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# Fungicide control of apple scab: 2011 field trial

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## Summary

Apple scab, caused by the fungal pathogen *Venturia inaequalis*, is a significant fruit and foliar disease worldwide (Jones and Sundin 2006). Apples grown in regions of California characterized by spring precipitation or damp microclimates are subject to infection. Initial pathogen colonization of green tissue occurs when water stimulates ascospore release from pseudothecia located in overwintering leaf litter, followed by dispersal to leaves, flowers or fruit. Asexually-produced conidia from the primary sites of infection on the host can also colonize new tissue if spores are transported in the air or by water splash (Jones and Sundin 2006). In California, periodic applications of synthetic or organic fungicides from approximately March to June are required to control apple scab; the timing of fungicide applications is dependent on season to season patterns in precipitation (Gubler 2006). Based on research in other apple producing regions, additional control measures such as post-harvest fungicide applications at the time of leaf fall to reduce inoculum for the following growing season (Beresford et al. 2008), leaf litter removal (Gomez et al. 2007) or use of cultivar mixtures in an orchard (Didelot et al. 2007) may effectively reduce disease impacts.

We conducted a field experiment near Camino, El Dorado County, California (elevation 3200 ft) to test the effects of several registered and experimental fungicides on control of apple scab in mature Golden Delicious Trees. Four applications were made from early April (green tip) to late May 2011 (petal fall). We compared disease levels obtained on foliage and fruit in untreated trees with disease control exhibited by synthetic, organic and biological products in combination, with and without adjuvants, and in alternation with other products.

Figure 1. Apples at disease evaluation on 6 Jul 2011. A) Untreated Control B) Treated with Sovran



## Materials and Methods

### A. Trial layout

Experimental unit	1 tree = 1 plot			
Row and tree spacing	18 ft (row) and 13 ft (tree)	Plot unit area	234 ft <sup>2</sup>	
Area/treatment	936 ft <sup>2</sup> or 0.0214 acre/treatment (4 replicate trees = 1 treatment)			
Fungicide applications	A	green tip	Wed 6 April	150 gallons/acre
	B	red bud	Tues 19 April	150 gallons/acre
	C	full bloom	Thurs 12 May	200 gallons/acre
	D	petal fall	Fri 27 May	200 gallons/acre
				3.2 gallons/4 replicates
				3.2 gallons/4 replicates
				4.3 gallons/4 replicates
				4.3 gallons/4 replicates

## B. Trial Map

### 2011 Trial

•	Pu	B	•	•	•	•
•	K	Y	•	•	•	•
OKS	YKD	BS	•	•	•	•
•	B	OKS	•	•	•	•
BC	BS	KC	•	•	•	•
OKS	BD	Pu	•	•	•	•
KC	Y	YKC	•	•	•	•
P	KS	O	•	•	•	•
BS	•	GD	•	•	•	•
BC	•	BD	•	•	•	•
Y	•	BC	•	•	•	•
Pu	YKS	W	•	•	•	•
YKS	P	KS	•	•	•	•
W	YKC	K	•	•	•	•
YKD	BKS	YKC	YKD	•	•	•
BKS	O	Pu	BC	•	•	•
KS	KC	OKS	P	•	•	•
K	GD	P	W	•	•	•
GD	W	BS	K	•	•	•
B	GD	YKD	BD	•	•	•
O	KC	Y	KS	•	•	•
BD	O	BKS	BKS	•	•	•
YKC	YKS	B	YKS	•	•	•

