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Fungicide control of apple scab: 2010 field trial

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Publication Date
2010-10-01

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University of California Cooperative Extension,
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University of California, Davis, October 2010

Published November 2010 at: http://plantpathology.ucdavis.edu/ext/index.htm

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.

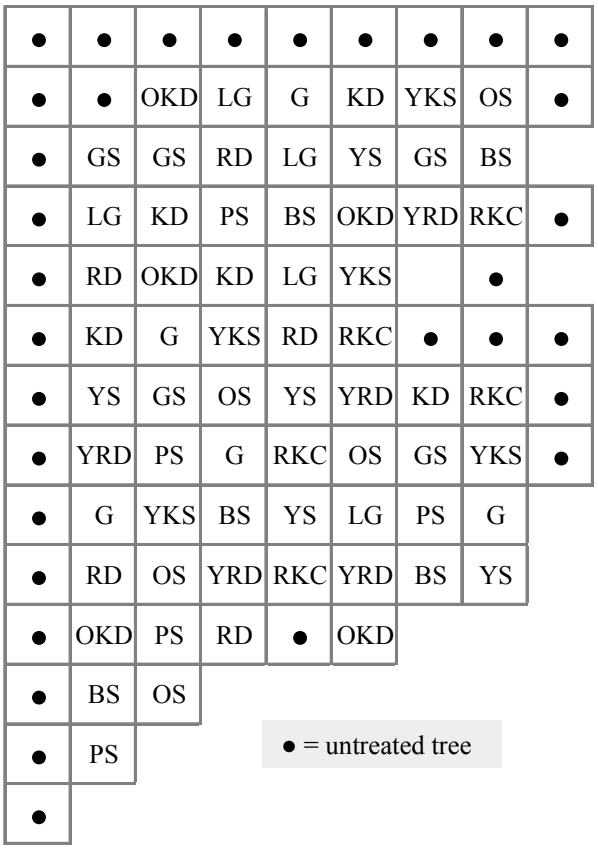
We conducted a field experiment near Camino, El Dorado County, California (elevation 3200 ft) to test the effects of several registered and experimental fungicides on control of apple scab in mature Red Delicious Trees. Five applications were made from late March (green tip) to late May 2010 (post-bloom). We compared disease levels obtained on foliage in untreated trees with disease control exhibited by synthetic products in combination, with and without adjuvants, and in alternation with other products.

Materials and Methods

A. Trial layout

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	1296 ft^2 or 0.0298 acre/treatment (4 replicate trees = 1 treatment)				
Fungicide applications	A	green tip	Fri 26 March	150 gallons/acre	4.5 gallons/4 replicates
	B	red bud	Fri 9 April	150 gallons/acre	4.5 gallons/4 replicates
	C	full bloom	Fri 23 April	200 gallons/acre	6.0 gallons/4 replicates
	D	petal fall	Sat 8 May	200 gallons/acre	6.0 gallons/4 replicates
	E	additional	Fri 21 May	200 gallons/acre	6.0 gallons/4 replicates

B. Trial Map



●	●	●	●	●	●	●	●	●
●	●	OKD	LG	G	KD	YKS	OS	●
●	GS	GS	RD	LG	YS	GS	BS	
●	LG	KD	PS	BS	OKD	YRD	RKC	●
●	RD	OKD	KD	LG	YKS		●	
●	KD	G	YKS	RD	RKC	●	●	●
●	YS	GS	OS	YS	YRD	KD	RKC	●
●	YRD	PS	G	RKC	OS	GS	YKS	●
●	G	YKS	BS	YS	LG	PS	G	
●	RD	OS	YRD	RKC	YRD	BS	YS	
●	OKD	PS	RD	●	OKD			
●	BS	OS						
●	PS							
●								

Experimental treatments

Flag	Product(s)	Applications	FP/Acre	FP/Treatment
OKD	Unsprayed control	none		
OD	Topguard + Dithane Rainshield 75DF	10-14	13 fl oz + 48 oz	11.5 ml 40.5 g
BD	Topguard + Captan 80 WDG	10-14	13 fl oz + 40 oz	11.5 ml 33.8 g

