Chemical and biological control of grape powdery mildew: 2008 field trials

Christopher N. Janousek and W. Douglas Gubler

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

University of California Cooperative Extension,
Department of Plant Pathology,
University of California, Davis, November 2008

Published, November 2008, at http://plantpathology.ucdavis.edu/ext/index.htm and at the
eScholarship Repository of the California Digital Library: http://repositories.cdlib.org/escholarship/

I. Introduction

Powdery mildew is one of the most significant diseases affecting grape (*Vitis vinifera*) production around the world. The disease is caused by the hyaline ascomycete, *Erysiphe necator*, a pathogen capable of rapid proliferation under optimal environmental conditions. Disease onset begins in the spring with the release of ascospores from over-wintering chasmothecia (Gubler and Hirschfelt 1992). Once initial colonies are established, the fungus can asexually propagate via large numbers of conidia that disperse and re-infect additional leaves and developing fruits. Powdery mildew effects on the host include reduction in berry mass, potential cracking of berries, and increased susceptibility to berry rots (Gubler and Hirschfelt 1992, Calonnec et al. 2004, Gadoury et al. 2007). Economically, the disease may be damaging to California's grape industry because of lost yield, a shortened shelf life for table grapes, and alterations in wine flavor (Gubler and Hirschfelt 1992, Gadoury et al. 2007).

In California, powdery mildew is principally controlled via periodic application of foliar fungicides, including sulfur and synthetic materials such as demethylase inhibitors and strobilurins (California Department of Pesticide Regulation 2004). A wide range of materials show at least some reduction in disease levels under field conditions (Janousek et al. 2007, Adaskaveg et al. 2008). We continued our annual powdery mildew trials during 2008 to evaluate the efficacy of various fungicide products, including registered synthetic materials of varied chemical classes, oils, and biocontrol products. We present the results of five trials conducted in a Chardonnay vineyard at Herzog Ranch in Sacramento County, California.

II. Materials and Methods

A. Trial layout

Trials 1-3 and 5

Experimental design	Complete randomized complete design with 5 replicates.		
Experimental unit	2 vines = 1 plot		
Row spacing	11 ft	Vine spacing within row	7 ft
Plot unit area	154 ft^2		
Area/treatment	770 ft^2 (5 reps. = 1 treatment)	Area/treatment	0.018 acre/treatment
Volume water/acre	150 gallons 200 gallons	Vol. water/treatment	2.7 gallons 3.5 gallons
Application method	Handgun sprayers (attached to Nifty Fifty brand 25 or 50 gallon sprayers).		

Trial 4

Experimental design	Complete randomized design with 6 replicates.		
Experimental unit	2 vines = 1 plot		
Row spacing	11 ft	Vine spacing within row	7 ft
Plot unit area	154 ft^2		
Area/treatment	924 ft^2 (6 reps. = 1 treatment)	Area/treatment	0.021 acre/treatment
Volume water/acre	150 gallons 200 gallons	Vol. water/treatment	3.2 gallons 4.2 gallons
Application method	Handgun sprayers (attached to Nifty Fifty brand 25 gallon sprayer).		

B. Experimental treatments

Trial 1

Trt no.	Flag	Product(s)	Frequency (days)	FP[1]/Acre	FP/Treatment
1	GS	Unsprayed control	none	none	none
2	OYS	Rally	21	4 oz	2.0 g
3	BD	Procure (2 applications) then Kumulus	21	6 fl oz 10 lb	3.1 ml 80 g
4	GKC	Procure (2 applications) then Kumulus	21	8 fl oz 10 lb	4.2 ml 80 g
5	R	Procure (2 applications) then Pristine	21	6 fl oz 12 oz	3.1 ml 6.0 g
6	RC	A16001 alt[2] Flint	21	12 fl oz 2 oz	6.3 ml 1.0 g
7	W	A16001 alt Flint	21	20 fl oz 2 oz	10.5 ml 1.0 g
8	KC	A7402 alt Flint	21	7 fl oz 2 oz	3.7 ml 1.0 g
9	YS	Vangard + A7402 alt Flint	21	7 oz 7 fl oz 2 oz	3.5 g 3.7 ml 1.0 g
10	PC	Quintec alt Flint	21	6.6 fl oz 2 oz	3.5 ml 1.0 g
11	YKS	Quintec + Induce	14	4 fl oz + 0.125%	2.1 ml 12.8 ml (at 150 gal) 17.1 ml (at 200 gal)
12	RKD	Quintec + Induce	21	6.6 fl oz + 0.125%	3.5 ml 12.8 ml (at 150 gal) 17.1 ml (at 200 gal)
13	RS	Rally + Induce alt Quintec + Induce	14	4 oz + 0.125% alt 4 fl oz 0.125%	2.0 g + 12.8 ml (at 150 gal) 17.1 ml (at 200 gal) 2.1 ml + 12.8 ml (at 150 gal) 17.1 ml (at 200 gal)
14	Pu	Rally + Induce (2x) then Quintec + Induce	21	5 oz + 0.125% alt 6.6 fl oz + 0.125%	2.5 g + 12.8 ml (at 150 gal) 17.1 ml (at 200 gal) 3.5 ml + 17.1 ml (at 200 gal)

[1]FP = formulated product
[2]alt = alternated with.

Trial 2

Trt no.	Flag	Product	Frequency (days)	FP/Acre	FP/Treatment
1	RKC	Unsprayed control	none	none	none
2	GD	Pristine 38WDG + Silwet L-77	14	8.0 oz 4.0 fl oz	4.0 g 2.1 ml
3	YKC	Pristine + Silwet L-77	21	10.5 oz 4.0 fl oz	5.3 g 2.1 ml
4	PKD	BAS 56000F + Silwet L-77	14	10.2 fl oz 4.0 fl oz	5.3 ml 2.1 ml
5	YD	BAS 56000F + Silwet L-77	21	15.4 fl oz 4.0 fl oz	8.1 ml 2.1 ml
6	BS	BAS 56000F + Silwet L-77 alt Pristine + Silwet L-77	21	15.4 fl oz + 4.0 fl oz alt 10.5 oz + 4.0 fl oz	8.1 ml 2.1 ml 5.3 g 2.1 ml
7	LG	BAS 56000F + Silwet L-77 alt Sovran + Silwet L-77	14	10.2 fl oz + 4.0 fl oz alt 3.2 oz + 4.0 fl oz	5.3 ml 2.1 ml 1.6 g 2.1 ml
8	KD	LEM17 SC	14	14.4 fl oz	7.5 ml
9	GKS	LEM17 SC	14	20.6 fl oz	10.8 ml
10	OKS	LEM17 SC	14	24.0 fl oz	12.6 ml
11	OC	LEM17 SC	21	24.0 fl oz	12.6 ml
12	RD	LEM17 SC + Kumulus	14	20.6 fl oz 2 lb	10.8 ml 16 g
13	PS	Pristine then Vintage + Latron B-1956 then Pristine then Vintage then Vintage	21 then 14 then 21 then 14 then 14	10.5 oz 4 fl oz 6 fl oz 10.5 oz 5 fl oz 6 fl oz	5.3 g 2.1 ml 3.1 ml 5.3 g 2.6 ml 3.1 ml
14	BKD	Quintec then Vintage + Latron B-1956 then Quintec then Vintage + Latron B-1956 then Quintec	21 14 21 14 21	6.6 fl oz 4 fl oz 6 fl oz 6.6 fl oz 5 fl oz 6 fl oz 6.6 fl oz	3.5 ml 2.1 ml 3.1 ml 3.5 ml 2.6 ml 3.1 ml 3.5 ml
15	OS	Pristine then Rubigan + Latron B-1956 then Pristine then Vintage then Vintage	21 then 14 then 21 then 14 then 14	10.5 oz 3 fl oz 6 fl oz 10.5 oz 4 fl oz 5 fl oz	5.3 g 1.6 ml 3.1 ml 5.3 g 2.1 ml 2.6 ml

