Powdery mildew control on pumpkin and zucchini with organic and synthetic fungicides: 2010 field trial

Ian S. Bay, James D. Eynard, W.D. 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 2010

Published December 2010 at http://escholarship.org/uc/plantpath_ucd.

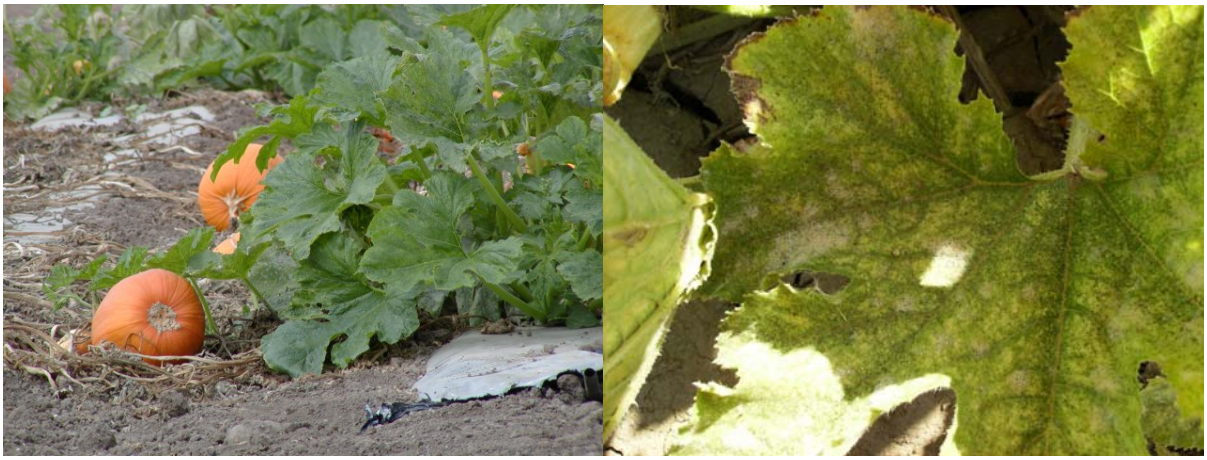
Summary

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 two field trials 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 and zucchini (*Cucurbita pepo*) using the susceptible cultivars Sorcerer and Elite, respectively. We applied fungicides every 7 to 14 days for a six week period beginning Sept 2 and continuing through Oct 13. 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	2 Sept – Oct 13 (7 and 14 day intervals)		
Volume water applied	100 gallons/acre (=1.0 gallons per treatment) 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	Flag color	Application interval (days)	Application rate (per acre)	FP/application
Unsprayed control	W	None	none	none
Torino	Y	14	3.4 fl oz	1.0 ml
Torino alt Rally 40 WP	Pu/K	14	3.4 fl oz alt 5 oz	1.0 ml alt 1.5 g
Torino alt Quintec	P/Br	14	3.4 fl oz alt 4 fl oz	1.0 ml alt 1.2 ml
LEM 17	S	14	16 fl oz	4.9 ml
LEM 17 + Dyneamic	Pu	14	16 fl oz + 0.025% (v/v)	4.9 ml + 1 ml (100 gal) 4.9 ml + 1.5 ml (150 gal) 4.9 ml + 2.2 ml (225 gal)
LEM 17 + Dyneamic alt Quintec	K	14	16 fl oz + 0.025% (v/v) alt 4 fl oz	4.9 ml + 1 ml (100 gal) 4.9 ml + 1.5 ml (150 gal) 4.9 ml + 2.2 ml (225 gal) Alt 1.2 ml
LEM 17 + Dyneamic alt Rally	K/W	14	16 fl oz + 0.025% (v/v) alt 5 oz	4.9 ml + 1 ml (100 gal) 4.9 ml + 1.5 ml (150 gal) 4.9 ml + 2.2 ml (225 gal) Alt 1.5 g
Rally alt Quintec	Pu/B	14	5 oz alt 4 fl oz	1.5 g alt 1.2 ml
Material A	Pu/G	7	1% (8.4 lbs per 100 gallons) + 2 fl oz	39.2 g (100 gal) 58.9 g (150 gal) 88.3 g (225 gal)
Material B	O/G	7	1% (8.4 lbs per 100 gallons) + 2 fl oz	39.2 g (100 gal) 58.9 g (150 gal) 88.3 g (225 gal)
Material A then B then A, then repeat (A-B-A-A-B-A)	O	7	1% (8.4 lbs per 100 gallons) + 2 fl oz	39.2 g (100 gal) 58.9 g (150 gal) 88.3 g (225 gal)
Material B then A then B then repeat (B-A-B-B-A-B)	Pu/W	7	1% (8.4 lbs per 100 gallons) + 2 fl oz	39.2 g (100 gal) 58.9 g (150 gal) 88.3 g (225 gal)
Quintec	G	14	4 fl oz	1.2 ml
Stylet oil, 0.5%	Br	7	0.5%	18.9 ml (100 gal) 28.4 ml (150 gal) 42.6 ml (225 gal)
Stylet oil, .5% + OE444, 0.5%	O/K	7	0.5% + 0.5%	18.9 ml (100gal) 28.4 ml (150gal) 42.6 ml (225gal)