YD	Exp I	14	2.28 fl oz	2.0 ml
GD	Exp I	14	3.2 fl oz	2.8 ml
KD	Exp I	14	4.1 fl oz	3.6 ml
OS	Manzate (4lb)+ Vangard (2x) then LEM17 (3x) then Manzate (6lb) (1x)	14	4 lb + 4 oz then 20 fl oz then 6 lb	54 g + 3.4 g then 17.6 ml then 81.1 g
GS	Manzate (4lb)+ Vangard (2x) then LEM17 + Purespray (3x) then Manzate (6lb) (1x)	14	4 lb + 4 oz then 20 fl oz + 1% (v/v) then 6 lb	54 g + 3.4 g then 17.6 ml+ 170 ml (150 gal)/225.6 (200 gal) then 81.1 g
KS	Manzate (4lb)+ Vangard (2x) then LEM17 + Manzate 3 lb (3x) then Manzate (6lb) (1x)	14	4 lb + 4 oz then 14 fl oz + 3 lb then 6 lb	54 g + 3.4 g then 12.3 ml + 40.5 g then 81.1 g
PKS	LEM17 (20 fl oz) + Purespray (6x)	14	20 fl oz + 1% (v/v)	17.6 ml + 170 ml (150 gal)/225.6 (200 gal)
BS	LEM17 (12 fl oz) (6x)	14	12 fl oz	10.6 ml
YKS	LEM17 (12 fl oz) + Dyneamic	14	12 fl oz + 0.25% (v/v)	10.6 ml + 42.3 ml (150 gal)/ 56.4 ml (200 gal)
OKS	LEM17 (16 fl oz)	14	16 fl oz	14.1 ml
YS	LEM17 (20 fl oz)	14	20 fl oz	17.6 ml
YKC	YT669 + Dyneamic	14	12 fl oz + 0.25% v/v	10.6 ml + 42.3 (150 gal)/56.4 (200 gal)
KC	Manzate 4 lb + Vangard 4 oz (2x) then Flint 2 oz (3x) then Manzate 6 lb (1x)	14	4 lb + 4 oz then 2 oz then 6 lb	54 g + 3.4 g then 1.7 g then 81.1 g
GKC	Flint 2.5 oz alt Procure 12 fl oz	14	2.5 oz alt 12 fl oz	2.1 g alt 42.3 ml
YC	Rally	14	5 oz	4.2 g

C. Disease and statistical analysis

Disease was assessed on 21 June 2010 when fruits were large enough to observe scab lesions. Forty leaves were randomly selected from each tree. The number of lesions was scored for each leaf; 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. Data was analyzed and means were compared using Fisher's protected LSD test ($\alpha = 0.05$).

D. Weather and Disease

Weather for the growing season was exceptionally rainy with 32 rain events (Mar 1 – May 31) of between 1-36 mm of rain. Low temperatures reached below freezing on at least four occasions after the first application. The combination of these two factors likely led to loss of most fruit blossoms. For this reason, it was necessary to use leaf rating data for the best disease analysis.

Results

Figure 1. Daily precipitation and temperatures at the CIMIS weather station in Camino, California