Trial 3

Trt no.	Flag	Product	Frequency (days)	FP/Acre	FP/Treatment
1	OD	Unsprayed control	none	none	none
2	RC	Flint alt Quintec	14	2 oz 4 fl oz	1.0 g 2.1 ml
3	RKD	Flint alt Elite	14	2 oz 4 oz	1.0 g 2.0 g
4	KS	Topguard	14	5 fl oz	2.6 ml
5	P	Topguard	14	8 fl oz	4.2 ml
6	OKD	Topguard	14	10 fl oz	5.2 ml
7	B	Topguard	14	28 fl oz	14.7 ml
8	W	V-10118 + Silwet L-77 alt Quintec	14	0.03 lb ai 4 fl oz 4 fl oz	4.9 ml 2.1 ml 2.1 ml
9	RS	Mettle	14-21	5 fl oz	2.6 ml
10	BC	Mettle then Pristine + Latron B-1956 then Mettle then Quintec	21	5 fl oz 12.5 oz 6 fl oz 5 fl oz 6.6 fl oz	2.6 ml 6.3 g 3.1 ml 2.6 ml 3.5 ml
11	G	Adament WG	14	3 oz	1.5 g
12	YC	Adament WG	21	4 oz	2.0 g

Trial 4

Trt no.	Flag	Product	Frequency (days)	FP/Acre	FP/Treatment
1	GD	Unsprayed control	none	none	none
2	YS	Rally alt Flint	14	4.0 oz 2.0 oz	2.4 g 1.2 g
3	LG	Silwet L-77 (adjuvant control)	10	200 ml	4.2 ml
4	KD	Actinovate + Silwet L-77	7	9.0 oz 200 ml	5.4 g 4.2 ml
5	GKC	Actinovate + Silwet L-77	10	12.0 oz 200 ml	7.2 g 4.2 ml
6	RKS	Companion	10	3 qt	60 ml
7	OS	Serenade MAX + Silwet L-77	10	32 oz 200 ml	19.1 g 4.2 ml
8	KC	SP2059	10	28 oz	16.6 g

Trial 5

Trt no.	Flag	Product	Frequency (days)	FP/Acre	FP/Treatment
1	RS	Unsprayed control	none	none	none
2	OKD	Phyton-016-B	7	0.31 %	32 ml (at 150 gal) 43 ml (at 200 gal)
3	BD	Whey	7	6 lb	48 g
4	GS	Whey	10	6 lb	48 g
5	OC	Sil-MATRIX	10	3 qt	50 ml
6	RKC	Sil-MATRIX	14	3 qt	50 ml
7	PC	Sil-MATRIX + Induce	14-21	3 qt 0.125 %	50 ml 12.8 ml (at 150 gal) 17.1 ml (at 200 gal)
8	YD	FBS 100BP	10	2 qt	33 ml
9	KS	SilverDYNE	10	0.4 %	41 ml (at 150 gal) 55 ml (at 200 gal)
10	YKS	JMS Stylet-Oil (3 times) then FS 1610 + Hi Wett	10	1.0 % 3 qt + 6 fl oz	102 ml (at 150 gal) 50 ml 3.0 ml
11	K	OM 1 (Experimental mineral oil)	14	2.0 %	204 ml (at 150 gal) 272 ml (at 200 gal)
12	R	OM 2 (Experimental mineral oil)	14	2.0 %	204 ml (at 150 gal) 272 ml (at 200 gal)
13	Y	MOI-104	14	0.5 %	51 ml (at 150 gal) 68 ml (at 200 gal)
14	YRS	Timorex Gold	14	0.5 %	51 ml (at 150 gal) 68 ml (at 200 gal)
15	OKS	Timorex Gold	14	0.75 %	77 ml (at 150 gal) 103 ml (at 200 gal)

C. Maps of the trials

The overview map indicates the relative positions of the five trials. Plots were arranged within a trial in a complete randomized design. Dots represent individual vines.

During progression of the research trials, vines showing stunted growth (probably due to phylloxera) were noted. Such vines had dramatically shorter shoot lengths, leading to more open canopies and greater ultraviolet light penetration to developing berries. This appeared to have significantly reduced powdery mildew severity on affected clusters, so these plots were not included in data analysis. They are indicated in this section by darker shading in the individual trial maps that follow the overview map.

Overview map

Snodgrass Slough

TRIAL 1
TRIAL 2
TRIAL 3
Vineyard row
60
61
62
63
44
45
46
47
48
49
50
50
51
52
53

