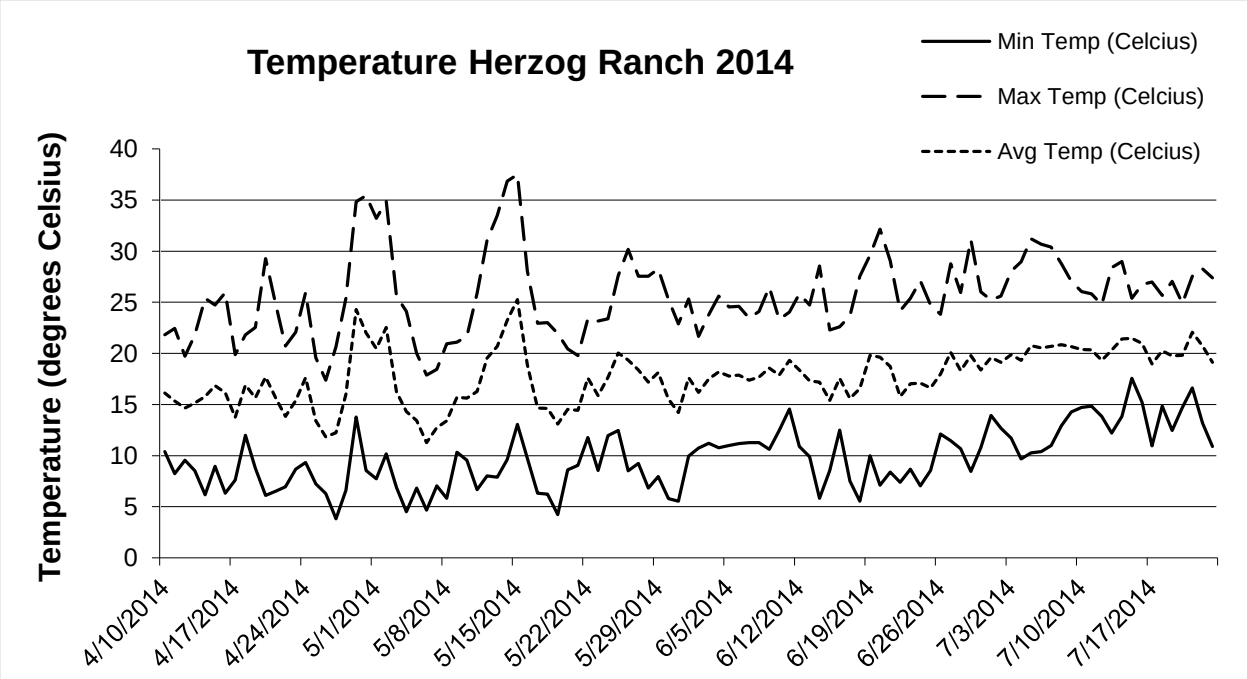


Figure 2. Daily precipitation data from Apr 1 to Jul 23.