Main Road

• = untreated tree

## Apple Scab - Experimental treatments

No.	Flag	Product(s)	FP/Acre	FP/Treatment
1	W	Unsprayed control	none	none
2	Pu	Manzate + Vangard (2x) then Fontelis (2x)	4 lb + 4 oz then 20 oz then 6 lb	38.8 g + 2.4 g then 12.1 g then 58.2 g
3	BD	Manzate + Vangard (2x) then Fontelis + Damoil (2x)	4 lb + 4 oz then 20 oz + 0.5 % (v/v) then 6 lb	38.8 g + 2.4 g then 12.1 g + (61 ml (150 gal) OR 82 ml (200 gal)) then 58.2 g
4	YKS	Manzate + Vangard (3x) then Fontelis (1x)	4 lb + 4 oz then 20 oz	38.8 g + 2.4 g then 12.1 g
5	KC	Manzate + Vangard (2x) then Fontelis + Manzate (2x)	4 lb + 4 oz then 14 oz + 3 lb then 6 lb	38.8 g + 2.4 g then 8.5 g + 29.1 g then 58.2 g
6	BKS	Manzate + Vangard (2x) then Manzate (2x)	4 lb + 4 oz then 6 lb	38.8 g + 2.4 g then 3.2 ml then 58.2 g
7	YKC	MAR-YS (Yucca Ag Aide)	5 % (v/v)	606 ml (150 gal) 814 ml (200 gal)
8	BC	IKF-5411	10 fl oz	6.3 ml
9	K	IKF-5411	12.5 fl oz	7.9 ml
10	KS	Companion	1 gal	81 ml
11	B	Companion then Recover RX then Exp. D	1 gal then 2 gal then 0.5 gal	81 ml then 162 ml then 41 ml
12	O	Sovran-Chemical Standard	4 oz	2.4 g
13	OKS	Antica	3.0% (v/v)	364 ml (150 gal) 488 ml (200 gal)
14	P	Antica	4.0% (v/v)	485 ml (150 gal) 651 ml (200 gal)
15	YKD	Antica	5.0% (v/v)	606 ml (150 gal) 814 ml (200 gal)
16	Y	Antica	6.0% (v/v)	728 ml (150 gal) 977 ml (200 gal)
17	GD	Flint + Koverall alt Topguard + Koverall	2.5 oz + 48 oz alt 13 fl oz + 48 oz	1.5g + 30.4g alt 8.2 ml + 30.4g

