Powdery mildew control on pumpkin with organic and synthetic fungicides: 2011 field trial

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Published December 2011 at http://escholarship.org/uc/plantpath_ucd.

Summary

Powdery mildew is an important disease in commerciall members of the cucumber family. The specific pathogen that infects cucurbits in California is *Podosphaera fusca* (synonyms: *P. xanthii*, *Sphaerotheca fulginea* and *S. fusca*), (Janousek et al. 2009, McGrath and Thomas 1996, Pérez-García et al. 2009). Over-wintering chasmothecia produce ascospores that then develop into whitish colonies on leaves, leaf petioles, and stems (McGrath and Thomas 1996, Glawe 2008). Wind or insect vectors disperse asexually-produced conidia and thus spread the disease (Blancard et al. 1994). Favorable conditions for disease epidemics include temperatures between 20-27°C and lower-intensity light (McGrath and Thomas 1996). Disease outbreaks in the Central Valley of California tend to occur during late summer and autumn months, but coastal areas may be continuously threatened (Davey et al. 2008). Infections have the potential to reduce the yield and quality of fruit and can lead to early plant senescence (Blancard et al. 1994, McGrath and Thomas 1996).

Disease management in cucurbits usually involves foliar applications of synthetic fungicides and/or use of disease resistant cultivars (McGrath and Thomas 1996). Fungicides such as azoxystrobin, myclobutanil, quinoxyfen, trifloxystrobin, triflumizole, and micronized sulfur can be used to treat plants (Davis et al. 2008). Sulfur has the advantage of little or no risk of selecting for resistant mildew strains (Blancard et al. 1994). Previous work in our lab has shown that quinoxyfen, triflumizole, and penthiopyrad are highly effective at managing powdery mildew in disease susceptible varieties (Janousek et al. 2007, 2009).

We conducted a field trial at the UC Davis plant pathology experimental farm in Solano County, California to evaluate the effectiveness of 'soft-chemistry' and synthetic fungicides in managing powdery mildew on pumpkins (*Cucurbita pepo*) using the susceptible cultivar 'Sorcerer'. We applied fungicides every 7 to 14 days for a six week period beginning Aug 22 and continuing through Oct 3. Following four or seven applications, depending on treatment, we assessed disease incidence and powdery mildew colony density on the upper and lower surfaces of leaves in each treatment.

Figure 1. a) Pumpkins in field at maturity and b) Pumpkin leaf showing powdery mildew.

Materials and Methods

Experimental design	Complete randomized block design with 4 replicates.		
Application method	Backpack sprayers		
Plot length	14 feet	Bed spacing	16 feet
No. plants/plot	Approximately 7	Plot area	112 ft^2 (14 ft by 8 ft)
Plant spacing	variable	Area/4 plots	448 ft^2 (=0.0103 acres)
Application period	22 Aug – (?)(7 and 14 day intervals)		
Volume water applied	100 gallons/acre=1.0 gallons/acre 150 gallons/acre (=1.6 gallons per treatment) 225 gallons/acre (=2.3 gallons per treatment)		

Table 1. Pumpkin Trial - Experimental fungicide treatments. "alt" = alternated with; "FP" = formulated product

