Synthetic and organic fungicide control of apple scab: 2008 field trial

Christopher N. Janousek[1], Lynn Wunderlich[2] and W. Douglas Gubler[1]

[1] Department of Plant Pathology, University of California, Davis, CA 95616
[2] University of California Cooperative Extension,
Division of Agriculture and Natural Resources, Placerville, CA 95667

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

Address correspondence to: cnjanousek@ucdavis.edu or wdgubler@ucdavis.edu
Published August 2008 at: http://plantpathology.ucdavis.edu/ext/index.htm

I. Introduction

Apple scab is caused by the fungal pathogen *Venturia inaequalis*. The pathogen overwinters as ascospores in leaf litter and infection occurs when spores are carried by wind and rain to susceptible apple tissue (green tip, flower and fruit stages) in spring and early summer (Gubler 2006). Apple scab is a serious disease in the coastal and Sierra foothill growing regions of California, especially during years in which high spring rainfall coincides with bloom. The disease appears on fruit and leaves as velvety olive green lesions, making the fruit unmarketable. In heavy infection years, scab can decrease fruit yield. Historically, growers have relied on the fungicides Dithane and Captan for control of scab, but newer materials are being developed for resistance management, improved environmental and worker health, or for organic apple production.

The efficacy of several experimental fungicides for the control of apple scab was evaluated in a field trial with Red Delicious trees (*Malus* x *domestica*) near Camino, El Dorado Co., California. The incidence and severity of scab lesions was evaluated on leaves treated with Topguard (active ingredient = flutriafol) at a series of concentrations with and without Dithane (mancozeb), and several experimental organic treatments (Actinovate, Phyton 016-B and JMS Stylet-Oil). The strobilurin, Sovran (kresoxim methyl), was used as an industry standard. Early fungicide applications were made weekly or at a 14 day interval during leaf emergence and flowering; the final application was timed to precede a likely rain event at this site.

II. Materials and Methods

A. Trial layout

Treatments were applied to individual mature trees arranged in a complete randomized design with five replicates per treatment. Fungicides were tank mixed in a 25 gallon sprayer and applied with a hand gun. Applications were made from shortly after leaf emergence to petal fall, but subsequent spraying was not required because of unusually dry conditions during the spring.

Experimental unit	1 tree = 1 plot				
Row and tree spacing	18 ft (row) and 18 ft (tree)		Plot unit area	324 ft^2	
Area/treatment	1620 ft^2 or 0.0372 acre/treatment (5 replicate trees = 1 treatment)				
Fungicide applications	A	1” leaves/red bud	M 24 March	150 gallons/acre	5.6 gallons/5 replicates
	B	red bud	M 31 March	150 gallons/acre	5.6 gallons/5 reps
	C	red bud/flowering	M 7 April	150 gallons/acre	5.6 gallons/5 reps
	D	petal fall	M 21 April	200 gallons/acre	7.4 gallons/5 reps