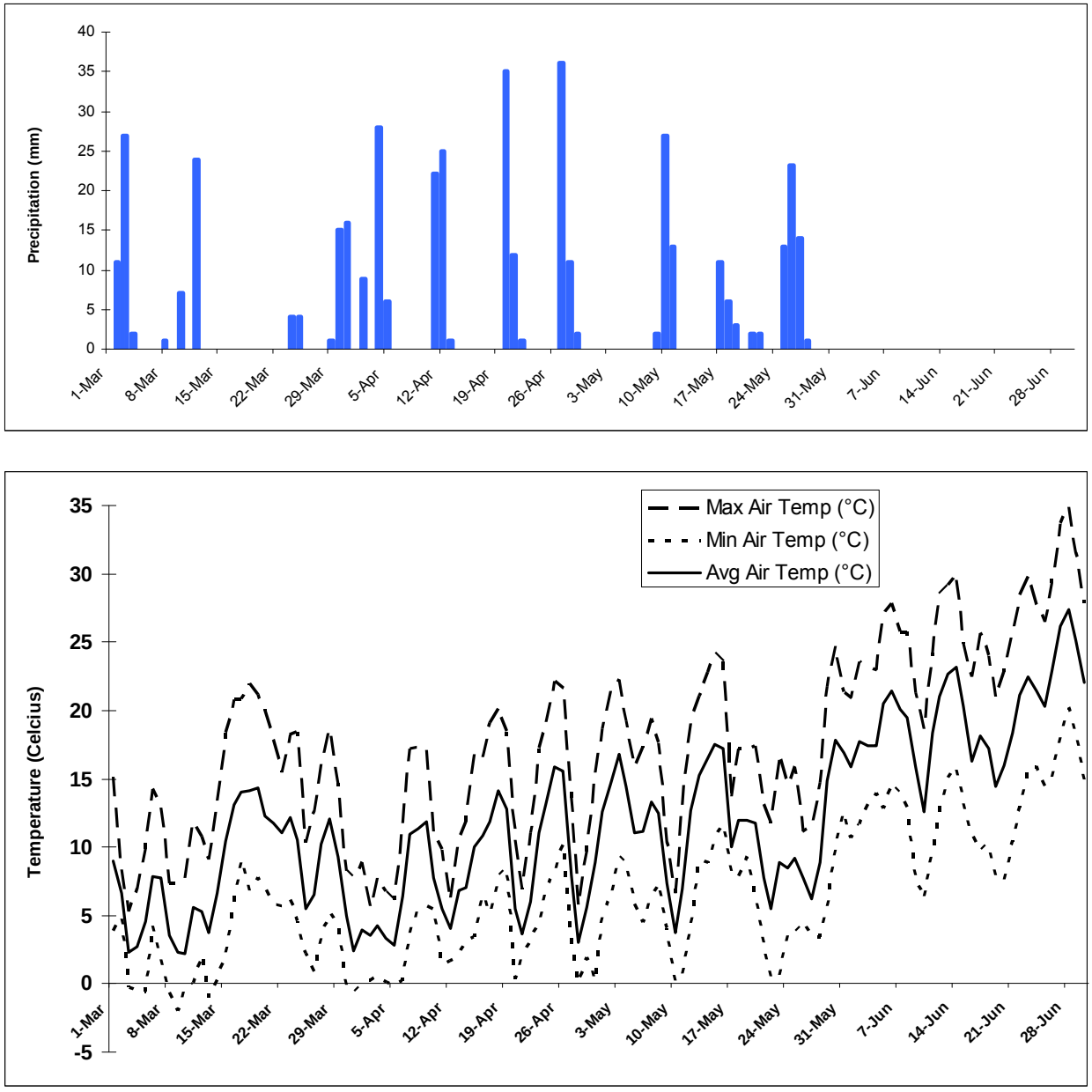


Table 1. Apple scab leaf incidence (means ± SE). Product names are followed by rate (per acre). Treatment means followed by the same letter are not significantly different according to Fisher's protected LSD test at α=0.05; alt=alternated with.

Treatment	Leaf Incidence (%)	
Topguard, 13 fl oz + Captan, 40 oz	8.1 ± 1.9	f
Manzate, 4 lb + Vangard, 4 oz (2x) then Flint, 2 oz (3x) then Manzate, 6 lb	18.1 ± 4.8	ef
YT669, 12 fl oz + Dyneamic, 0.25%	18.1 ± 4.7	ef
Manzate, 4 lb + Vangard, 4 oz (2x) then LEM17, 20 fl oz (3x) then Manzate, 6 lb	20.0 ± 1.0	ef
LEM17, 20 fl oz + Purespray, 1%	22.5 ± 4.0	ef
LEM17, 12 fl oz + Dyneamic, 0.25%	24.4 ± 5.7	de
Manzate, 4 lb + Vangard, 4 oz (2x) then LEM17, 20 fl oz +Purespray, 1% (3x) then Manzate, 6 lb	25.0 ± 5.3	de
Flint, 2.5 oz alt Procure, 12 fl oz	26.3 ± 5.2	de
Topguard, 13 fl oz + Dithane, 48 oz	30.0 ± 9.7	de
LEM17, 20 fl oz	30.6 ± 5.3	de
Rally, 5 oz	30.6 ± 4.7	de
LEM17, 16 fl oz	31.3 ± 5.2	de
Manzate, 4 lb + Vangard, 4 oz (2x) then LEM17, 14 fl oz + Manzate, 3 lb (3x) then Manzate, 6 lb	39.4 ± 6.1	cd
LEM17, 12 fl oz	49.4 ± 8.7	c
Exp 1, 4.1 fl oz	65.6 ± 11.0	b
Exp 1, 2.28 fl oz	69.4 ± 6.8	ab
Exp 1, 3.2 fl oz	83.8 ± 1.6	a
Untreated Control	83.8 ± 5.3	a

Table 2. Apple scab leaf severity (lesion density) (means ± SE). 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 α=0.05; alt=alternated with.