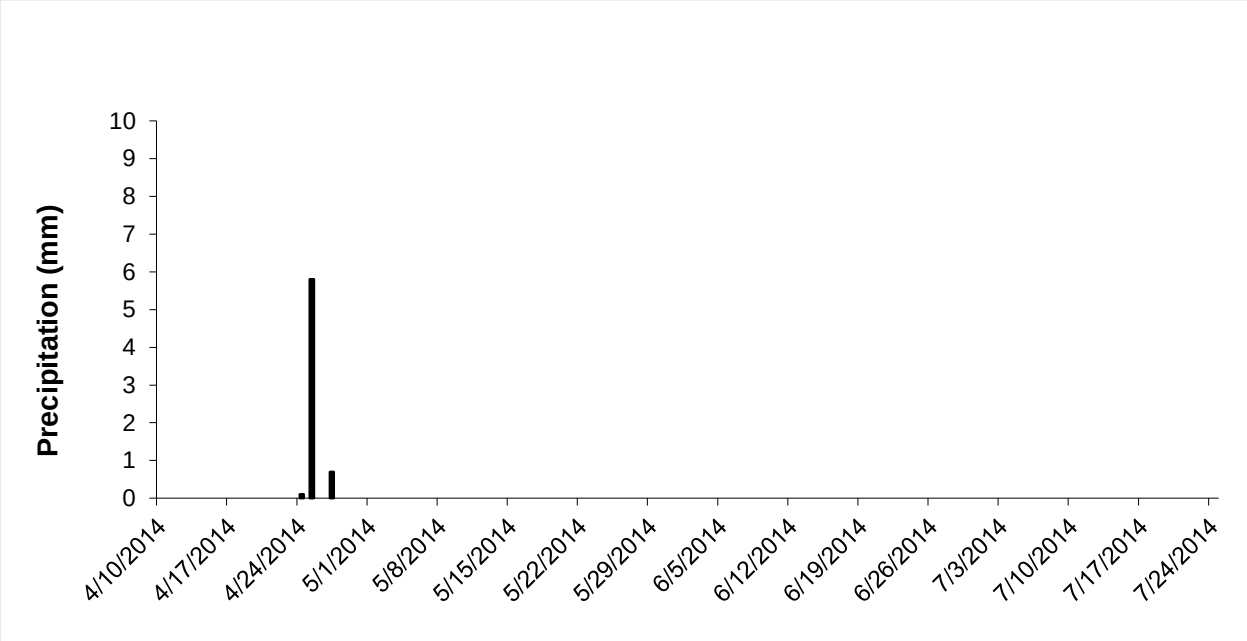
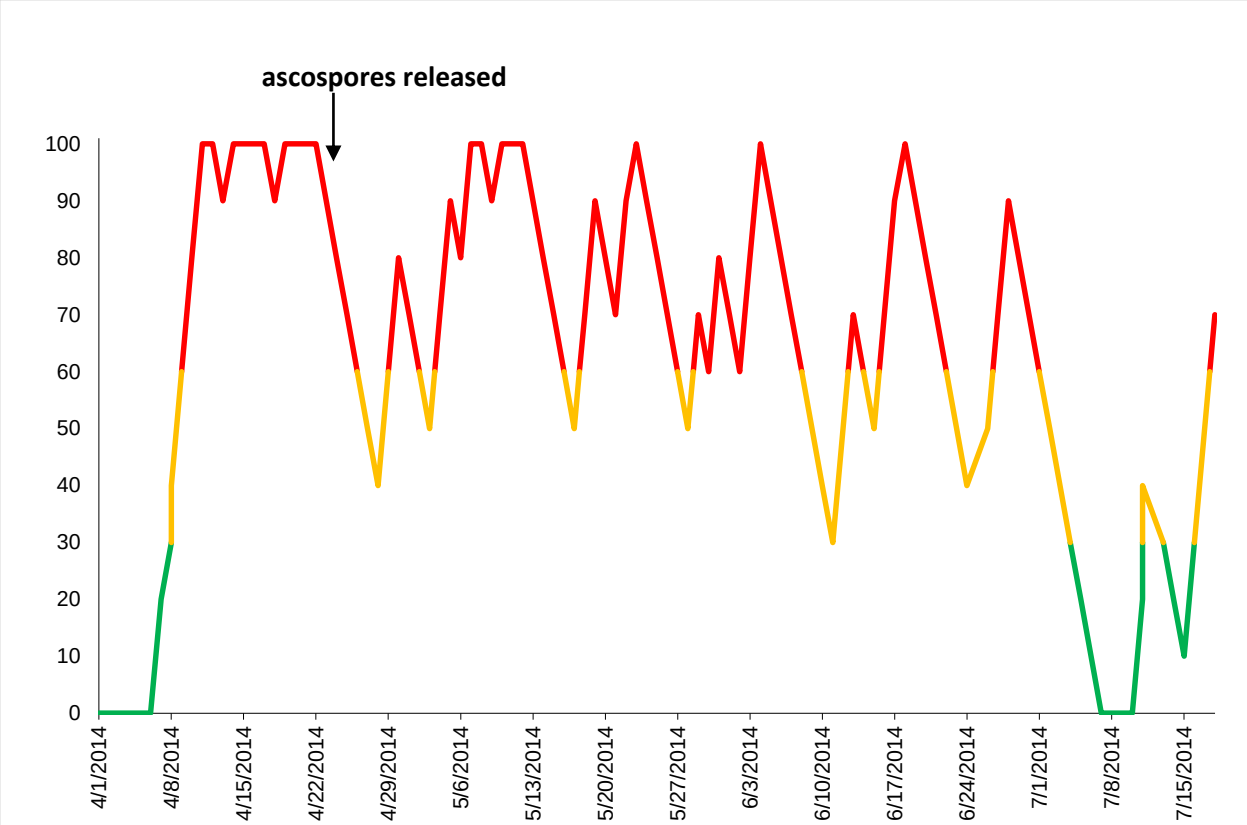