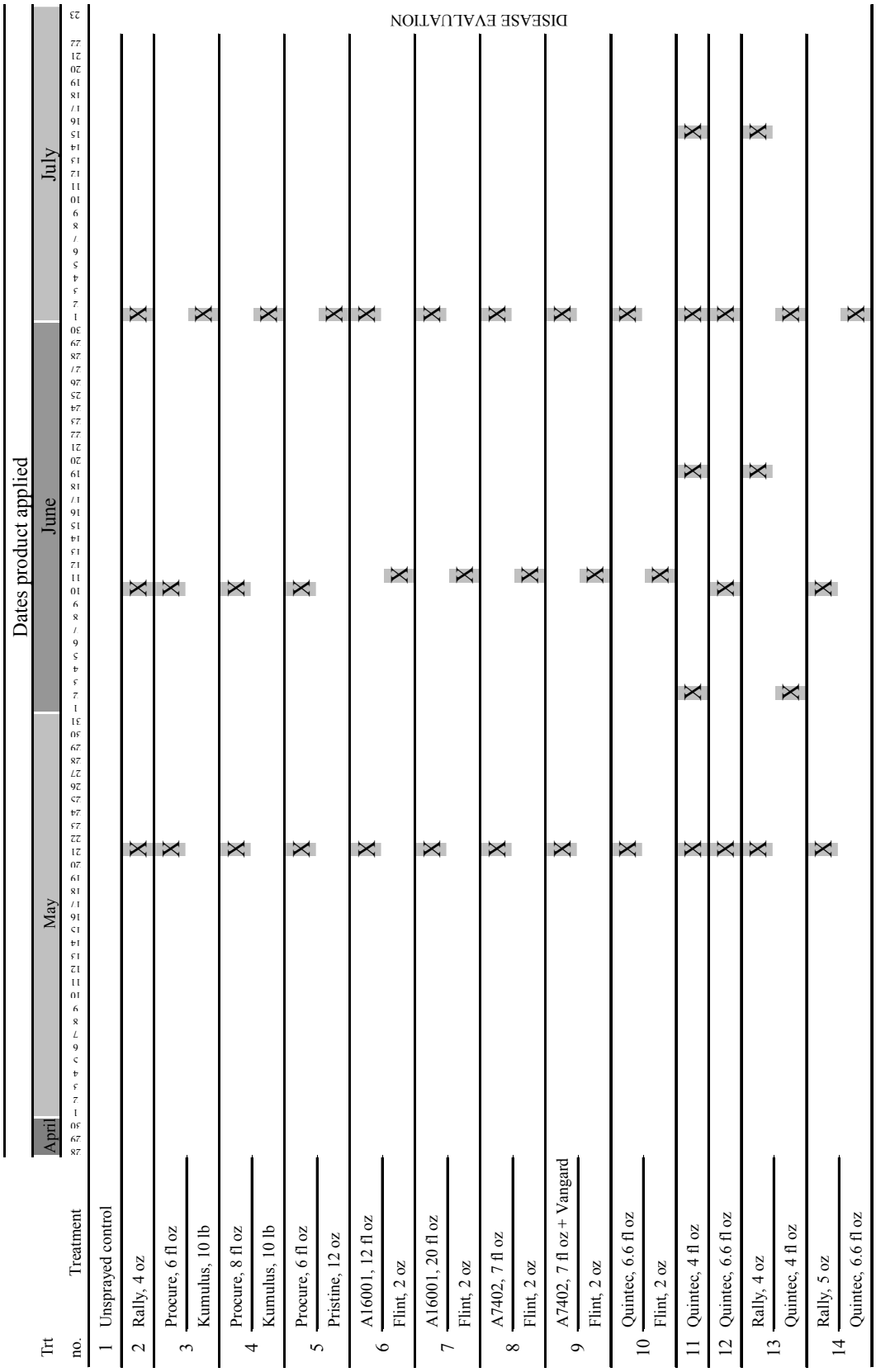
TRIAL 4

TRIAL 5

Vineyard row	Plots (top to bottom)
53	· KC LG YKI BS **LG** **YKI** **GKC** **YS** ·
54	GD RKS KC YS GD KD KC GKC BS YKI KD LG YRD RKS KD KC GD **YRD** **KC** · ·
55	· LG YRD YKI OS GKC KD YRD BS KD YS GD BS GKC **LG** **RKS** **GD** **YS** **OS** **GD** · ·
56	GD GKC YKI OS BS GD OS KC RKS LG YRD OS RKS KD RKS YS **YKI** **OS** **BS** **YRD** **GKC** **YS**
57	· OKD BD OC YRS Y KS OKD YKS OKD RKC PC R BD PC R GS **YD** **RS** **YRS** **OC** **BD** **RS**
58	RS OKS GS YKS PC YKS YRS YD R K Y OKS Y RKC KS OKD KS Y PC **R** **K** YRS OC
59	· BD · · OKS R PC RS RKC RS YKS KS GS OKS OC GS YD GS OKD OKS OC BD YKS K KS ·
60	· K RKC YD Y RKC YRS K YD ·

D. Application history

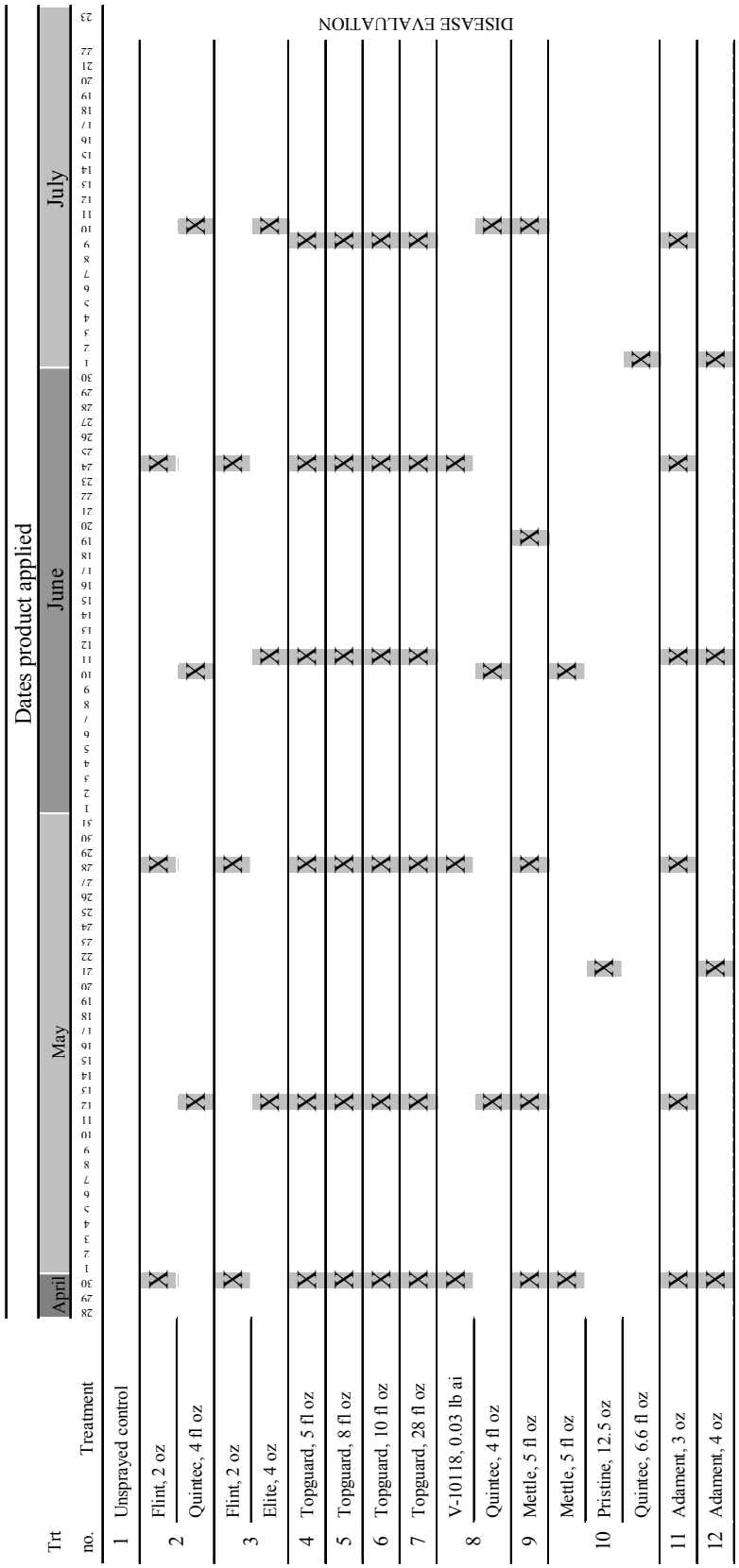
TRIAL 1



TRIAL 2

Trt no.	Treatment	Apr 29	Apr 30	May 12	May 21	May 28	Jun 2	Jun 10	Jun 24	Jul 1	Jul 10	Jul 23 (DISEASE EVALUATION)
1	Unsprayed control											
2	Pristine, 8 oz	X		X		X		X	X		X	
3	Pristine, 10.5 oz	X			X			X		X		
4	BAS560 00F, 10.2 fl oz		X	X		X		X	X		X	
5	BAS560 00F, 15.4 fl oz		X		X			X		X		
6	BAS560 00F, 15.4 fl oz		X					X				
	Pristine, 10.5 oz				X					X		
7	BAS560 00F, 10.2 fl oz		X			X			X			
	Sovran, 3.2 oz			X				X		X		
8	LEM17, 14.4 fl oz		X	X		X		X	X		X	
9	LEM17, 20.6 fl oz		X	X		X		X	X		X	
10	LEM17, 24 fl oz		X	X		X		X	X		X	
11	LEM17, 24 fl oz		X		X			X		X		
12	LEM17, 20.6 + Kumulus		X	X		X		X	X		X	
13	Pristine, 10.5 oz	X					X					
	Vintage, various				X				X		X	
14	Quintec, 6.6 fl oz	X					X				X	
	Vintage, various				X				X			
15	Pristine, 10.5 oz	X					X					
	Rubigan, 3 fl oz				X							
	Vintage, various								X		X	