B. Experimental treatments

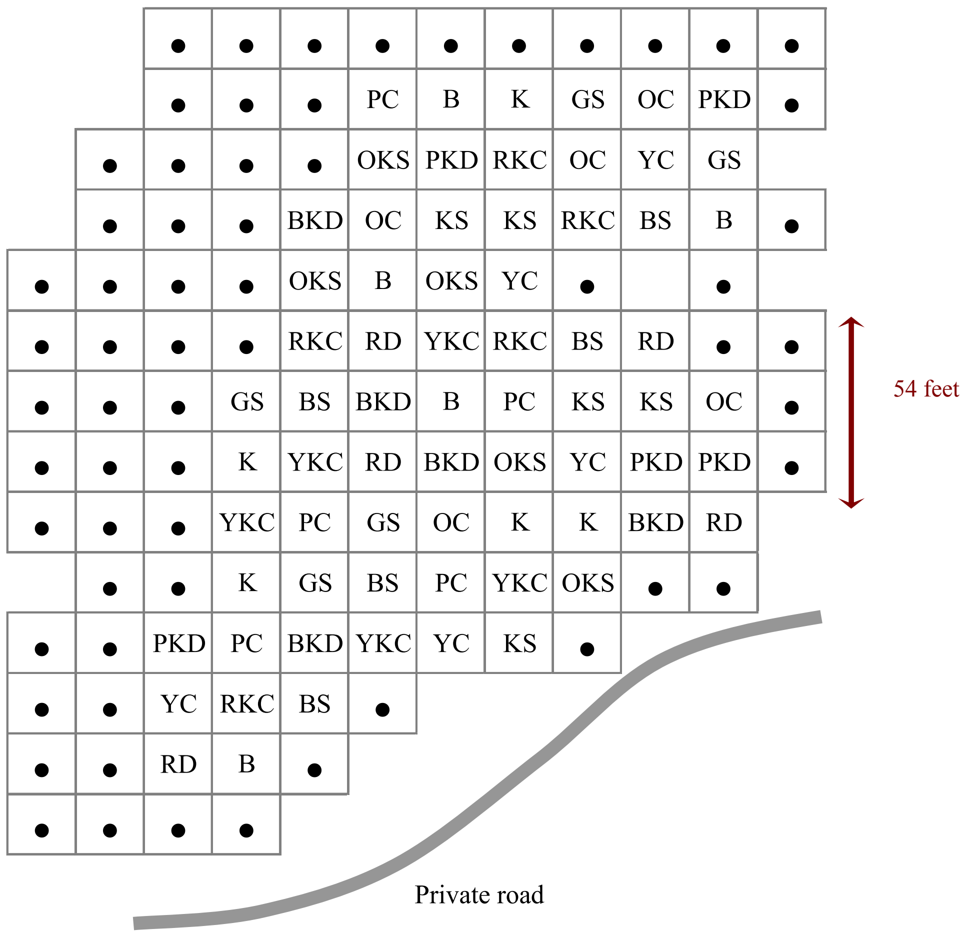
Trt no.	Flag	Product(s)	Applications	FP/Acre	FP/Treatment
1	PC	Unsprayed control	none	none	none
2	YKC	Water and adjuvant (ThermX-70) control	ABC	4.0 fl oz/100 gal	6.6 ml (at 150 gal) 8.8 ml (at 200 gal)
3	OKS	Actinovate AG + ThermX-70	ABC	6 oz + 4 fl oz/100 gal	6.3 g + 6.6 ml (at 150 gal) 8.8 ml (at 200 gal)
4	BS	Actinovate AG + ThermX-70	ABC	12 oz + 4 fl oz/100 gal	12.6 g + 6.6 ml (at 150 gal) 8.8 ml (at 200 gal)
5	PKD	JMS Stylet-Oil (first application at 1%, subsequent applications at 2%)	ABC	1 % then 2 %	211 ml (1% at 150 gal) 422 ml (2% at 150 gal) 562 ml (2% at 200 gal)
6	RKC	Phyton 016-B	ABC	40 fl oz	44 ml
7	OC	Sovran	AC	4 oz	4.2 g
8	RD	Topguard 1.04SC	AC	3.5 fl oz	3.9 ml
9	B	Topguard 1.04SC	AC	7 fl oz	7.7 ml
10	KS	Topguard 1.04SC	AC	13 fl oz	14.3 ml
11	YC	Topguard 1.04SC	AC	26 fl oz	28.6 ml
12	GS	Topguard 1.04SC + Dithane 76DF	AC	3.5 fl oz + 3 lb	3.9 ml + 51 g
13	K	Topguard 1.04SC + Dithane 76DF	AC	7.0 fl oz + 3 lb	7.7 ml + 51 g
14	BKD	Topguard 1.04SC + Dithane 76DF	AC	13.0 fl oz + 3 lb	14.3 ml + 51 g

Notes: FP=formulated product. Dithane coverage was uneven in treatments 12-14 due to incomplete dissolution of the product.