Treatment	No.	Flag color	Application interval (days)	Application rate (per acre)	FP/application
Unsprayed control	1	W	None	none	none
Oxidate 2.0 + Silwett L-77 alt Quintec	2	Br	14	1% + (.1%) alt 4 fl oz	56.8 ml (150 gal) 42.6 ml (200 gal) + 6.1 ml (150 gal) 8.1 ml (200 gal) alt 1.2 ml
BPS (Biotectic treatment)_	3	Y	7	2%	75.2 ml (100 gal) 150.4 ml (200 gal)
Quintec + Dynamic	4	O	14	4 fl oz + 0.125%(v/v)	1.2 ml + 7.6 ml (150 gal) 10.1 ml (200 gal)
Rally + Dynamic	5	C	14	5 fl oz + 0.125% (v/v)	1.5 ml + 7.6 ml (150 gal)
Rally + Dyneamic alt Quintec + Dyneamic alt Flint + Dyneamic	6	LG	14	5 oz + 0.125% (v/v) alt 4 fl ozoz + 0.125% (v/v) alt 2 oz + 0.125% (v/v)	1.5 ml + see below alt 1.2 ml + see below alt .6 g + 7.6 ml (150 gal) 10.1 ml (200 gal)
Fontelis	7	G	14	16 fl oz	4.8 ml
Fontelis + Dyneamic	8	K	14	16 fl oz + 0.25% (v/v)	4.8 ml + 15.2 ml (150 gal) 20.2 ml (200 gal)
Fontelis alt Quintec	9	B	14	16 fl oz alt 4 fl oz	4.8 ml alt 1.2 ml
YT669	10	S	14	12 fl oz	3.6 ml
Rally 40 W alt Quintec	11	Pu	14	5 oz alt 4 fl oz	1.5 ml alt 1.2 ml
IKF-309	12	O/C	14	4 fl oz	1.2 ml
Companion alt Recover	13	Pu/C	14	64 oz alt 2 gal	19.5 ml alt 19.5 ml
Antica	14	LG/C	7	0.1% (v/v)	6.1 ml (150 gal) 8.1 ml (200 gal)
Antica	15	O/S	7	0.2% (v/v)	13.2 ml (150 gal) 16.2 ml (200 gal)
Antica	16	G/O	7	0.3% (v/v)	18.3 ml (150 gal) 24.3 ml (200 gal)
Antica	17	Pu/G	7	0.4% (v/v)	24.4 ml (150 gal) 32.4 ml (200 gal)

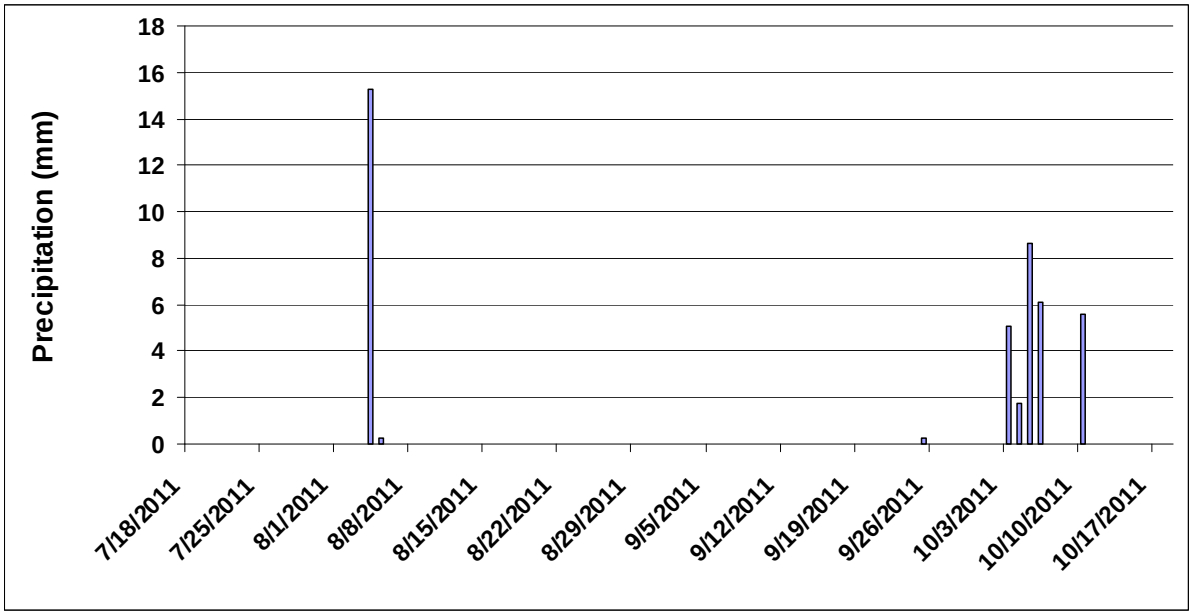
Figure 2. Layout of plots in the experimental area. Grey box = unused plot (plant density too low).