TRIAL 3


Dates product applied
April
May
June
July
Trt no.
Treatment
1 Unsprayed control
2 Flint, 2 oz / Quintec, 4 fl oz
3 Flint, 2 oz / Elite, 4 oz
4 Topguard, 5 fl oz
5 Topguard, 8 fl oz
6 Topguard, 10 fl oz
7 Topguard, 28 fl oz
8 V-10118, 0.03 lb ai / Quintec, 4 fl oz
9 Mettle, 5 fl oz
10 Mettle, 5 fl oz / Pristine, 12.5 oz / Quintec, 6.6 fl oz
11 Adament, 3 oz
12 Adament, 4 oz
DISEASE EVALUATION

TRIAL 4

Trt no.	Treatment	Dates product applied: April	May	June	July
1	Unsprayed control				
2	Rally, 4 oz + Flint, 2 oz	X	X	X	X
3	Silwet L-77	X	X	X	X
4	Actinovate, 9 oz	X	X	X	X
5	Actinovate, 12 oz	X	X	X	X
6	Companion, 3 qt	X	X	X	X
7	Serenade MAX, 32 oz	X	X	X	X
8	SP2059, 28 oz	X	X	X	X

DISEASE EVALUATION

TRIAL 5

Trt no.	Treatment	Dates product applied: April	May	June	July
1	Unsprayed control				
2	Phyton 016-B, 0.31%	X	X	X	X
3	Whey, 6 lb	X	X	X	X
4	Whey, 6 lb	X	X	X	X
5	Sil-MATRIX, 3 qt	X	X	X	X
6	Sil-MATRIX, 3 qt	X	X	X	X
7	Sil-MATRIX, 3qt	X	X	X	X
8	FBS 100BP, 2 qt	X	X	X	X
9	SilverDYNE, 0.4%	X	X	X	X
10	JMS Stylet Oil, 1% + FS 1610, 3 qt	X	X	X	X
11	OM 1, 2%	X	X	X	X
12	OM 2, 2%	X	X	X	X
13	MOI-104, 0.5%	X	X	X	X
14	Timorex Gold, 0.5%	X	X	X	X
15	Timorex Gold, 0.75%	X	X	X	X

DISEASE EVALUATION

E. Disease evaluation and statistical analysis

Treatment effects on powdery mildew were assessed on 23 July 2008 by determining disease incidence and severity on approximately 15 clusters in each plot. Disease incidence was estimated as the percentage of clusters within a plot containing at least one infected berry. Disease severity was obtained by averaging the percentage of infected berries on all clusters observed within a plot. Incidence and severity estimates were made by visual inspection. When infected berries were uncommon, the number of infected berries per cluster was recorded followed by conversion to a percentage by dividing by the mean number of berries per cluster for the appropriate size class (47 berries/small cluster, 71 berries/medium cluster, 145 berries/large cluster).

Incidence and severity data are presented as untransformed means (± 1 standard error). Treatment differences were evaluated with Fisher's LSD test ($\alpha = 0.10$). Arcsine transformation usually did not substantially improve heteroscedasticity (according to visual inspection of the distribution of residuals); untransformed data were used throughout the analyses. Treatments in figures are color coded according to major chemical class after Adaskaveg et al. (2008). Up to two chemical classes are shown per treatment (some treatments had active ingredients from three chemical classes).

III. Results and discussion

Temperature data suggested that optimal conditions existed for powdery mildew growth through much of May and June 2008 (Figure 1). Natural disease onset, however, was not observed before about early June. Delay in the onset of disease may have been due to application by the grower of JMS Stylet-oil, a mildew eradicant, during April and/or lack of spring precipitation necessary for release of meiospores. During mid-June disease proliferation was stimulated by (1), dousing trunks and cordons with water to stimulate spore release, and (2) later inoculating the edges of all plots with a conidia suspension prepared from greenhouse-grown colonies. A sharp increase in disease incidence on leaves was observed during late June and early July (Figure 2).

Despite seasonally-late disease onset, by mid-July, untreated plots across the five trials attained disease incidence levels of 86.7% to 100% and severity levels ranging from 46.7% to 78.9%. Substantial reductions in disease incidence and severity were obtained with at least some treatments in each trial (Figures 3-7). Generally, severity levels of ≤3% can be considered acceptable for commercial harvest (Calonnec et al. 2004). In trial 1, only Quintec 6.6 fl oz/A alternated with Flint attained this level of disease management. In trial 2, all treatments except LEM at 14.4 fl oz, 14 days and both Rubigan protocols were under the 3% threshold. All fungicide treatments had disease levels acceptable for harvest in trial 3. Only Flint alternated with Rally had severity ≤3% in trial 4, and no treatments were acceptable in trial 5.

As in previous years, top performing registered fungicides included Quintec (quinoxyfen), Pristine (pyraclostrobin + boscalid) and Flint/Elite (trifloxystrobin/tebuconazole). Several non-registered experimental materials also substantially reduced disease incidence and severity: BAS56000F (pyraclostrobin + boscalid), LEM17 (penthiopyrad) and Adament (trifloxystrobin + tebuconazole).

Oils, biologicals, and other soft chemistry products generally did not perform as well as synthetic fungicides of other chemical classes. Timorex Gold (tea tree oil) and mineral-oil based treatments modestly reduced disease severity, with OM1 and OM2 (mineral oil with adjuvants) performing best (Figure 7). Biofungicides showed some reductions in disease, but not of a magnitude comparable to most other treatments. Other soft chemistry materials gave varied results: for example, whey applied weekly was fairly effective at disease management (Figure 7), but FBS100BP and SilverDYNE were ineffective.

Figure 1. Daily variation in the Gubler Thomas Powdery Mildew Risk Index near Herzog Ranch. The risk index value was computed from climatological data recorded for the Russel Road PestCast station, positioned near the experimental site (http://www.ipm.ucdavis.edu/WEATHER/wxretrieve.html).

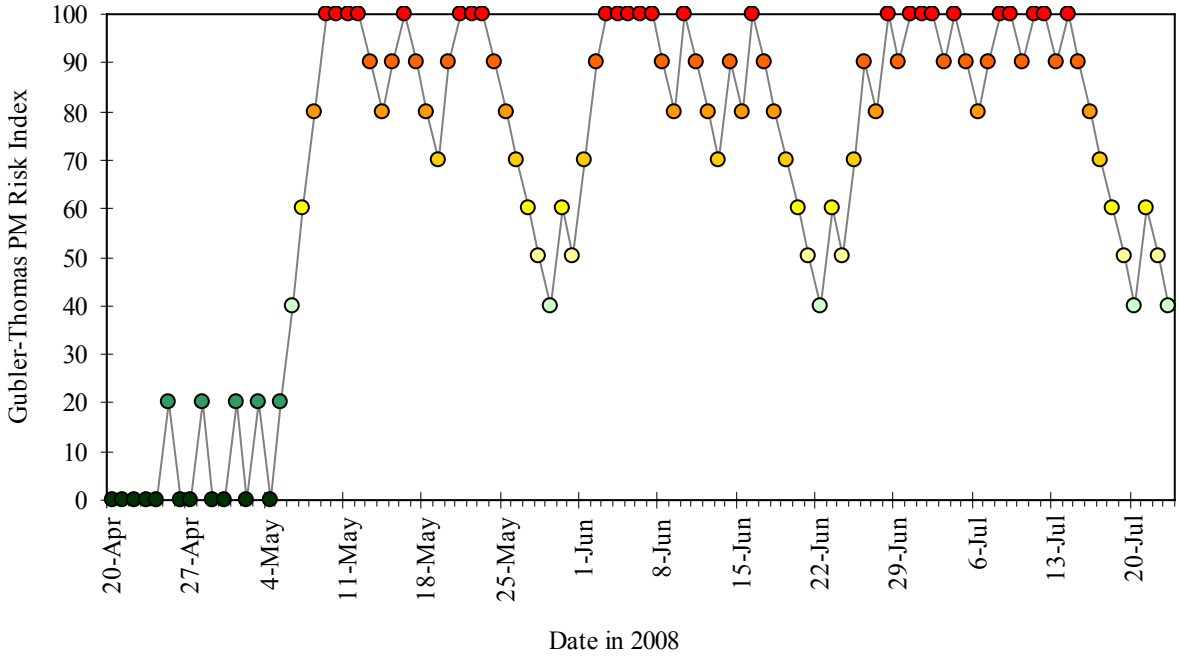


Figure 2. Weekly progression of disease incidence on the upper surface of leaves in trial 4 from early May to mid-July 2008. 15-20 leaves were collected from each plot and evaluated in the lab to determine the presence or absence of powdery mildew. Data in means ± 1 standard deviation (n=6).