Stylet oil, .5% + OE444, 1.0%	B	7	0.5% + 1.0%	18.9 ml (100gal) 28.4 ml (150gal) 42.6 ml (225gal)
Stylet oil, .5% + OE444, 2.0%	O/W	7	0.5% + 2.0%	18.9 ml (100gal) 28.4ml (150gal) 42.6ml (225gal)
Stylet oil, .5% + OE444, 4.0%	Y/K	7	0.5% + 4.0%	18.9ml (100gal) 28.4ml (150gal) 42.6ml (225gal)
Stylet oil, 1%	P/S	7	1.0%	37.9 ml (100 gal) 56.8 ml (150 gal) 85.2 ml (225 gal)
Stylet oil, 1% + OE444, 0.5%	Y/G	7	1.0% + 0.5%	37.9 ml (100gal) 56.8 ml (150gal) 85.2 ml (225gal)
Stylet oil, 1% + OE444, 1.0%	B/G	7	1.0% + 1.0%	37.9 ml (100gal) 56.8 ml (150gal) 85.2 ml (225gal)
Stylet oil, 1% + OE444, 2.0%	C	7	1.0% + 2.0%	37.9 ml (100gal) 56.8ml (150gal) 85.2 ml (225gal)
Stylet oil, 1% + OE444, 4.0%	Y/W	7	1.0% + 4.0%	37.9 ml (100gal) 56.8ml (150gal) 85.2ml (225gal)
Stylet oil, 2.0%	P	7	2.0%	75.7 ml (100 gal) 113.6 ml (150 gal) 170.3 ml (225 gal)
Exp. 5	O/Y	7	RTU	RTU

Table 2. Zucchini Trial - Experimental fungicide treatments. “alt” = alternated with; “FP” = formulated product

Treatment	Flag color	Application interval (days)	Application rate (per acre)	FP/application
Unsprayed control	W	none	none	none
Material A	Y	7	1% (8.4 lbs per 100 gallons) + 2 fl oz	39.2 g (100 gal) 58.9 g (150 gal) 88.3 g (225 gal)
Material B	B	7	1% (8.4 lbs per 100 gallons) + 2 fl oz	39.2 g (100 gal) 58.9 g (150 gal) 88.3 g (225 gal)
Material A then B then A, then repeat (A-B-A-A-B-A)	G	7	1% (8.4 lbs per 100 gallons) + 2 fl oz	39.2 g (100 gal) 58.9 g (150 gal) 88.3 g (225 gal)
Material B then A then B then repeat (B-A-B-B-A-B)	O	7	1% (8.4 lbs per 100 gallons) + 2 fl oz	39.2 g (100 gal) 58.9 g (150 gal) 88.3 g (225 gal)
Quintec	K	14	4 fl oz	1.2 ml