Pumpkins

K	Pu				O/C	
	Pu/G		W	Br	G	
W	B	Br	G		LG	
O	O/S	G	B	O/S		
Pu/C	Y	LG/C	Pu/C	LG		Y
C		Pu		Y	K	
	O/C			Br	S	Pu/C
S	Pu/G	O	S	LG/C	LG/C	
LG	C	LG	C	O/C		Pu
G	B			K		W
Br	Pu/C	Y		Pu	G/O	O/S
G/O		K		O		O
	W	S		Pu/G	C	B
LG/C	O/S			G/O		
O/C		G/O				Pu/G
Row	1	2	3	4	5	6	7

Results and Discussion

Figure 3. Precipitation and daily high, low and average temperatures for Davis, California (from http://www.cimis.water.ca.gov/) during the experimental period.



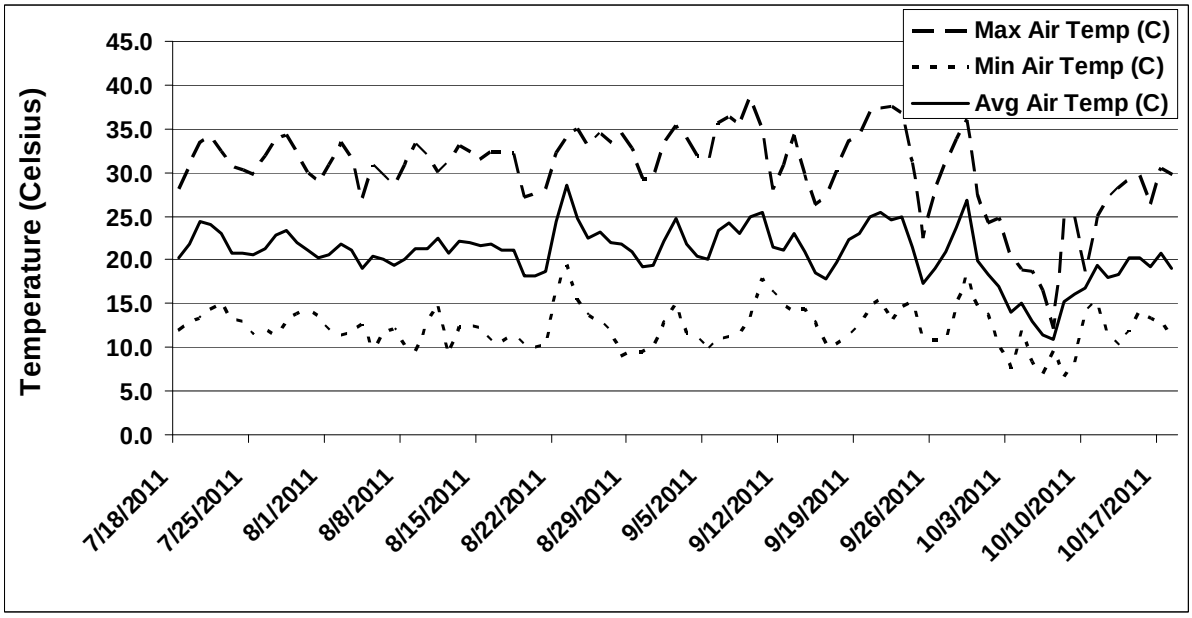


Table 3. Treatment effects on disease incidence on the upper surfaces of leaves of pumpkin. Treatments sharing the same letter within a column are not significantly different according to Fisher's protected LSD test at $\alpha = 0.05$.