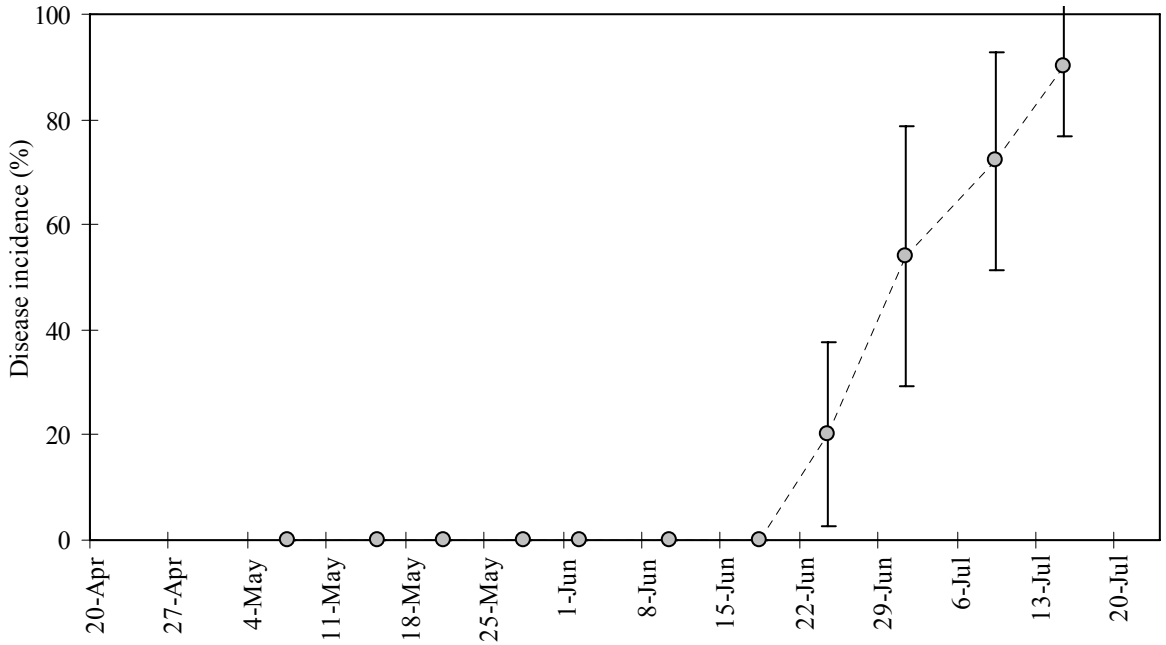


Figure 3. Disease incidence (A) and severity (B) in trial 1 treatments (means ± 1S.E.). Letters indicate significantly different groups of means with Fisher's LSD test at α = 0.10.

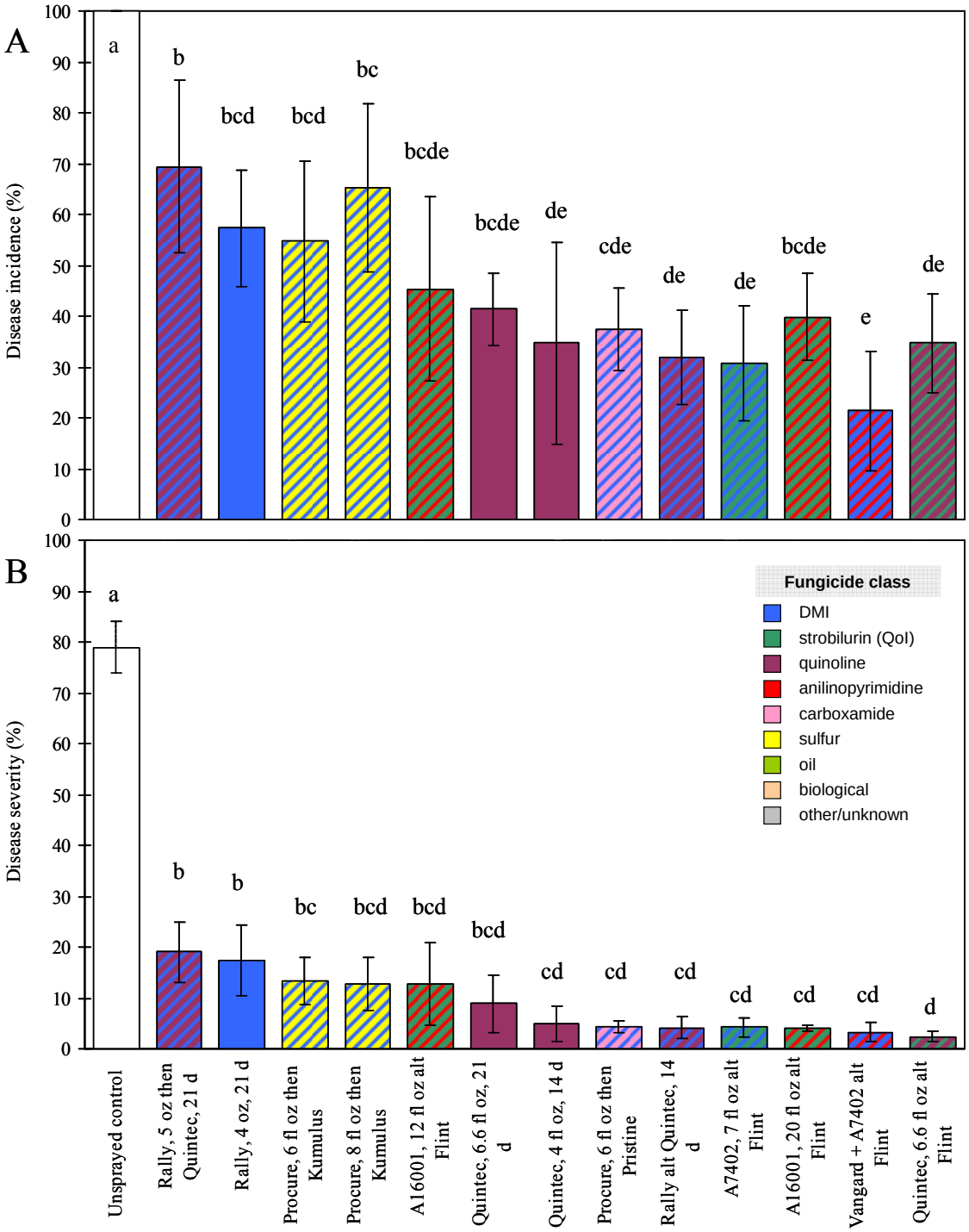


Figure 4. Disease incidence (A) and severity (B) in trial 2 treatments (means ± 1S.E.). Letters indicate significantly different groups of means with Fisher's LSD test at α = 0.10.