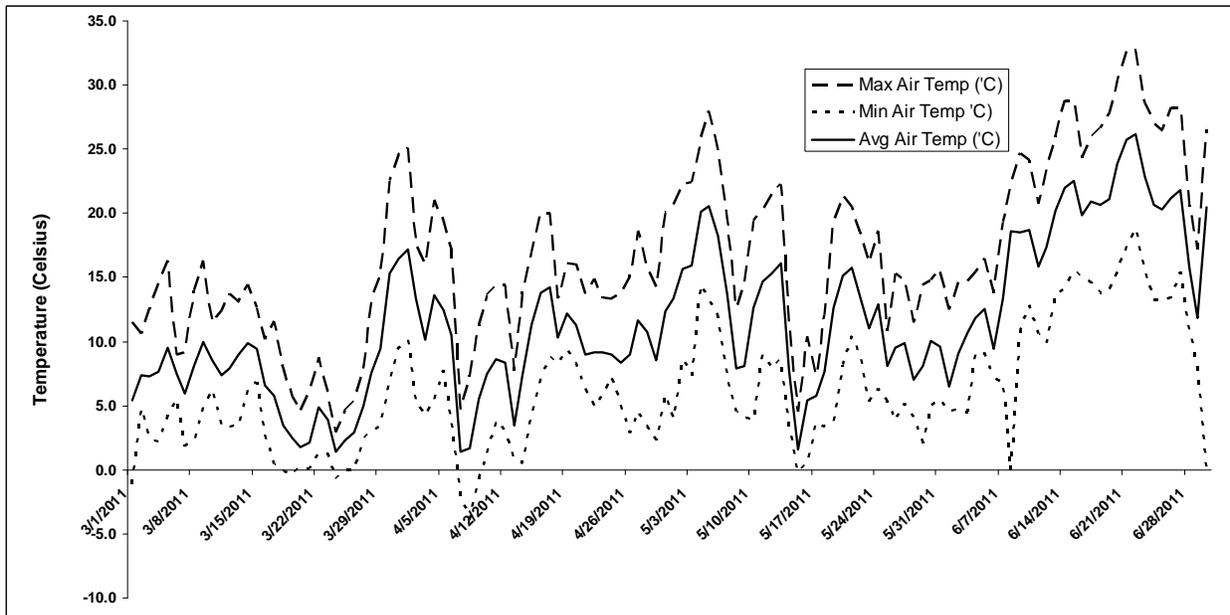
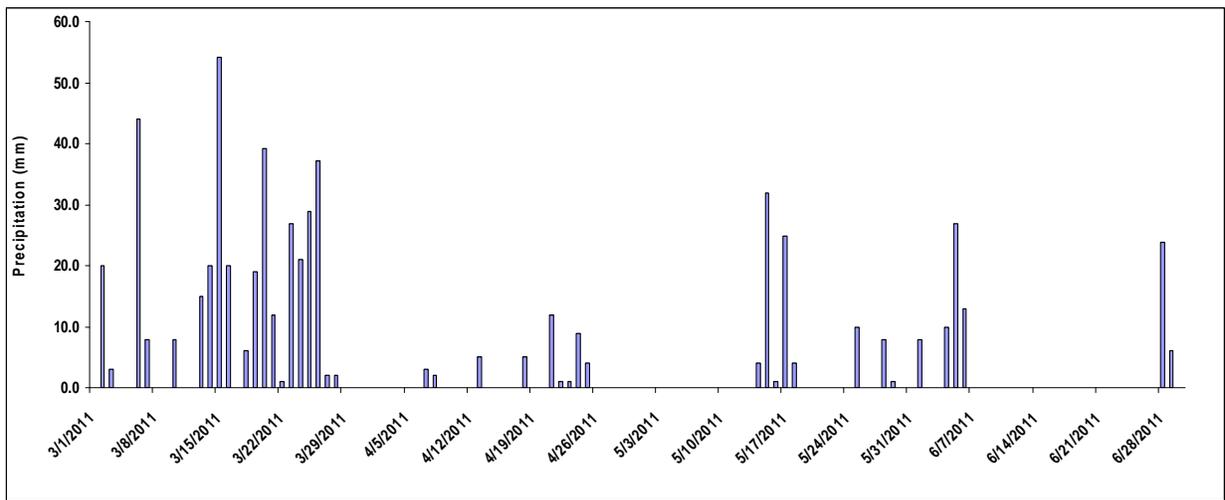
### C. Disease and statistical analysis

Disease was assessed on 06 July 2011 when fruits were large enough to observe scab lesions. Forty leaves and fruits were randomly selected from each tree. The number of lesions was scored for each leaf and fruit; estimated counts were made when the boundaries of individual lesions could not be easily distinguished. Disease incidence per replicate tree was determined as the proportion of leaves and fruits that were infected by at least one lesion. Disease severity for each plot was obtained as the mean density of lesions on leaves and fruits. Data was analyzed and means were compared using Fisher's protected LSD test ( $\alpha = 0.05$ ).

### D. Weather and Disease

Weather for the spray season was exceptionally rainy with 23 rain events (Apr 1 – June 31) of between 1-56 mm of rain.

## Results



**Table 1.** Apple scab leaf incidence (means). Product names are followed by rate (per acre). Treatment means were not significantly different according to a one-way ANOVA.