C. Fungicide application history

A	M 24 March 2008	Many trees with red buds 	150 gallons/acre (=5.6 gallons/5 trees)	Applications made to treatments 2-14.
B	M 31 March 2008	Red buds 	150 gallons/acre (=5.6 gallons/5 trees)	Applications made to treatments 2-6.
C	M 7 April 2008	Red buds/flowers 	150 gallons/acre (=5.6 gallons/5 trees)	Applications made to treatments 2-14. Applications to individual trees for treatment 4 somewhat variable.
D	M 21 April 2008	Petal fall 	200 gallons/acre (=7.4 gallons/5 trees)	Applications made to treatments 2-14.

D. Map of the experimental plots



E. Disease evaluation and statistical analysis

A frost event occurring throughout northern California during late April 2008 was responsible for loss of almost all viable fruit on trees in the trial. At the time of disease evaluation on 16 June, essentially no fruit remained on the trees. Disease evaluation was therefore conducted by rating scab lesions on 200 leaves in each plot (tree). Scab incidence was estimated as the percentage of leaves per tree with at least one lesion. Lesion density was also determined within a plot by obtaining the average number of lesions per 100 leaves.

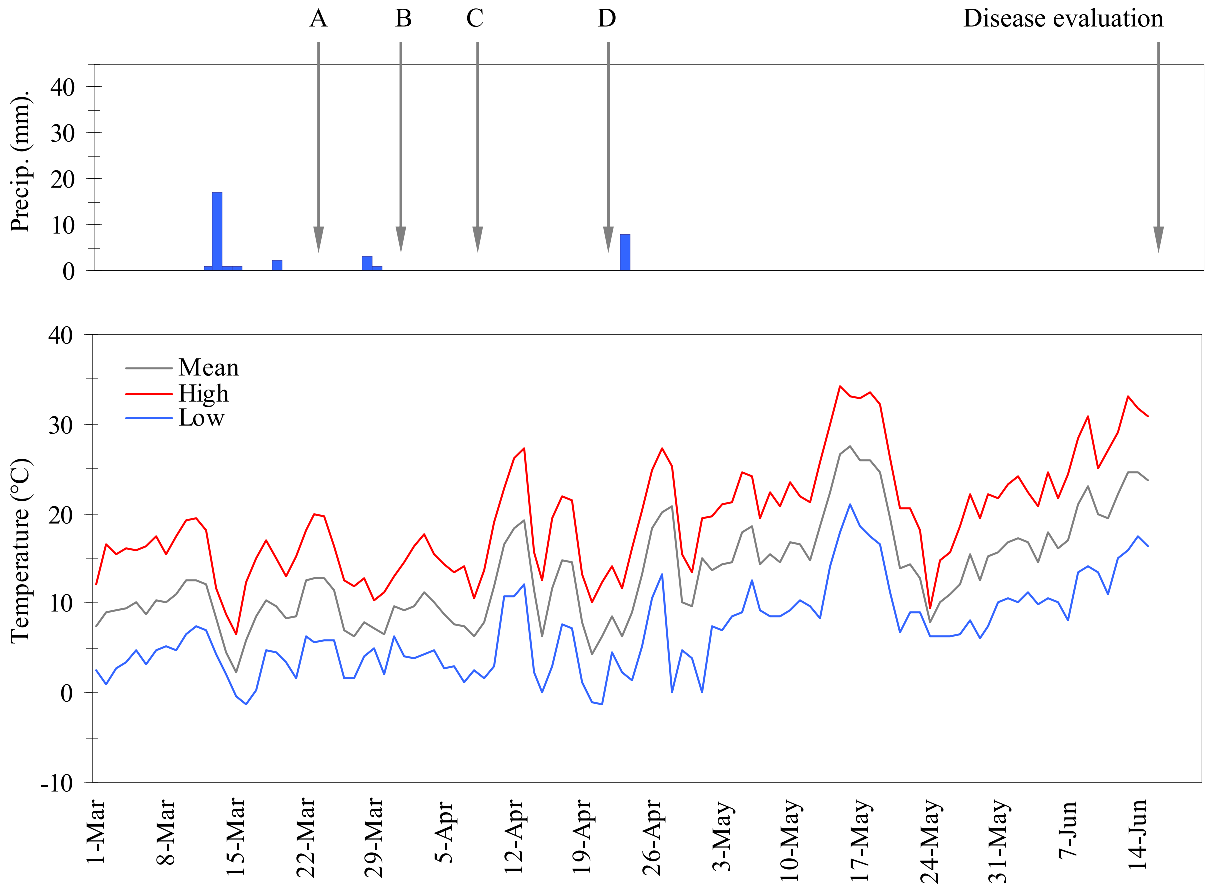
Means and 90% confidence intervals were determined for each treatment in the experiment. Additionally, differences among means were tested with Fisher's LSD *a posteriori* test at α=0.10. Transformed data (arcsine transformation for incidence data; log+1 transformation for lesion density data) were used for Fisher's LSD test since it substantially improved the distribution of residuals.