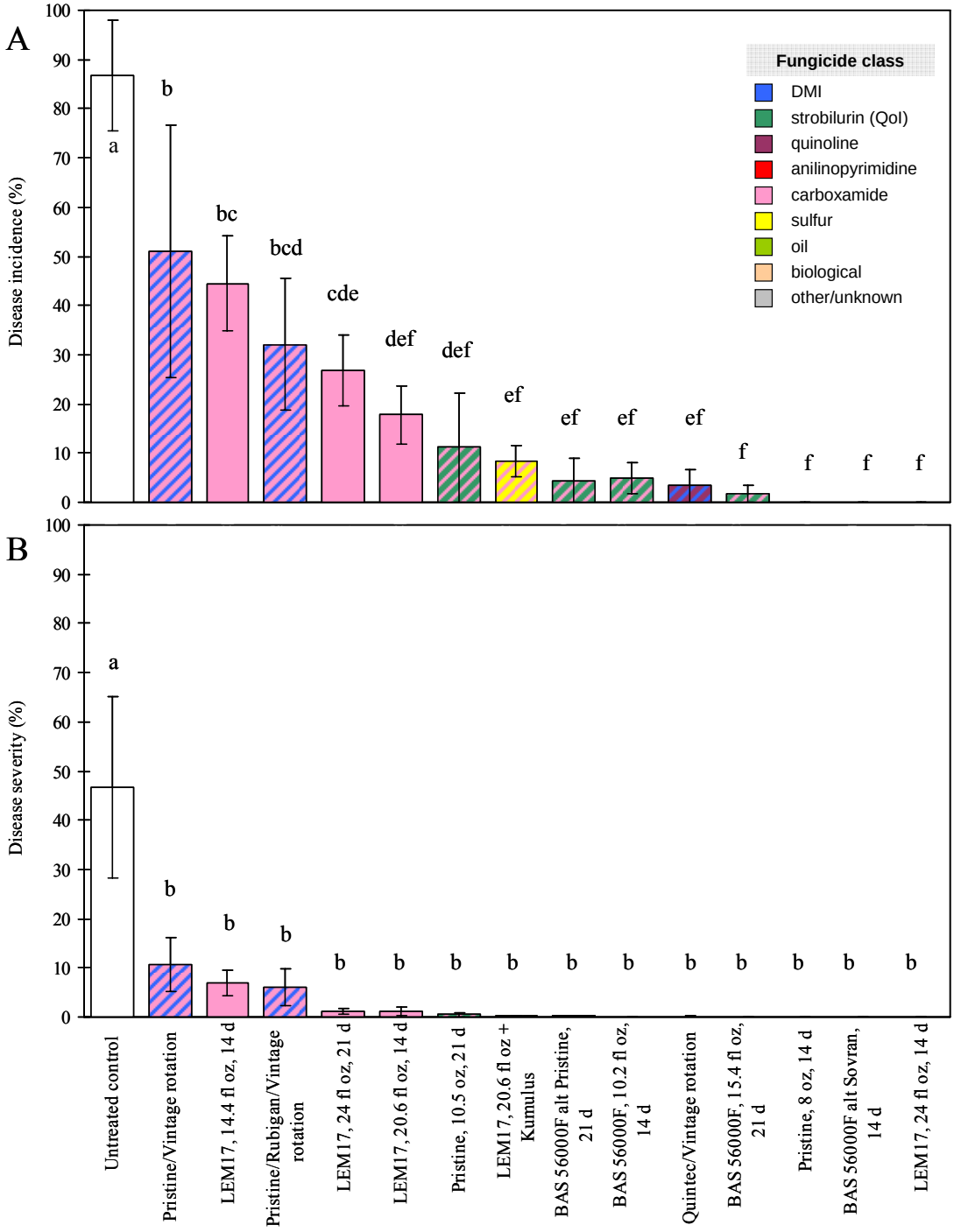


Figure 5. Disease incidence (A) and severity (B) in trial 3 treatments (means ± 1S.E.). Letters indicate significantly different groups of means with Fisher's LSD test at α = 0.10.

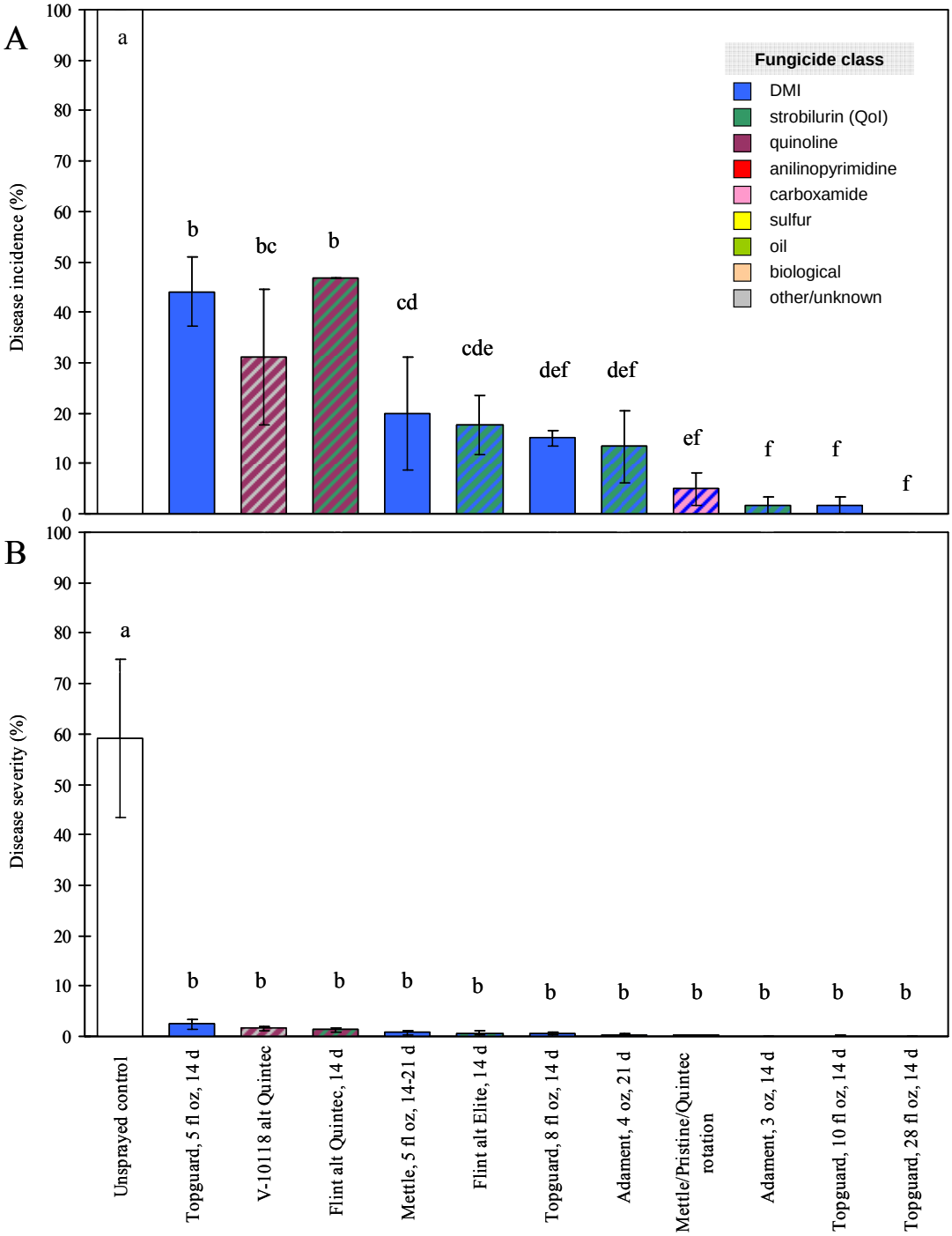


Figure 6. Disease incidence (A) and severity (B) in trial 4 treatments (means ± 1S.E.). Letters indicate significantly different groups of means with Fisher's LSD test at α = 0.10.