Figure 3. Thomas-Gubler Risk Index data from 1 Apr to 23 Jul. Red data points indicate risk index > 60, yellow data points indicate risk index data between 30 and 60 and green data points are values below 30.



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. Note: Timorex Gold treatments were sprayed with Luna Experience 6 fl oz and JMS Stylet Oil 0.5% (v/v) on April 25 and May 9.

Treatment	Disease Incidence (%)		Disease Severity (%)	
SSS6 0.5 gal + OR 009 1 qt, 7-10d (RI)	85.00	b	26.05	g
Timorex Gold 0.86 qt alt Quintec 4 fl oz, 10d alt 14d	99.00	a	27.55	fg
OR 114 0.5 gal + OR 009 1 qt, 7-10d (RI)	100.00	a	33.80	efg
Microthiol disperss 5 lb alt Regalia 2 qt + Kinetic 0.05% (v/v), 7-14d (RI)	100.00	a	36.25	defg
Microthiol disperss 5 lb alt Taegro 5.2 oz + Kinetic 0.05% (v/v), 7-14d (RI)	100.00	a	37.20	defg
Purespray Green 1% (v/v) + Serenade Optimum 8 oz, 10d	100.00	a	40.55	def
Microthiol disperss 5 lb alt Serenade Optimum 1 lb + Kinetic 0.5% (v/v), 7-14d (RI)	100.00	a	40.95	def
Timorex Gold 0.86 qt, 10d	99.00	a	43.30	de
Purespray Green 1% (v/v), 10d	100.00	a	47.60	cd
Microthiol disperss 5 lb alt Taegro 2.6 oz + Kinetic 0.05% (v/v), 7-14d (RI)	100.00	a	57.60	c
OR 114 0.5 gal, 7-10d (RI)	99.00	a	73.13	b
SSS6, 0.5 gal, 7-10d (RI)	100.00	a	81.05	b
Serenade Optimum 14 oz, 10d	100.00	a	94.61	a
Untreated Control	100.00	a	99.78	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 Incidence (%)		Disease Severity (%)	
(MCW-710 SC 8.6 fl oz alt Quintec 4 fl oz) + Dyneamic 0.125% (v/v), 10-14d (RI)	84.00	b	8.78	g
MCW-710 SC 8.6 fl oz + Dyneamic 0.125% (v/v), 10-14d (RI)	78.40	b	12.13	fg
Pyriofenone 4 fl oz alt Quintec 4 fl oz, 14d	100.00	a	17.86	efg
MCW-710 SC 6 fl oz + Dyneamic 0.0125% (v/v), 10-14d (RI)	96.80	a	24.40	ef
Pyriofenone 5 fl oz, 14d	100.00	a	31.37	de
Pyriofenone 4 fl oz, 14d	100.00	a	39.77	cd
Pyriofenone 4 fl oz alt Elite 4 fl oz, 14d	100.00	a	53.28	bc
Pyriofenone 4 fl oz alt Abound 11 fl oz, 14d	98.40	a	54.89	b
Untreated Control	100.00	a	99.72	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 Fisher's LSD at α=0.05; alt =alternated with.