III. Results and discussion

Climatic conditions

During spring 2008, very light seasonal rainfall was recorded at the Camino CIMIS weather station. Only two modest rainfall events occurred during the period of March to mid-June 2008; these were the most likely times for *Venturia* ascospore release and dispersal to the foliage.

Figure 1. Daily meteorological data from the Camino CIMIS weather station: (a) precipitation, (b) low, mean, and maximum air temperature. Arrows and letters indicate dates of fungicide applications.



Disease incidence and severity

Scab lesion incidence on untreated leaves approached 10% (Figures 2,3). Disease incidence in the water + adjuvant (ThermX-70) control and most organic treatments (Actinovate, JMS Stylet-Oil) varied between 4-5%. Good disease control (<1% incidence) was obtained with the experimental organic product Phyton 016-B, the industry standard Sovran, and most treatments containing Topguard. The inability to statistically distinguish among the best performing treatments (e.g., Topguard applied at different concentrations) however, may have been due to light disease pressure stemming from an unusually dry spring.

Figure 2. Scab lesions on unsprayed leaves (left) and on foliage treated with Actinovate at 12 oz/acre (right).

Figure 3. Scab incidence on leaves. Data in untransformed means ± 90% confidence intervals. Statistical separation of arcsine-transformed means using Fisher's LSD test is indicated above each treatment (treatments with the same letter are not significantly different at α=0.1).