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

x	x	x	x	x	x	x	x	x	x
x	x	x	x	P	K	O/G	Pu	O/Y	B
x	B	x	x	Pu/K	B/G	Y/G	Br	O/G	x
x	K	W	Br	Br	B	Pu/B	O	O/W	Pu
x	x	x	B/G	G	Y/G	P/S	Y/W	O/K	Y
x	G	x	S	K	x	Pu/G	C	Y/G	O
x	O	x	P/Br	x	O/W	Y/K	O/Y	Y/K	C
x	Y	x	B	P	O	G	Pu/W	x	K
x	B	O	W	x	S	O/W	Pu/K	Y/W	P
x	O	x	Y/K	Pu	W	K/W	B/G	x	G
x	Y	B	C	x	x	P/Br	Y	Pu/B	x
x	K	x	Y/G	Y	C	Pu/B	K	Pu/W	W
x	G	x	Pu/K	P/S	O/K	G	W	Pu/K	Br
W	x	Y	Pu/B	Y/W	O/G	Pu/W	P	Pu/G	S
x	x	K	O/W	Pu/W	K/W	Y	O/K	K/W	x
G	W	G	O/Y	O	O/Y	Y/W	S	P/S	x
K	B	x	Pu/G	O/G	Pu/G	P/S	B	P/Br	x
Y	O	W	K/W	O/K	Pu	Y/K	P/Br	B/G	x
Zucchini			Pumpkin						

Results and Discussion

Figure 3. Daily high, low and average temperatures for Davis, California (from http://www.cimis.water.ca.gov/) during the experimental period. No measurable precipitation fell during this time.

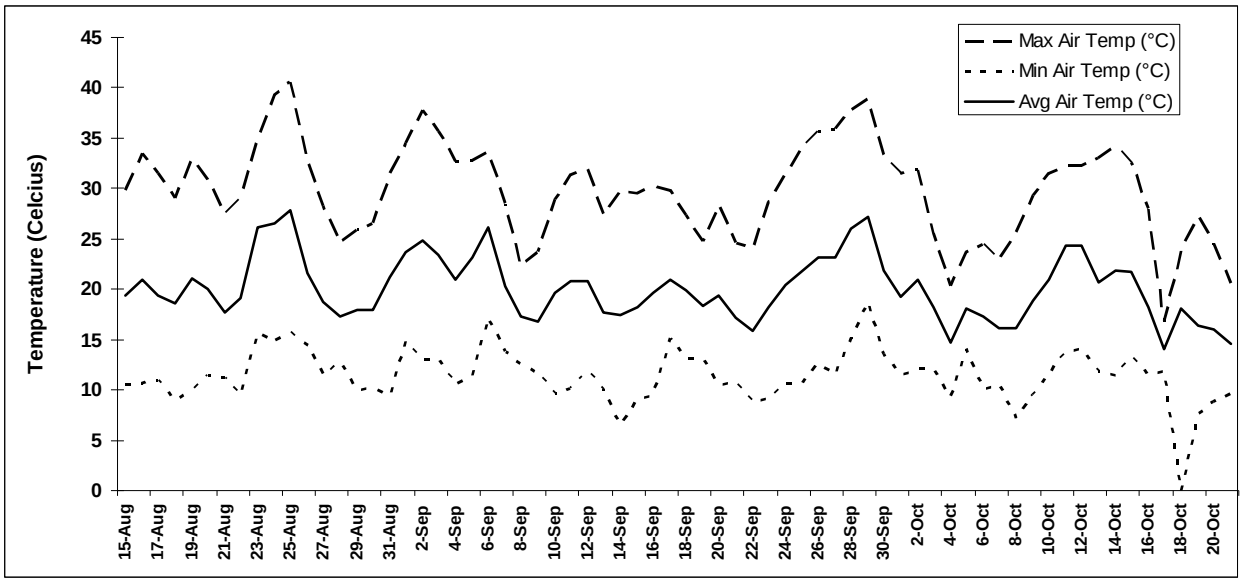


Table 3. Treatment effects on disease incidence on the upper surfaces of leaves of pumpkin. Treatments sharing the same letter within a column are not significantly different according to Fisher's protected LSD test at $\alpha = 0.05$.