Treatment	Disease Incidence (%)		Disease Severity (%)	
JMS Stylet Oil 0.5% (v/v), 7d, then Luna Experience 6 fl oz, 21d, then Regalia (2x) 2 qt, 7d, then Flint 2oz, 14d	84.80	b	23.76	d
Regalia (2x) 2 qt, 7d, then Luna Experience 6 fl oz, 21d, then Pristine 8 oz, 14d, then Flint 2oz, 14d	91.20	ab	33.84	cd
Rally 5 oz alt Regalia 2 qt, 14d alt 7d	97.60	a	53.80	bc
JMS Stylet Oil 0.5% (v/v), 7d, then Regalia (2x) 2 qt, 7d (2x), then JMS Stylet Oil 0.5% (v/v), 7d, then Luna Experience 6 fl oz, 21d	94.40	ab	56.04	b
Rally 5 oz, 14d	100.00	a	66.84	ab
JMS Stylet Oil 0.5% (v/v) alt Regalia 2 qt, 7d	100.00	a	67.24	ab
Rally 5 oz + Regalia 2 qt, 14d	100.00	a	81.48	a
Untreated Control	100.00	a	100.00	a

Table 4. Disease severity in trial 4. 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 Incidence (%)		Disease Severity (%)	
GOP-1 Bran 7 oz/25 gal + GOP-1 Oil 32 oz/25 gal, 7d	96.80	c	22.61	g
Golden Pest Spray Oil (2x) 2% (v/v), 7d then Quintec 6.6 fl oz, 21d alt Rally 5 oz, 14d	97.60	bc	23.39	g
Golden Pest Spray Oil (2x) 1% (v/v), 7d then Quintec 6.6 fl oz, 21d alt Rally 5 oz, 14d	100.00	a	35.18	fg
QSE-60 2.03 oz/25.4 gal, 10d	99.20	ab	48.94	ef
K-PHITE 7LP 3 qt + Tactic 6 oz/100 gal, 14d	100.00	a	52.54	ef
K-PHITE 7LP 3 qt + Latron B-1956 6 oz/100 gal, 14d	100.00	a	58.22	de
Serenade Optimum 20 oz, 10d	100.00	a	72.12	cd
Sysstem SeaCal 2 qt, 14d	100.00	a	73.96	bcd
Cinnerate 25 fl oz, 7-10d (RI)	100.00	a	78.52	bc
Double Nikel 55 WDG, 20oz, 10-14d (RI)	100.00	a	80.04	bc
Sysstem SeaCal 1 qt, 14d	100.00	a	81.76	abc
QSE-40 1.35 oz/25.4 gal, 10d	100.00	a	81.88	abc
Tavano 5% SC, 6.5 fl oz, 18d	99.20	ab	82.40	abc
Vigor Cal 2 qt, 14d	100.00	a	85.36	abc
Sysstem Cal 1 qt, 14d	100.00	a	87.28	abc
Sysstem Cal 2 qt, 14d	100.00	a	87.60	abc
Double Nikel LC, 2 qt, 10-14d (RI)	100.00	a	89.96	ab
Vigor Cal 1 qt, 14d	100.00	a	91.56	ab
Untreated Control	100.00	a	98.80	a