Treatment	Top Leaf Incidence (%)	Means Comp
Rally, 40 W, 5 oz alt Quintec 4 fl oz	15.0	f
Fontelis, 16 fl oz, alt Quintec, 4 fl oz	15.0	f
Quintec, 4 fl oz + Dyneamic, 0.125% (v/v)	32.5	ef
Rally, 40 W, 5 oz + Dyneamic, 0.125% (v/v)	35.0	ef
BPS, 2%, (v/v)	37.5	ef
Rally, 5 oz + Dyneamic, 0.125% (v/v) alt Quintec, 4 fl oz + Dyneamic 0.125% (v/v) alt Flint, 2 oz + Dyneamic 0.125% (v/v)	43.8	e
Fontelis, 16 fl oz	51.3	de
IKF-309, 4 fl oz	53.8	cde
Oxidate 2.0, 1% (v/v) + Silwett L-77 0.1% alt Quintec, 4 fl oz	56.3	bcde
YTT669, 12 fl oz	75.0	abcd
Antica, 0.4% (v/v)	76.3	abc
Fontelis, 16 fl oz + Dyneamic, 0.25% (v/v)	78.8	ab
Antica, .2% (v/v)	81.3	a
Companion, 64 fl oz alt Recover, 2 gal	83.8	a
Antica , 0.1% (v/v)	85.0	a
Antica 0.3%, (v/v)	93.8	a
Untreated Control	97.5	a

Table 4. Treatment effects on disease severity on the upper surfaces of leaves of pumpkin. Treatments sharing the same letter within a column are not significantly different according to Fisher's protected LSD test at $\alpha = 0.05$.

Treatment	Top Leaf Severity (%)	Means Comp.
Rally, 40 W, 5 oz alt Quintec 4 fl oz	0.25	d
Fontelis, 16 fl oz, alt Quintec, 4 fl oz	0.25	d
Quintec, 4 fl oz + Dyneamic, 0.125% (v/v)	0.53	d
Rally, 40 W, 5 oz + Dyneamic, 0.125% (v/v)	1.18	d
Rally, 5 oz + Dyneamic, 0.125% (v/v) alt Quintec, 4 fl oz + Dyneamic 0.125% (v/v) alt Flint, 2 oz + Dyneamic 0.125% (v/v)	1.30	d
BPS, 2%, (v/v)	1.33	d
Fontelis, 16 fl oz	2.23	cd
IKF-309, 4 fl oz	2.25	cd
Oxidate 2.0, 1% (v/v) + Silwett L-77 0.1% alt Quintec, 4 fl oz	4.87	cd
Fontelis, 16 fl oz + Dyneamic, 0.25% (v/v)	4.90	cd
Antica, .2% (v/v)	5.28	cd
Antica, 0.4% (v/v)	5.90	cd
YTT669, 12 fl oz	6.60	cd
Antica , 0.1% (v/v)	11.70	bc
Companion, 64 fl oz alt Recover, 2 gal	12.10	bc
Antica 0.3%, (v/v)	21.18	b
Untreated Control	33.93	a

Table 5. Treatment effects on disease incidence on the lower surfaces of leaves of pumpkin. Treatments sharing the same letter within a column are not significantly different according to Fisher's protected LSD test at $\alpha = 0.05$.

Treatment	Bottom Leaf Incidence (%)	Means Comp.
Rally, 40 W, 5 oz alt Quintec 4 fl oz	17.5	f
Fontelis, 16 fl oz, alt Quintec, 4 fl oz	26.3	f
Rally, 40 W, 5 oz + Dyneamic, 0.125% (v/v)	41.3	ef
Quintec, 4 fl oz + Dyneamic, 0.125% (v/v)	43.8	ef
Oxidate 2.0, 1% (v/v) + Silwett L-77 0.1% alt Quintec, 4 fl oz	53.8	de
Rally, 5 oz + Dyneamic, 0.125% (v/v) alt Quintec, 4 fl oz + Dyneamic 0.125% (v/v) alt Flint, 2 oz + Dyneamic 0.125% (v/v)	58.8	cde
Fontelis, 16 fl oz	60.0	cde
IKF-309, 4 fl oz	61.3	bcde
Antica, .2% (v/v)	75.0	abcd
BPS, 2%, (v/v)	76.3	abcd
YTT669, 12 fl oz	80.0	abcd
Antica, 0.4% (v/v)	81.3	abc
Fontelis, 16 fl oz + Dyneamic, 0.25% (v/v)	82.5	abc
Antica , 0.1% (v/v)	85.0	abc
Companion, 64 fl oz alt Recover, 2 gal	87.5	ab
Untreated Control	95.0	a
Antica 0.3%, (v/v)	95.0	a