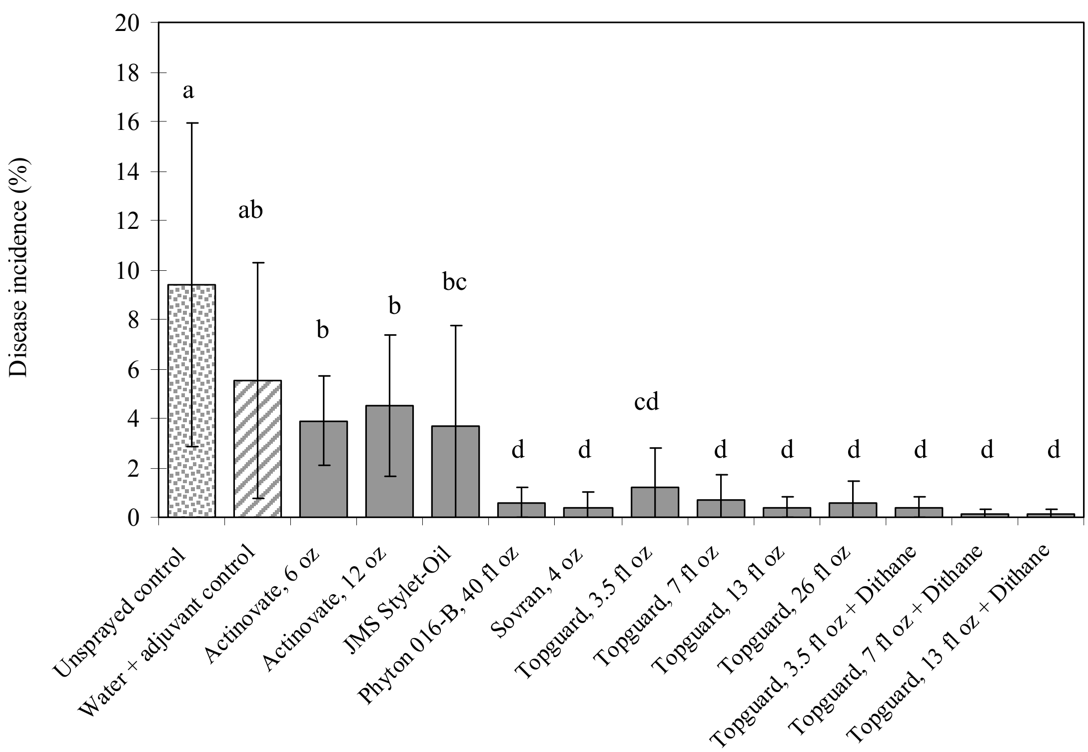
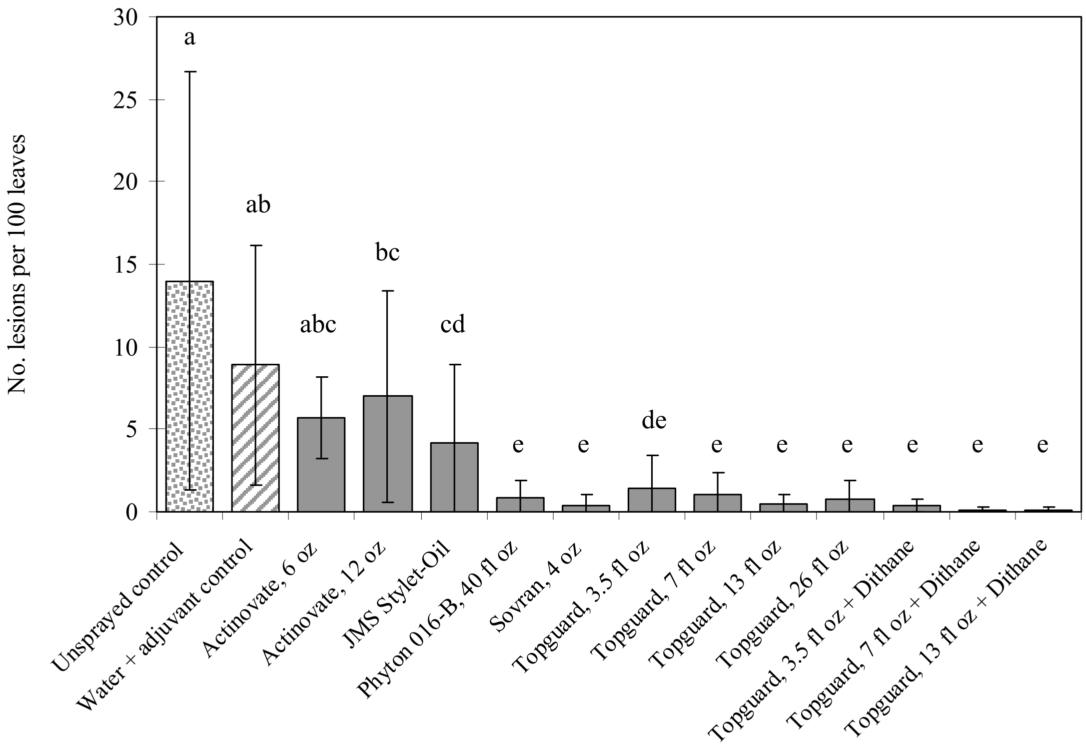


Figure 4. Mean number of scab lesions per 100 leaves. Data in untransformed means ± 90% confidence intervals. Separation of (log+1)-transformed means by Fisher's LSD test is indicated above each treatment (treatments with the same letter are not significantly different at α=0.1).