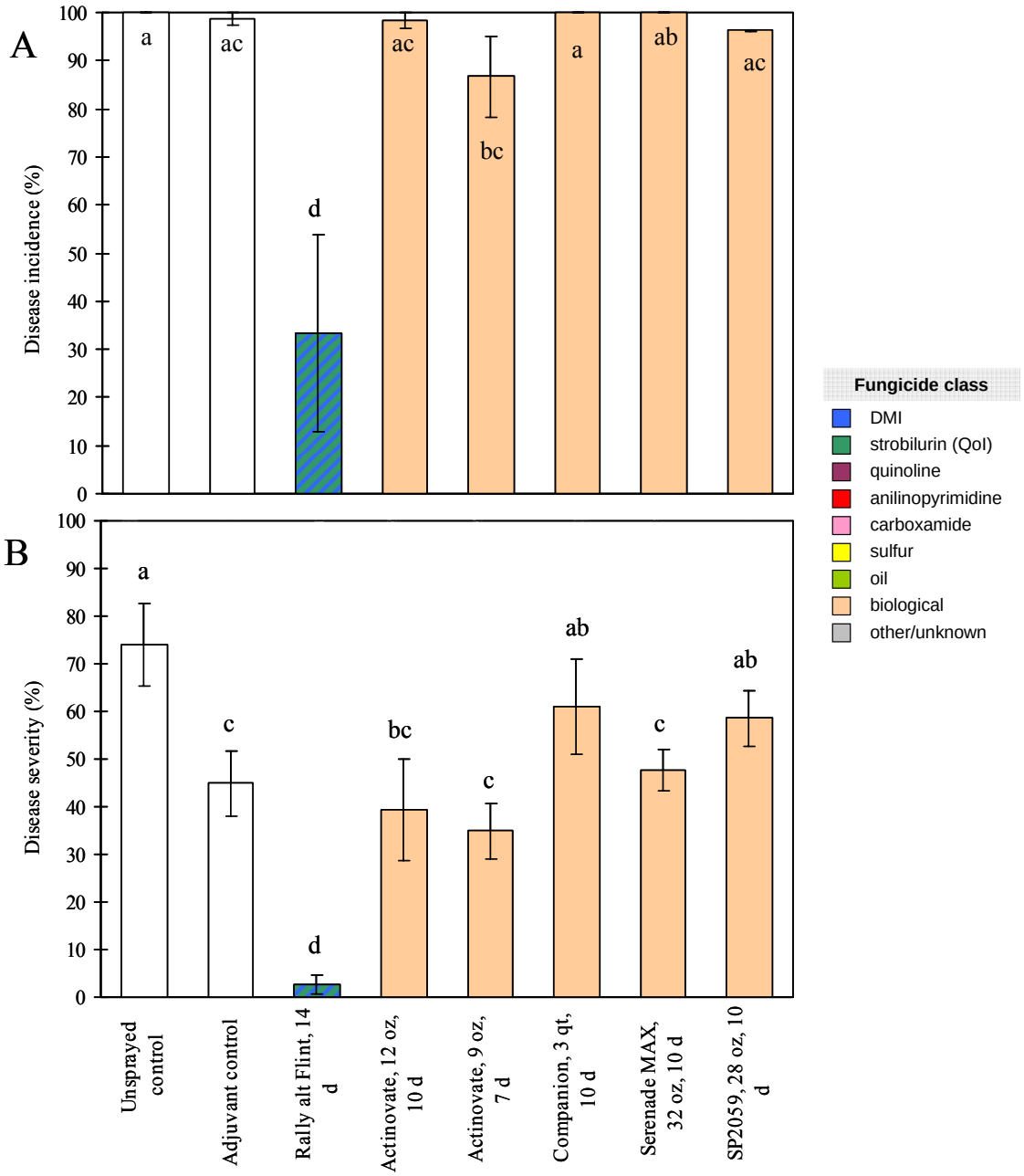
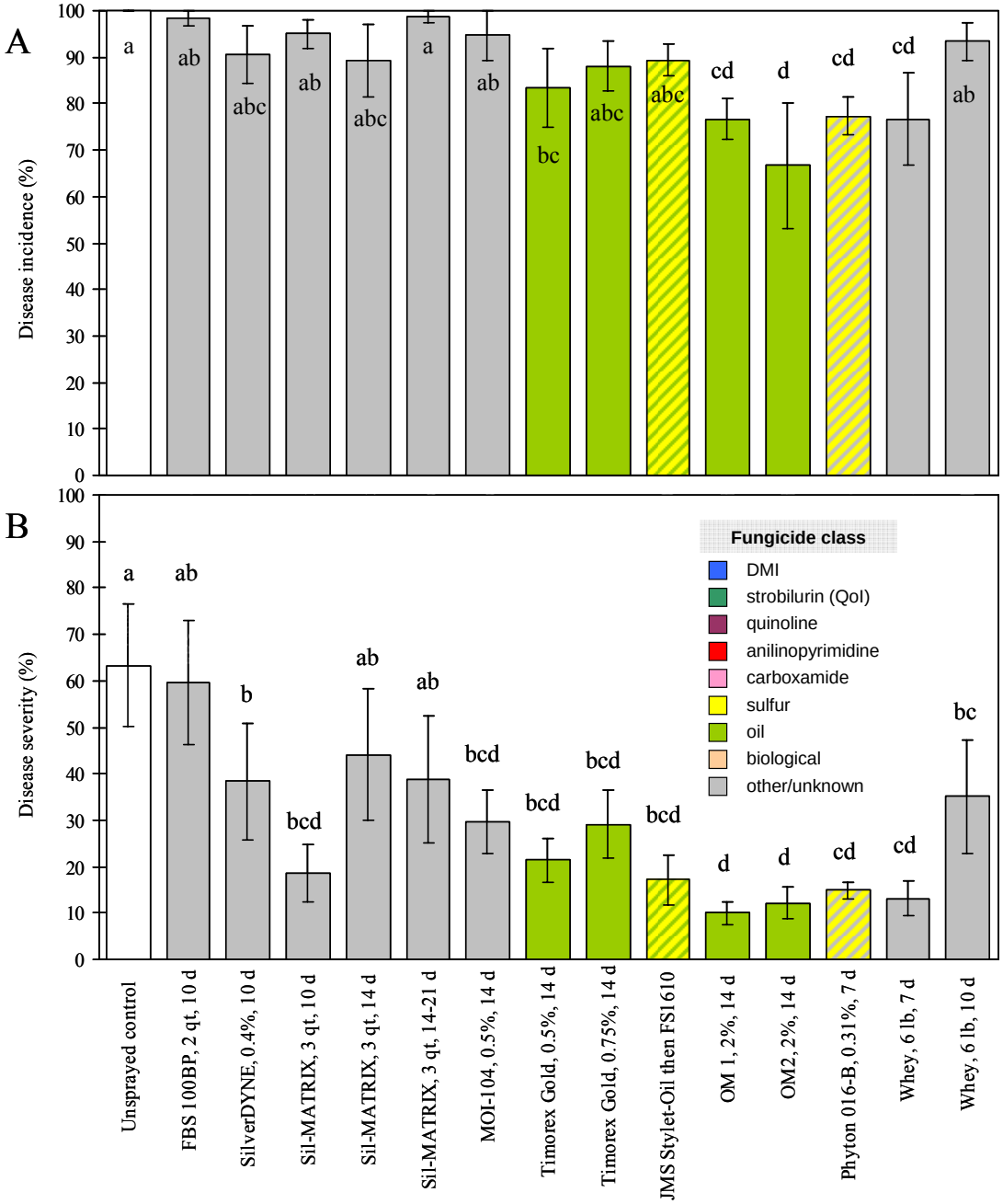


Figure 7. Disease incidence (A) and severity (B) in trial 5 treatments (means ± 1S.E.). Letters indicate significantly different groups of means with Fisher's LSD test at α = 0.10.