Treatment	Upper leaf surface Incidence (%)	
Untreated Control	98.8 ± 1.3	a
Stylet oil, 0.5% + OE444, 2.0%	86.3 ± 8.8	ab
Stylet oil, 0.5% + OE444, 4.0%	81.4 ± 2.5	ab
Material A, 1.0%	81.3 ± 8.3	ab
Stylet oil, 0.5%	78.8 ± 4.7	abc
Stylet oil, 0.5% + OE444, 0.5%	76.3 ± 8.3	abc
Stylet oil, 1.0% + OE444, 0.5%	72.8 ± 7.7	bcd
Material A then B then A, 1.0% then repeat	68.8 ± 10.5	bcde
Stylet oil, 1.0% + OE444, 1.0%	65.0 ± 11.4	bcdef
Stylet oil, 0.5% + OE444, 1.0%	64.4 ± 7.4	bcdef
Stylet oil, 1.0% + OE444, 2.0%	63.8 ± 6.6	bcdef
Stylet oil, 1.0% + OE444, 4.0%	57.5 ± 10.5	cdef
LEM 17, 16 fl oz	51.3 ± 13.4	defg
Material B, 1.0%	50.0 ± 9.8	efg
LEM 17, 16 fl oz + Dyneamic, 0.025%	46.3 ± 12.0	efgh
Stylet oil, 1.0%	45.0 ± 9.4	fgh
Material B then A then B, 1.0% then repeat	43.8 ± 9.4	fgh
Stylet oil, 2.0%	43.8 ± 6.3	fgh
Rally, 5 oz alt Quintec, 4 fl oz	32.5 ± 11.6	ghi
Experimental 5	25.0 ± 7.4	hij
LEM 17, 16 fl oz + Dyneamic, 0.025% alt Rally, 5 oz	18.8 ± 3.1	ijk
LEM 17, 16 fl oz + Dyneamic, 0.025% alt Quintec, 4 fl oz	10.0 ± 10.0	ijk
Quintec, 4 fl oz	7.5 ± 1.4	jk
Torino, 3.4 fl oz alt Rally, 5 oz	2.5 ± 2.5	jk
Torino, 3.4 fl oz	0.0 ± 0.0	k
Torino, 3.4 fl oz alt Quintec, 4 fl oz	0.0 ± 0.0	k

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	Upper leaf surface Severity (%)	
Untreated Control	52.35 ± 4.42	a
Stylet oil, 0.5% + OE444, 4.0%	13.41 ± 0.60	b
Material A, 1.0%	13.10 ± 2.83	b
Stylet oil, 0.5% + OE444, 0.5%	13.03 ± 1.66	b
Stylet oil, 0.5% + OE444, 2.0%	12.74 ± 1.85	b
Stylet oil, 0.5%	9.54 ± 1.29	bc
Material A then B then A, 1.0% then repeat	7.76 ± 1.51	cd
Stylet oil, 0.5% + OE444, 1.0%	6.74 ± 1.86	cde
Stylet oil, 1% + OE444, 2.0%	6.73 ± 1.84	cde
Stylet oil, 1.0% + OE444, 0.5%	6.44 ± 1.94	cdef
Stylet oil, 1.0% + OE444, 1.0%	5.93 ± 1.02	cdefg
Stylet oil, 1.0% + OE444, 4.0%	3.94 ± 1.06	defgh
Stylet oil, 1.0%	2.94 ± 1.28	efgh
Material B then A then B, 1.0% then repeat	2.46 ± 0.48	fgh
Stylet oil, 2.0%	2.44 ± 1.06	fgh
Material B, 1.0%	2.23 ± 0.52	gh
LEM 17, 16 fl oz + Dyneamic, 0.025%	2.10 ± 0.97	gh
Experimental 5	1.93 ± 1.06	gh
LEM 17, 16 fl oz	1.65 ± 0.53	h
Rally, 5 oz alt Quintec, 4 fl oz	1.35 ± 0.54	h
Torino, 3.4 fl oz alt Rally, 5 oz	0.44 ± 0.44	h
LEM 17, 16 fl oz + Dyneamic, 0.025% alt Rally, 5 oz	0.35 ± 0.11	h
LEM 17, 16 fl oz + Dyneamic, 0.025% alt Quintec, 4 fl oz	0.14 ± 0.14	h
Quintec, 4 fl oz	0.11 ± 0.05	h
Torino, 3.4 fl oz	0.00 ± 0.00	h
Torino, 3.4 fl oz alt Quintec, 4 fl oz	0.00 ± 0.00	h