Table 5. Disease severity in trial 5. 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 Incidence (%)		Disease Severity (%)	
(Luna Experience 6 fl oz then Quintec 4 fl oz then Luna Tranquility 16 fl oz then Sonata ASO 3 qt then Flint 2 oz then Torino SC 3.4 fl oz) + Syl-Coat 4 fl oz/100 gal, 14d (from bloom)	5.60	e	0.09	g
(Luna Experience 8 fl oz alt Quintec 6.6 fl oz) + Dyneamic 0.25% (v/v), 21d	4.80	e	0.09	g
Luna Tranquility 16 fl oz + Syl-Coat 4 fl/100 gal, 14d (from bloom)	4.80	e	0.16	g
Luna Experience 8 fl oz + Syl-Coat 4 fl/100 gal, 21d (from bloom)	39.20	d	1.22	fg
(Pristine 10.5 oz alt Quintec 6.6 fl oz) + Dyneamic 0.25% (v/v), 21d	36.00	d	1.41	efg
(Inspire Super 20 fl oz alt Quintec 4 fl oz) + Dyneamic 0.125% (v/v), 14d	38.40	d	1.98	efg
Quintec 6.6 fl oz + Dyneamic 0.25% (v/v), 21d	84.80	abc	5.57	efg
Mettle 5 fl oz + Dyneamic 0.125% (v/v), 14-17 (RI)	68.80	c	5.58	efg
(Mettle 5 fl oz then Pristine 10.5 oz then Torino SC 3.4 fl oz then Mettle 5 fl oz then Quintec 6 fl oz then Torino SC 3.4 fl oz) + Dyneamic 0.125% (v/v), 14-17 (RI)	76.00	bc	5.65	efg
(Torino SC 3.4 fl oz alt Quintec 4 fl oz) + Dyneamic 0.25% (v/v), 14d	69.60	c	5.86	efg
(Inspire Super 20 fl oz then Quintec 4 fl oz then Inspire Super 20 fl oz then Taegro 5.2 fl oz (4x)) + Dyneamic 0.125% (v/v), 14d	86.40	abc	12.41	defg
Rhyme 5 fl oz, 14d	96.80	a	12.56	defg
(Rally 5 oz alt Quintec 4 fl oz) + Dyneamic 0.25% (v/v), 14d	94.40	ab	14.36	defg
Torino SC 3.4 fl oz + Dyneamic 0.125% (v/v), 14-17d (RI)	91.20	ab	15.23	def
Viticure 6 fl oz alt Quintec 4 fl oz, 14d	96.00	a	15.91	cde
Sovran 4 oz then Rhyme 5 fl oz alt Quintec 4 fl oz 14d	97.60	a	20.98	bcd
Viticure 6 fl oz alt Pristine 8 oz, 14d	97.60	a	29.75	bc
Rhyme 2.5 fl oz, 14d	100.00	a	32.30	b
(Mettle 5 fl oz then Pristine 10.5 oz then Mettle 5 fl oz then Torino SC 3.4 fl oz then Quintec 6 fl oz then Torino SC 3.4 fl oz) + Dyneamic 0.125% (v/v), 14-17d (RI)	99.20	a	33.42	b
Pristine 14.5 oz, 21d (Dyneamic added at 0.25% (v/v) in last application)	99.20	a	34.58	b
Untreated Control	100.00	a	98.30	a

Acknowledgements

We thank John Baranek for research cooperation. Thanks to Bob Silvera for use of the vineyard. Thanks to the various industry donors for providing of testing materials. We thank A. Erickson, B. McGuire, A. Abramians, C. Waters, R. Choudhury, G. Puccinelli, D. Castillo, R. Deneger, I. Shah, K. Arnold for assisting with disease evaluation in the field.