Treatment	Leaf Incidence (%)
Manzate + Vangard (2x), 4 lb + 4 oz then Fontelis + Manzate (2x), 14 oz + 3 lb	16.9
Sovran-Chemical Standard, 4 oz	17.5
Flint + Koverall, 2.5 oz + 48 oz alt Topguard + Koverall, 13 fl oz + 48 oz	19.4
IKF-5411, 10 fl oz	20.0
Manzate + Vangard (2x), 4 lb + 4 oz then Manzate (2x), 6 lb	22.5
Manzate + Vangard (3x), 4 lb + 4 oz then Fontelis (1x), 20 oz	24.4
IKF-5411, 12.5 fl oz	26.9
Manzate + Vangard (2x), 4 lb + 4 oz then Fontelis + Damoil (2x), 20 oz + 0.5 % (v/v)	28.1
Antica, 4.0%(v/v)	28.1
Manzate + Vangard (2x), 4lb + 4 oz then Fontelis (2x), 2 oz	28.8
Antica, 6.0%(v/v)	30.0
Companion, 1 gal	30.6
Companion, 1 gal then Recover RX, 2 gal then Sil-Phite, 0.5 gal	31.2
Antica, 3.0%(v/v)	33.1
Antica, 5.0%(v/v)	36.9
MAR-YS (Yucca Ag Aide), 5 % (v/v)	39.4
Untreated Control	40.6

**Table 2.** Apple scab leaf severity (lesion density) (means). Product names are followed by rate (per acre). Treatment means followed by the same letter are not significantly different according to Fisher's protected LSD test at  $\alpha=0.05$ .

Treatment	Leaf Severity (lesions/leaf)	Means Comp.
Flint + Koverall, 2.5 oz + 48 oz alt Topguard + Koverall, 13 fl oz + 48 oz	0.30	e
Sovran-Chemical Standard, 4 oz	0.33	e
Manzate + Vangard (2x), 4 lb + 4 oz then Fontelis + Manzate (2x), 14 oz + 3 lb	0.45	e
IKF-5411, 12.5 fl oz	0.53	de
Manzate + Vangard (2x), 4 lb + 4 oz then Manzate (2x), 6 lb	0.55	de
IKF-5411, 10 fl oz	0.55	de
Manzate + Vangard (2x), 4 lb + 4 oz then Fontelis + Damoil (2x), 20 oz + 0.5 % (v/v)	0.60	cde
Manzate + Vangard (3x), 4 lb + 4 oz then Fontelis (1x), 20 oz	0.68	bcde
Manzate + Vangard (2x), 4lb + 4 oz then Fontelis (2x), 2 oz	0.75	bcde
Antica, 4.0%(v/v)	0.75	bcde
Antica, 3.0%(v/v)	0.93	abcde
Companion, 1 gal then Recover RX, 2 gal then Sil-Phite, 0.5 gal	1.03	abcde
Companion, 1 gal	1.03	abcde
MAR-YS (Yucca Ag Aide), 5 % (v/v)	1.43	abcd
Antica, 6.0%(v/v)	1.48	abc
Untreated Control	1.60	ab
Antica, 5.0%(v/v)	1.68	a

**Table 3.** Apple scab fruit incidence (means). Product names are followed by rate (per acre). Treatment means followed by the same letter are not significantly different according to Fisher's protected LSD test at  $\alpha=0.05$ .

<b>Treatment</b>	<b>Fruit Incidence (%)</b>	<b>Means Comp.</b>
Manzate + Vangard (2x), 4 lb + 4 oz then Fontelis + Manzate (2x), 14 oz + 3 lb	18.1	e
Manzate + Vangard (2x), 4lb + 4 oz then Fontelis (2x), 2 oz	19.4	de
Manzate + Vangard (3x), 4 lb + 4 oz then Fontelis (1x), 20 oz	22.5	cde
Flint + Koverall, 2.5 oz + 48 oz alt Topguard + Koverall, 13 fl oz + 48 oz	23.8	cde
Manzate + Vangard (2x), 4 lb + 4 oz then Fontelis + Damoil (2x), 20 oz + 0.5 % (v/v)	26.2	cde
IKF-5411, 12.5 fl oz	30.0	cde
Manzate + Vangard (2x), 4 lb + 4 oz then Manzate (2x), 6 lb	30.6	bcde
IKF-5411, 10 fl oz	33.1	bcde
Companion, 1 gal then Recover RX, 2 gal then Sil-Phite, 0.5 gal	35.6	abcde
MAR-YS (Yucca Ag Aide), 5 % (v/v)	36.9	abcde
Sovran-Chemical Standard, 4 oz	37.5	abcde
Companion, 1 gal	40.6	abcde
Antica, 3.0%(v/v)	42.5	abcd
Antica, 4.0%(v/v)	45.0	abc
Antica, 5.0%(v/v)	54.3	ab
Untreated Control	58.1	a
Antica, 6.0%(v/v)	59.4	a