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	Lower leaf surface Incidence (%)	
Untreated Control	98.8 ± 1.3	a
Material A then B then A, 1.0% then repeat	71.3 ± 9.0	b
Stylet oil, 0.5% + OE444, 0.5%	67.5 ± 13.3	bc
Material A, 1.0%	66.3 ± 12.8	bc
Stylet oil, 0.5% + OE444, 2.0%	65.0 ± 14.6	bcd
Stylet oil, 1.0% + OE444, 1.0%	60.0 ± 7.4	bcde
Stylet oil, 1.0% + OE444, 4.0%	56.3 ± 7.5	bcdef
Stylet oil, 1.0% + OE444, 0.5%	55.6 ± 7.3	bcdef
Stylet oil, 0.5% + OE444, 4.0%	55.2 ± 9.6	bcdef
LEM 17, 16 fl oz	53.8 ± 14.1	bcdef
Stylet oil, 1.0% + OE444, 2.0%	52.5 ± 6.6	bcdef
Stylet oil, 0.5%	48.8 ± 5.9	bcdef
Experimental 5	47.5 ± 13.6	bcdef
Stylet oil, 0.5% + OE444, 1.0%	44.8 ± 7.0	cdef
Stylet oil, 2.0%	43.8 ± 7.5	cdef
Stylet oil, 1.0%	40.0 ± 9.4	def
Material B, 1.0%	38.8 ± 7.2	ef
LEM 17, 16 fl oz + Dyneamic, 0.025%	37.5 ± 16.0	ef
Material B then A then B, 1.0% then repeat	35.0 ± 6.8	efg
Rally, 5 oz alt Quintec, 4 fl oz	31.3 ± 10.3	fgh
LEM 17, 16 fl oz + Dyneamic, 0.025% alt Rally, 5 oz	11.3 ± 5.2	ghi
LEM 17, 16 fl oz + Dyneamic, 0.025% alt Quintec, 4 fl oz	7.5 ± 6.0	hi
Torino, 3.4 fl oz alt Rally, 5 oz	5.0 ± 2.0	i
Quintec, 4 fl oz	3.8 ± 2.4	i
Torino, 3.4 fl oz	1.3 ± 1.3	i
Torino, 3.4 fl oz alt Quintec, 4 fl oz	1.3 ± 1.3	i