Appendix: Materials

Product	Active ingredient(s) and concentration	Manufacturer or distributor	Chemical class (after Adaskaveg et al. 2008)
Abound	azoxystrobin (22.9%)	Syngenta	QoI (11)
Cinnerate	cinnamon oil (60%)	Sym-Agro	natural product
Double Nickel LC	*Bacillus amyloliquefaciens* strain D747* (98.85%)	Certis	biological
Double Nickel 55 WDG	*Bacillus amyloliquefaciens* strain D747* (25.0%)	Certis	biological
Dyne-Amic	polyalkyleneoxide modified polydimethylsiloxane, nonionic emulsifiers, methyl ester of C16-C18 fatty acids (99%)	Helena Chemical Co.	adjuvant
Elite	tebuconazole (45%)	United Phosphorus Inc.	DMI-triazole (3)
Flint 50WG	trifloxystrobin (50%)	Bayer Crop Science	QoI (11)
GOP-1 Bran	proprietary	N/A	proprietary
GOP-1 Oil	proprietary	N/A	proprietary
Golden Pest Spray Oil	soybean oil (93%)	Stoller Enterprises	Oil
Inspire Super 2.82	difenoconazole (8.4%), cyprodinil (24%)	Syngenta Crop Protection, Inc.	DMI (3)/anilinopyrimidine (9)
JMS Stylet-Oil	paraffinic oil (97.1%)	JMS Flower Farms, Inc.	Oil
K-Phite 7LP	potassium phosphate (56%)	Plant Food Systems, Inc.	Phosphonates
Kinetic	blend of polyalkyleneoxide modified polydimethylsiloxane and nonionic surfactants (99%)	Helena Chemical Co.	Adjuvant
Latron B-1956	modified phthalic glycerol alkyd resin (77.0%)	Dow AgroSciences LLP	Adjuvant
Luna Experience	fluopyram (17.54%), tebuconazole (17.54%)	Bayer Crop Science	SDHI (7)/DMI-triazole (3)
Luna Tranquility	fluopyram (11.3%) pyrimethanil (33.8%)	Bayer Crop Science	SDHI (7)/AP (9)
MCW-710 SC	proprietary	proprietary	N/A
Mettle 125 ME	tetraconazole (11.6%)	Isagro USA	DMI-triazole (3)
Microthiol Disperss	sulfer (80%)	United Phosphorus Inc.	inorganic (M2)
OR009	proprietary	proprietary	N/A
OR114	proprietary	proprietary	N/A

Pristine	pyraclostrobin (12.8%) boscalid (25.2%)	BASF	SDHI (7)/QoI(11)
Purespray Green	low range oil	Petro-Canada	oil
Pyriofenone	proprietary	proprietary	N/A
QSE-40	proprietary	N/A	proprietary
QSE-60	proprietary	N/A	proprietary
Quintec	quinoxyfen (22.6%)	Dow AgroSciences LLP	quinoline (13)
Rally 40 WSP	myclobutanil (40%)	Dow AgroSciences LLP	DMI-triazole (3)
Regalia	extract of *Reynoutria sachalinensis* (5%)	Marrone Bio Innovations	natural product
Rhyme	flutriafol (12%)	Cheminova	DMI-triazole (3)
Serenade Optimum	*Bacillus subtilis* QST 713 (26%)	Bayer Crop Science	biological
Sonata	*Bacillus pumilus* QST 2808 (1.38%)	Agraquest	biological
Sovran	kresoxim-methyl (50%)	BASF	QoI (11)
Sysstem Cal	phosphoric acid (14%) calcium (4%) copper (0.25%)	Agro-K	inorganic salt
Sysstem SeaCal	phosphoric acid (14%) calcium (4%)	Agro-K	inorganic salt
SSS6	proprietary	N/A	proprietary
Tactic	synthetic latex, 1,2-propanediol, Alcohol ethoxylate, silicone polyether copolymer (63.4%)	Loveland	adjuvant
Taegro 13 WP	*Bacillus subtilis* Strain FZB24 (13.0%)	Novozymes	biological
Tavano 5% SC	polyoxin D zinc salt (5%)	Certis	Polyoxins (19)
Timorex Gold	oil derived from the tea tree, *Melaleuca alterniflora* (23.8%)	Biomor Israel Ltd.	oil
Torino	cyflufenamid (10%)	Gowan	phenyl-acetamide (U6)
Vigor Cal	calcium (5%)	Agro-K	inorganic salt
Viticure	triflumizole (42.14%)	Chemtura	DMI-imidazole (3)

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) Gubler Lab field trials, available at http://plantpathology.ucdavis.edu/Cooperative_Extension/ (3) product-specific MSDS and/or labels.