Lesion density (no. lesions per 100 leaves) was light across the trial, but highest in the untreated control and most organic treatments (Figure 3). Leaves treated with Sovran, Topguard, or Phyton 016-B tended to host the fewest scab lesions (often <1 lesion per 100 leaves).

Overall, our results suggest that Topguard, Sovran, and Phyton 016-B provided better control of scab lesions than the biofungicide Actinovate and JMS Stylet-Oil. Topguard also provided good control of scab in a 2007 trial conducted at the same site (Janousek et al. 2007). Our results with JMS Stylet-Oil are similar to other recently published trial data. Yoder et al. (2006) found a modest reduction in scab incidence in Rome, Golden Delicious and Red Delicious fruits at an application rate of 2 gallons/acre, but efficacy was dwarfed by Captan and Nova. Yoder et al. (2007) found that during a season of lighter scab pressure, JMS Stylet-Oil (at 1.5 gallons/acre) performed better.

IV. Acknowledgements

We thank the Gastaldi family for use of the property and J. Jertberg and J. Úrbez-Torres for assistance with disease evaluation.

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

V. References

Gubler, W.D. 2006. UC IPM Pest Management Guidelines, Apple. UC ANR Publication 3432, at http://www.ipm.ucdavis.edu/PMG/r4100411.html

Janousek, C.N., J.D. Lorber, Z. Varga, L. Wunderlich and W.D. Gubler. 2007. Fungicide control of apple scab: 2007 trial results. Published at: http://plantpathology.ucdavis.edu/ext/index.htm

Yoder, K.S., A.E. Cochran II, W.S. Royston Jr., S.W. Kilmer. 2006. Broad-spectrum disease management by certified organic and home fruit fungicides, 2005. F&N Tests 61:PF019.

Yoder, K.S., A.E. Cochran II, S.W. Kilmer, W.S. Royston, Jr., and S. Cochran. 2007. Broad-spectrum disease management by alternate fungicide programs on three apple cultivars, 2006. Plant Disease Management Reports 1:PF030.

VI. Appendix 1: Products tested

Product	Active ingredient(s) and concentration	Class	Manufacturer	OMRI
Actinovate AG	*Streptomyces lydicus* strain WYEC 108 (0.037%)	biological	Natural Industries, Inc.	√
Dithane 75DF Rainshield	mancozeb (75%)	carbamate	Dow AgroSciences LLC	
JMS Stylet-Oil	paraffinic oil (97.1%)	mineral oil	JMS Flower Farms, Inc.	√
Phyton 016-B	copper sulfate (21.4%) and tannic acid (1.1%)	inorganic/organic	Phyton Corporation	
Sovran	kresoxim methyl (50%)	strobilurin	BASF Corporation	
ThermX-70	saponin from *Yucca schidigera* (20%)	spray adjuvant	American Extracts	√
Topguard 1.04SC	flutriafol (12%)	demethylase inhibitor	Cheminova A/S	

Appendix 1 references: (1) 2008 Crop Protection Reference, Vance Publishing Corporation, Lenexa, KS, (2) http://ppis.ceris.purdue.edu, (3) 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, available at: http://plantpathology.ucdavis.edu/ext/file/IPMFungicidetables2-14-08.pdf, (4) Janousek et al. 2006. Grape powdery mildew fungicide Trial 4, available at http://plantpathology.ucdavis.edu/ext/gubler/fungtrials2006/file/trial4.pdf, (5) http://omri.org/index.html, and (6) various sources including product labels and/or MSDS, product websites, and personal communications.