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	Lower leaf surface Severity (%)	
Untreated Control	42.05 ± 6.15	a
Material A, 1.0%	9.94 ± 4.16	b
Material A then B then A, 1.0% then repeat	8.81 ± 1.03	bc
Stylet oil, 0.5% + OE444, 0.5%	8.68 ± 3.13	bc
Stylet oil, 0.5% + OE444, 2.0%	6.23 ± 2.16	bcd
Experimental 5	5.50 ± 3.11	bcde
Stylet oil, 0.5%	4.63 ± 0.67	cdef
Stylet oil, 1.0% + OE444, 2.0%	3.94 ± 0.40	cdef
Stylet oil, 1.0% + OE444, 1.0%	3.78 ± 0.62	cdef
Stylet oil, 0.5% + OE444, 1.0%	3.33 ± 0.72	def
Stylet oil, 1.0% + OE444, 4.0%	2.99 ± 0.93	def
Material B, 1.0%	2.71 ± 0.39	def
Stylet oil, 1.0% + OE444, 0.5%	2.53 ± 1.10	def
Stylet oil, 0.5% + OE444, 4.0%	2.40 ± 0.78	def
Stylet oil, 2.0%	2.33 ± 0.71	def
LEM 17, 16 fl oz + Dyneamic, 0.025%	1.88 ± 1.01	def
Material B then A then B, 1.0% then repeat	1.71 ± 0.26	def
LEM 17, 16 fl oz	1.61 ± 0.42	def
Stylet oil, 1.0%	1.10 ± 0.47	def
Rally, 5 oz alt Quintec, 4 fl oz	0.95 ± 0.41	ef
LEM 17, 16 fl oz + Dyneamic, 0.025% alt Rally, 5 oz	0.33 ± 0.22	f
LEM 17, 16 fl oz + Dyneamic, 0.025% alt Quintec, 4 fl oz	0.11 ± 0.10	f
Quintec, 4 fl oz	0.08 ± 0.06	f
Torino, 3.4 fl oz alt Rally, 5 oz	0.05 ± 0.02	f
Torino, 3.4 fl oz	0.03 ± 0.03	f
Torino, 3.4 fl oz alt Quintec, 4 fl oz	0.01 ± 0.01	f

Table 7. Treatment effects on disease incidence and severity on the upper surfaces of leaves of zucchini. Treatments sharing the same letter within a column are not significantly different according to Fisher's protected LSD test at $\alpha = 0.05$.

	Upper leaf surface			
Treatment	**Incidence (%)**		**Severity (%)**	
Untreated Control	92.5 ± 3.2	a	55.06 ± 9.05	a
Material A then B then A, 1.0% then repeat	75.0 ± 2.9	abc	20.81 ± 4.6	b
Material A, 1.0%	81.3 ± 11.3	ab	9.08 ± 1.2	bc
Material B then A then B, 1.0% then repeat	63.2 ± 12.8	bc	9.35 ± 3.1	bc
Material B, 1.0%	53.9 ± 8.4	c	5.90 ± 1.4	c
Quintec, 4 fl oz	21.0 ± 1.3	d	1.02 ± 0.5	c

Table 8. Treatment effects on disease incidence and severity on the lower surfaces of leaves of zucchini. Treatments sharing the same letter within a column are not significantly different according to Fisher's protected LSD test at $\alpha = 0.05$.

	Lower leaf surface			
Treatment	**Incidence (%)**		**Severity (%)**	
Untreated Control	90.0 ± 7.1	a	52.44 ± 11.01	a
Material A then B then A, 1.0% then repeat	68.8 ± 2.4	a	14.99 ± 3.10	b
Material B then A then B, 1.0% then repeat	58.7 ± 18.5	ab	8.31 ± 3.38	bc
Material A, 1.0%	70.0 ± 19.1	a	4.56 ± .69	bc
Material B, 1.0%	24.7 ± 7.6	b	0.90 ± 0.13	bc
Quintec, 4 fl oz	24.9 ± 12.5	b	0.43 ± 0.13	c

Acknowledgements

We thank Laura Costadone, Cristina Pisani, Trang Nguyen, Feraida Castro and Andrew Sutherland for assistance with disease evaluation 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.

References

Blancard, D, H Lecoq, M Pitrat and M Javoy. (1994) *A Colour Atlas of Cucurbit Diseases: Observation, Identification, and Control*. Manson Publishing Ltd., London, England.

Braun, U, RTA Cook, AJ Inman, and H-D Shin. (2002) The taxonomy of the powdery mildew fungi, in *The Powdery Mildews: A Comprehensive Treatise*, Bélanger, R, WR Bushnell, AJ Dik and TLW Carver (eds.) APS Press, St. Paul, MN, p.13-55.

Davis, RM, TA Turini, BJ Aegerter, WD Gubler and JJ Stapleton. (2008) UC Davis IPM Management Guidelines: Cucurbits, UC ANR Publication 3445, at http://www.ipm.ucdavis.edu/PMG/r116100711.html.