IV. Acknowledgements

R. Herche, J. Jertberg, J. Úrbez-Torres, H. Su, F. Trouillas and L. Gallegos assisted with spraying in the field. P. Backup kindly evaluated disease incidence weekly on leaves collected from trial 4. P. Backup, J. Broome, J. Edelstein, E. Hand, J. Jertberg, S. Mathauda, A. Poe, J. Úrbez-Torres, and F. Trouillas assisted with other aspects of the research including disease evaluation in the field.

Financial support and test materials for this research were provided by various fungicide industry donors. The treatments outlined in this report were conducted for experimental purposes only; crops treated in a similar manner may not be suitable for use or consumption.

V. References

Adaskaveg, J., D. Gubler, T. Michailides and B. Holtz. 2008. Efficacy and timing of fungicides, bactericides, and biologicals for deciduous tree fruit, nut, strawberry, and vine crops 2008. Published online at http://plantpathology.ucdavis.edu/ext/file/IPMFungicidetables2-14-08.pdf and http://repositories.cdlib.org/cgi/viewcontent.cgi?article=1000&context=plantpath_ucd.

Calonnec, A., P. Cartolaro, C. Poupot, D. Dubourdieu and P. Darriet. 2004. Effects of *Uncinula necator* on the yield and quality of grapes (*Vitis vinifera*) and wine. Plant Pathology 53:434-445.

California Department of Pesticide Regulation. 2004. *Summary of Pesticide Use Report Data 2004*. Sacramento, CA, 381 pp.

Gadoury, D.M., R.C. Seem, W.F. Wilcox, T. Henick-Kling, L. Conterno, A. Day and A. Ficke. 2007. Effects of diffuse colonization of grape berries by *Uncinula necator* on bunch rots, berry microflora, and juice and wine quality. Phytopathology 97:1356-1365.

Gubler, W.D. and D.J. Hirschfelt. 1992. Powdery mildew. In: D.E. Flaherty, L.P. Christensen, W.J. Lanino, J.J. Marois, P.A. Phillips, and L.T. Wilson (eds.), *Grape Pest Management*, 2nd edition, University of California, Division of Agriculture and Natural Resources, publication 3343, p.57-62.

Janousek, C.N., J.D. Lorber and W.D. Gubler. 2007. Control of powdery mildew in grapes: 2007 field trials. Published online at http://plantpathology.ucdavis.edu/ext/gubler/fungtrials2007/file/grape-pm-2007_web_report.pdf.

VI. Appendix 1: Materials

I. Biofungicides

Product	Organism and concentration	Manufacturer or distributor
Actinovate AG	*Streptomyces lydicus* WYEC 108 (0.0371%)	Natural Industries, Inc.
Companion	*Bacillus subtilis* GB03 (0.03%)	Growth Products, Ltd.
SP2059	*Clonostachys rosea* ($\geq 2 \times 10^7$ CFU/g)	SePRO Corporation
Serenade MAX	*Bacillus subtilis* QST713 (14.6%)	AgraQuest Inc.

II. Adjuvants

Product	Active ingredient(s) and concentration	Manufacturer or distributor
Hi Wett	polysiloxane polyether copolymer, polyoxyethylene-polyoxypropylene copolymer & alcohol ethoxylate (100%)	First Choice
Induce	alkyl aryl polyoxylkane ether & fatty acids (90%)	Helena Chemical Company
Latron B-1956	modified phthalic/glycerol alkyl resin (77%) + butyl alcohol (23%)	Dow AgroSciences LLP
Silwet L-77	polyalkyleneoxide modified hepta-methyltrisiloxane & allylooxy-polyethylene glycol methyl ether (100%)	Helena Chemical Company

III. Chemical fungicides and other materials

Product	Active ingredient(s) and concentration	Manufacturer or distributor	Chemical class (after Adaskaveg et al. 2008)
A7402 (Inspire)	difenoconazole (23.2%)	Syngenta Crop Protection, Inc.	demethylase inhibitor (DMI)
A16001 (Inspire Super)	difenoconazole (8.4%) + cyprodinil (24%)	Syngenta Crop Protection, Inc.	DMI + anilinopyrimidine
Adament 50WG (=USF 2010)	trifloxystrobin (25%) + tebuconazole (25%)	Bayer	strobilurin (QoI) + DMI
BAS 56 000 F	pyraclostrobin + boscalid	BASF Corporation	QoI + carboxamide
Elite 45WP	tebuconazole (45%)	Bayer	DMI
Flint 50WG	trifloxystrobin (50%)	Bayer	QoI
FBS 100 BP	potassium silicate (11.8%) + dipotassium phosphate (43.6%)	Floratine Biosciences, Inc.	other
FS 1610	phosphoric acid (P_2O_5) (16%) potash (K_2O) (10%) sulfur (30%)	First Choice	others + sulfur
JMS Stylet-Oil	paraffinic oil (97.1%)	JMS Flower Farms, Inc.	oil
Kumulus DF	sulfur (80%)	BASF Corporation	sulfur
LEM 17SC	penthiopyrad (20%)	DuPont Company	carboxamide
Mettle	tetraconazole (10-12.5%)	Isagro-USA	DMI
MOI-104	proprietary	Marrone Organic Innovations	other
OM1	paraffinic oil + OE444 (an oil-based adjuvant)	OE444: DuGussa/Goldschmidt	oil
OM2	paraffinic oil + OE444 (an oil-based adjuvant)	OE444: DuGussa/Goldschmidt	oil
Phyton-016-B	copper sulfate pentahydrate (21.4%)	Phyton Corporation	other
Pristine	pyraclostrobin (12.8%) boscalid (25.2%)	BASF Corporation	QoI + carboxamide
Procure 480SC	triflumizole (42.14%)	Crompton Manufacturing Company (Chemtura Corp.)	DMI
Quintec	quinoxyfen (22.6%)	Dow AgroSciences LLP	quinoline
Rally 40WSP	myclobutanil (40%)	Dow AgroSciences LLP	DMI
Rubigan	fenarimol (12%)	Gowan Co.	DMI
Sil-MATRIX	potassium silicate (29.1%)	PQ Corporation	other
SilverDYNE	silver colloid (0.39%)	World Health Alliance International Inc.	other
Timorex Gold	oil derived from the tea tree, *Melaleuca alterniflora* (23.8%)	Biomor Israel Ltd.	oil
Topguard	flutriafol (12%)	Cheminova	DMI
V-10118 .41EC	unknown (5%)	Valent	unknown
Vangard 75WG	cyprodinil (75%)	Syngenta	anilinopyrimidine
Vintage SC	fenarimol (11.6%)	Gowan Co.	DMI
Whey	whey	N/A	other

Appendix sources: (1): http://ppis.ceris.purdue.edu, (2) 2008 Crop Protection Reference, Vance Publishing Corporation, Lenexa, KS. (3) Product-associated documentation such as labels and MSDS, (4) personal communications, (5) Janousek et al. 2006 & 2007 grape powdery mildew reports, and (6) Adaskaveg et al. 2008.