**Table 4.** Apple scab fruit severity (means). Product names are followed by rate (per acre). Treatment means followed by the same letter are not significantly different according to Fisher's protected LSD test at  $\alpha=0.05$ .

<b>Treatment</b>	<b>Fruit Severity (Lesions/fruit)</b>	<b>Means Comp.</b>
Manzate + Vangard (2x), 4lb + 4 oz then Fontelis (2x), 2 oz	0.40	d
Manzate + Vangard (2x), 4 lb + 4 oz then Fontelis + Manzate (2x), 14 oz + 3 lb	0.43	cd
Manzate + Vangard (2x), 4 lb + 4 oz then Fontelis + Damoil (2x), 20 oz + 0.5 % (v/v)	0.43	cd
Flint + Koverall, 2.5 oz + 48 oz alt Topguard + Koverall, 13 fl oz + 48 oz	0.48	cd
MAR-YS (Yucca Ag Aide), 5 % (v/v)	0.50	cd
Manzate + Vangard (3x), 4 lb + 4 oz then Fontelis (1x), 20 oz	0.53	cd
IKF-5411, 12.5 fl oz	0.55	cd
Manzate + Vangard (2x), 4 lb + 4 oz then Manzate (2x), 6 lb	0.57	cd
Companion, 1 gal	0.57	cd
IKF-5411, 10 fl oz	0.78	bcd
Sovran-Chemical Standard, 4 oz	0.80	bcd
Antica, 3.0%(v/v)	0.98	bcd
Antica, 5.0%(v/v)	1.30	abcd
Antica, 4.0%(v/v)	1.33	abcd
Companion, 1 gal then Recover RX, 2 gal then Sil-Phite, 0.5 gal	1.38	abc
Untreated Control	1.67	ab
Antica, 6.0%(v/v)	2.18	a

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## Appendix: Products tested

Product	Active ingredient(s) and concentration	Class	Manufacturer
Antica	lactic acid (10%)	unknown	Ahcil Laboratories
Companion	bacillus subtilus QB03 (0.03%)	biological	Growth Products, Ltd
Damoil	petroleum oil (98%)	oil	Drexel Chemical Company
Experimental 2	proprietary	proprietary	proprietary
Flint	trifloxystrobin (50%)	QoI	Bayer
Fontelis	penthiopyrad (20%)	carboxamide	Dupont
Koverall	mancozeb (75%)	carbamate	Cheminova
Manzate	mancozeb (75%)	carbamate	Dupont
MAR - YS	Yucca schidigera (100%)	plant extract	Monterey Ag Resources
Recover RX	nitrogen (3%)/phosphoric acid (18%)/potash (18%)	fertilizer	Growth Products, Ltd.
Experimental D	proprietary	proprietary	Growth Products, Ltd.
Sovran	kresoxim-methyl (50%)	QoI	BASF
Topguard 1.04 SC	flutriafol (12%)	dimethylase inhibitor	Dow AgroSciences
Vanguard	cyprodinil (75%)	anilinopyrimidine	Syngenta Crop Protection, Inc.

*Appendix 1 references:* (1) Adaskaveg, et al. 2011. Efficacy and timing of fungicides, bactericides and biologicals for deciduous tree fruit, nut, strawberry, and vine crops 2011, available at <http://www.escholarship.org/uc/item/05b5z3vs>. (2) Bay, et al. 2011. Grape powdery mildew trials, available at <http://plantpathology.ucdavis.edu/ext>, (3) various sources including product labels and/or MSDS, product websites, and personal communications.