Table 6. Treatment effects on disease severity on the lower surfaces of leaves of pumpkin. Treatments sharing the same letter within a column are not significantly different according to Fisher's protected LSD test at $\alpha = 0.05$.

Treatment	Bottom Leaf Severity (%)	Means Comp.
Rally, 40 W, 5 oz alt Quintec 4 fl oz	0.32	e
Fontelis, 16 fl oz, alt Quintec, 4 fl oz	0.50	e
Quintec, 4 fl oz + Dyneamic, 0.125% (v/v)	0.83	e
Rally, 40 W, 5 oz + Dyneamic, 0.125% (v/v)	1.33	e
Rally, 5 oz + Dyneamic, 0.125% (v/v) alt Quintec, 4 fl oz + Dyneamic 0.125% (v/v) alt Flint, 2 oz + Dyneamic 0.125% (v/v)	1.53	e
Fontelis, 16 fl oz	2.45	e
IKF-309, 4 fl oz	3.18	e
Oxidate 2.0, 1% (v/v) + Silwett L-77 0.1% alt Quintec, 4 fl oz	3.88	de
Fontelis, 16 fl oz + Dyneamic, 0.25% (v/v)	4.38	de
Antica, .2% (v/v)	5.60	de
Antica, 0.4% (v/v)	5.68	de
BPS, 2%, (v/v)	6.35	cde
YTT669, 12 fl oz	7.08	cde
Companion, 64 fl oz alt Recover, 2 gal	11.83	bcd
Antica , 0.1% (v/v)	13.93	bc
Antica 0.3%, (v/v)	17.53	b
Untreated Control	26.53	a

Acknowledgements

We thank Andrew Sutherland for assistance with field set-up and insect control and staff at the Armstrong facility for maintenance of the field. The treatments described in this report were conducted for experimental purposes only. Crops treated in a similar manner may not be suitable for consumption or feed.

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Appendix: materials

Product	Active ingredient(s) and concentration	Class	Manufacturer or Distributor
Antica	Lactic acid (10%)	unknown	Ahcil Laboratories
BPS	biopolysan	unknown	Biotectics, LLC
Companion	Bacillus subtilus QB03 (0.03%)	biological	Growth Products, Ltd.
Dyneamic	Polyalkyleneoxide modified polydimethylsiloxane, nonionic emulsifiers, methyl ester of C16-C-18 fatty acids (99%)	adjuvant	Helena Chemical Co.
Flint	Trifloxystrobin (50%)	QoI	Bayer
Fontelis	penthiopyrad (20%)	N/A	DuPont
IKF - 309	proprietary	proprietary	N/A
Oxidate 2.0%	Hydrogen dioxide (27%)	N/A	BioSafe Systems LLC
Quintec	quinoxyfen (22.6%)	quinoline	Dow Agrosciences, LLP
Rally 40 WSP	myclobutanil (40%)	DMI-triazole	Dow Agrosciences, LLP
Recover RX	nitrogen (3%)/phosphoric acid (18%)/potash (18%)	fertilizer	Growth Products, Ltd.
Silwett L -77	Polyalkyleneoxide modified heptamethyltrisiloxane (99.5%)	adjuvant	Helena Chemical Company
YTT669	picoxystrobin (250 mg/L)	QoI	Dupont

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) Janousek et al. 2008, 2009. Grape powdery mildew trials, available at http://plantpathology.ucdavis.edu/ext/gubler/fungtrials2009/.
(3) various sources including product labels and/or MSDS, or product websites.