Treatment	Leaf Severity (lesions/leaf)	
Topguard, 13 fl oz + Captan, 40 oz	0.14 ± 0.04	e
Manzate, 4 lb + Vangard, 4 oz (2x) then Flint, 2 oz (3x) then Manzate, 6 lb	0.32 ± 0.10	e
YT669, 12 fl oz + Dyneamic, 0.25%	0.41 ± 0.14	e
Manzate, 4 lb +Vangard, 4 oz (2x) then LEM17, 20 fl oz (3x) then Manzate, 6 lb	0.46 ± 0.10	e
LEM17, 20 fl oz + Purespray, 1%	0.47 ± 0.16	e
Flint, 2.5 oz alt Procure, 12 fl oz	0.61 ± 0.22	e
LEM17, 12 fl oz + Dyneamic, 0.25%	0.63 ± 0.36	e
LEM17, 20 fl oz	0.68 ± 0.15	e
LEM17, 16 fl oz	0.78 ± 0.29	e
Manzate, 4 lb + Vangard, 4 oz (2x) then LEM17, 20 fl oz +Purespray, 1% (3x) then Manzate, 6 lb	0.82 ± 0.29	de
Rally, 5 oz	0.86 ± 0.21	de
Topguard, 13 fl oz + Dithane, 48 oz	0.99 ± 0.44	de
Manzate, 4 lb + Vangard, 4 oz (2x) then LEM17, 14 fl oz + Manzate, 3 lb (3x) then Manzate, 6 lb	1.11 ± 0.24	de
LEM17, 12 fl oz	1.96 ± 0.50	cd
Exp 1, 4.1 fl oz	2.74 ± 0.77	bc
Exp 1, 2.28 fl oz	3.12 ± 0.97	ab
Exp 1, 3.2 fl oz	3.33 ± 0.36	ab
Untreated Control	4.26 ± 0.75	a

Table 1. Apple scab fruit incidence (means ± SE). 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 α=0.05; alt=alternated with.

Treatment	Fruit Incidence	
LEM17, 12 fl oz + Dyneamic, 0.25%	11.0 ± 6.7	e
Topguard, 13 fl oz + Captan, 40 oz	11.7 ± 3.0	de
Manzate, 4 lb + Vangard, 4 oz (2x) then LEM17, 20 fl oz +Purespray, 1% (3x) then Manzate, 6 lb	14.4 ± 3.0	de
Manzate, 4 lb + Vangard, 4 oz (2x) then Flint, 2 oz (3x) then Manzate, 6 lb	18.3 ± 8.8	cde
YT669, 12 fl oz + Dyneamic, 0.25%	19.4 ± 7.7	cde
Manzate, 4 lb + Vangard, 4 oz (2x) then LEM17, 14 fl oz + Manzate, 3 lb (3x) then Manzate, 6 lb	20.3 ± 13.8	cde
Flint, 2.5 oz alt Procure, 12 fl oz	22.3 ± 9.9	cde
LEM17, 20 fl oz + Purespray, 1%	22.7 ± 8.4	cde
LEM17, 16 fl oz	30.9 ± 8.3	cde
LEM17, 20 fl oz	31.0 ± 5.3	cde
Manzate, 4 lb +Vangard, 4 oz (2x) then LEM17, 20 fl oz (3x) then Manzate, 6 lb	31.3 ± 10.5	cde
Topguard, 13 fl oz + Dithane, 48 oz	34.4 ± 10.5	cd
Rally, 5 oz	41.9 ± 9.5	bc
LEM17, 12 fl oz	59.0 ± 7.1	b
Untreated control	100.0 ± 0.0	a

Acknowledgements

We thank the Gastaldi family and Lynn Wunderlich. H. Su, R. Choudhury, A. Gallaher, F. Peduto, L. Costadone and C. Pisani assisted with disease and yield evaluation in the field or other aspects of the research.

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Appendix: Products tested

Product	Active ingredient(s) and concentration	Class	Manufacturer
Captan 80 WDG	captan (80%)	pthalamide	Arysta Life Sciences
Dithane Rainshield 75 DF	mancozeb (75%)	carbamate	Dow Agrosciences LLC
Dyneamic	polyalkyleneoxide modified polydimethylsiloxane, nonionic emulsifiers, methyl ester of C16-C-18 fatty acids (99%)	adjuvant	Helena Chemical Co.
Exp. 1	proprietary	proprietary	proprietary
Flint 50 WG	trifloxystrobin (50%)	QoI	Bayer
LEM 17 SC	penthiopyrad (20%)	carboximide	DuPont
Manzate	mancozeb (75%)	carbamate	Dupont
Procure	triflumizole (42.1%)	DMI-imidizole	Chemtura Corp.
Purespray	petroleum oil (98%)	oil	Petro-Canada
Rally 40WSP	myclobutanil (40%)	DMI-triazole	Dow AgroSciences
Topguard 1.04 SC	flutriafol (12%)	dimethylase inhibitor	Cheminova A/S
Vangard	cyprodinil (75%)	anilinopyrimidine	Syngenta Crop Protection, Inc.

Appendix 1 references: (1) Adaskaveg, et al. 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/gubler/fungtrials2008/file/IPMFungicidetables2-14-08.pdf (2) Janousek et al. 2008. Grape powdery mildew trials, available at http://plantpathology.ucdavis.edu/ext/gubler/fungtrials2008/file/Grape_PM_2008_web_report.pdf, (3) various sources including product labels and/or MSDS, product websites, and personal communications.