Gilardi, G, DC Manker, A Garibaldi and ML Gullino. (2008) Efficacy of the biocontrol agents *Bacillus subtilis* and *Ampelomyces quisqualis* applied in combination with fungicides against powdery mildew of zucchini. Journal of Plant Diseases Protection 115:208-213.

Glawe, DA. (2008) The powdery mildews: a review of the world's most familiar (yet poorly known) plant pathogens. Annual Review Phytopathology 46:27-51.

Hausbeck, MK and BD Cortright. (2005) Evaluation of fungicides for control of powdery mildew of pumpkin, 2006. Plant Disease Management Reports 1:V066.

Janousek, CN, JD Lorber and WD Gubler. (2007) Control of powdery mildew on pumpkin leaves by experimental and registered fungicides: 2007 trials. On-line report published at: http://plantpathology.ucdavis.edu/ext/gubler/fungtrials2007/.

Janousek, CN, H Su and WD Gubler. (2009) Control of powdery mildew on pumpkin leaves: 2008 field trial. UC Davis: Department of Plant Pathology. http://escholarship.org/uc/item/12t1z046.

Matheron, ME and M Porchas. (2004) Comparative efficacy of fungicides for control of powdery mildew on muskmelon, 2003. Fungicide & Nematicide Tests 59:V091.

McGrath, MT. (2003) Evaluation of fungicide programs for managing pathogen resistance and powdery mildew of pumpkin, 2004. Fungicide & Nematicide Tests 60:V049.

McGrath, MT and JF Davey. (2007a) Evaluation of fungicides for management of powdery mildew on pumpkin, 2006. Plant Disease Management Reports 1:V144.

McGrath, MT and JF Davey. (2007b) Evaluation of biofungicides for managing powdery mildew of pumpkin, 2006. Plant Disease Management Reports 1:V145.

McGrath, MT and N Shishkoff. (2003) First report of the cucurbit mildew fungus (*Podosphaera xanthii*) resistant to strobilurin fungicides in the United States. Plant Disease 87:1007.

McGrath, MT, H Staniszewska, N Shishkoff and G Casella. (1996) Fungicide sensitivity of *Sphaerotheca fuliginea* populations in the United States. Plant Disease 80:697-703.

McGrath, MT and CE Thomas. (1996) Powdery mildew. In: *Compendium of Cucurbit Diseases*, Zitter, TA, DL Hopkins and CE Thomas (eds.), APS Press, St. Paul, MN, p.28-30.

National Resources Conservation Service (2009) Web Soil Survey, United States Department of Agriculture, accessed http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx, November 2009.

Pérez-García, A, D Romero, D Fernández-Ortuño, F López-Ruiz, A de Vicente and JA Torés. (2009) The powdery mildew fungus *Podosphaera fusca* (synonym *Podosphaera xanthii*), a constant threat to cucurbits. Molecular Plant Pathology 10:153-160.

Appendix: materials

Product	Active ingredient(s) and concentration	Class	Manufacturer or Distributor
Dyneamic	Polyalkyleneoxide modified polydimethylsiloxane, nonionic emulsifiers, methyl ester of C16-C-18 fatty acids (99%)	adjuvant	Helena Chemical Co.
Exp. 5	proprietary	proprietary	proprietary
JMS Stylet oil	paraffinic oil (97.1%)	oil	JMS Flower Farms, Inc.
LEM 17 SC	penthiopyrad (20%)	N/A	DuPont
Material A	proprietary	proprietary	proprietary
Material B	proprietary	proprietary	proprietary
OE-444	organo-modified polysiloxane (100%)	adjuvant	Evonik Goldschmidt, Corporation
Quintec	quinoxyfen (22.6%)	quinoline	Dow Agrosciences, LLP
Rally 40 WSP	myclobutanil (40%)	DMI-triazole	Dow Agrosciences, LLP
Torino	N/A	N/A	Gowan Co.

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.