PUMPKIN (*Cucurbita pepo* 'Appalachian')
Powdery mildew; *Podosphaera xanthii*

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Evaluation of biofungicides for managing powdery mildew of pumpkin, 2006.

The objective of this study was to evaluate six EPA-classified biopesticides used alone for powdery mildew in pumpkin. The focus was on four plant oil products, because good control was achieved with a mineral oil (JMS Stylet-oil) in previous experiments conducted at LIHREC. All biopesticides (first six entries in the table) listed below are OMRI listed and most are exempt from EPA registration. Additional products tested were AgriLife (5% citric acid), Genica BP 300 (2.7% liquid concentrate derived from the microbial digestion of food waste), and Prev-Am (0.99% sodium tetraborohydrate decahydrate), which are not classified as biopesticides but are considered to be 'biocompatible' because they are less toxic than other conventional fungicides such as chlorothalonil. Sulfur formulated as Microthiol Disperss 80W and chlorothalonil formulated as Bravo Ultrex were also included as conventional protectant fungicides for comparison. We also included a 'conventional grower standard program' with fungicides that were previously shown to provide excellent control on lower leaf surfaces. This standard was Quintec 2.08 SC tank-mixed with Microthiol Disperss 80 W and applied in alternation with Procure 50 WS + Microthiol Disperss 80 W. Procure 50 WS is systemic and Quintec 2.08 SC redistributes very well due to its high volatility. A field experiment was conducted at LIHREC on Haven loam soil. The field was plowed on 19 Apr and tilled on 1 May. Fertilizer (N-P-K 10-10-10) at 500 lb/A was broadcast on 8 May. Red clover at 10 lb/A was planted to establish driveways on 25 May. On 19 Jun, the field was disked. Seeds were planted at approximately 24-in. plant spacing within rows with a Monosem vacuum seeder on 20 Jun. Cucumber beetles were managed by applying the insecticide Admire 2F (20 fl oz/A) in the furrow at planting and Asana XL (9.6 fl oz/A) as a foliar treatment on 15 Jul. Additional fertilizer (N-P-K 34-0-0) was side-dressed on 2 Jul. During the season weeds were controlled by cultivation, roto-tilling between plots, and hand weeding along with a single application of Strategy (3 pt/A) over seedbeds at planting. To manage Phytophthora fruit and crown rot (*Phytophthora capsici*), Ridomil Gold EC (1 pt/A) was broadcast over seedbeds on 20 Jun, Acrobat 50 WP (6.4 oz/A) was applied to foliage on 12 Jul, and Tanos 50 DF (8 oz/A) was applied on 24 Aug and 22 Sep. Downy mildew (*Pseudoperonospora cubensis*) was also managed with the two Tanos 50 DF applications along with one application of Previcur Flex (1.2 pt/A) on 29 Jul. These fungicides were selected because they were not expected to affect powdery mildew. Plots were three 15-ft rows spaced 68 in apart. There was 15 ft between plots. A randomized complete block design with four replications was used. Average monthly high and low temperatures (ºF) were 77/62 in Jun, 84/69 in Jul, 82/67 in Aug, 73/58 in Sep, and 64/48 in Oct. Rainfall (in.) was 5.83, 3.79, 5.48, 3.66, and 5.53 for these months, respectively. On 31 Jul, at least 15 old leaves per plot were inspected for powdery mildew symptoms, which revealed that the IPM threshold of one affected leaf out of 50 old leaves (Plant Dis. 80:910-916) had been reached based on observations from the five plots scouted. Treatments were started on 3 Aug. Additional treatments were applied on 10 Aug, 17 Aug, 23 Aug, and 1 Sep with a tractor-mounted boom sprayer equipped with D5-25 hollow cone nozzles spaced 17 in. apart that delivered 85 gal/A at 100 psi. GC-3 organic fungicide (30% cottonseed oil, 30% corn oil, and 27% garlic extract) was the only product applied with an adjuvant (Natural wet 8 fl oz/A). Upper and lower surfaces of 10 leaves were examined for powdery mildew beginning on 9 Aug when fruit were starting to enlarge. The examined leaves were selected from the oldest third of the foliage based on leaf physiological appearance and position in the canopy. Ten old leaves were again evaluated on 16 Aug, mid-aged leaves were examined beginning on 23 Aug and young leaves were also examined on 31 Aug. Powdery mildew colonies (spots) were counted; severity was assessed by visual estimation of percent leaf area affected when colonies could not be counted accurately because they had coalesced and/or were too numerous. Average severity for the entire canopy was calculated from the individual leaf assessments. A square root transformation was used when needed prior to analysis to achieve homogeneity of variance. Canopy condition including the amount of defoliation was assessed on 18 Sep. Fruit quality was evaluated in terms of handle (peduncle) condition for mature fruit without rot on 18 Sep. Handles were considered good if they were green, solid, and not rotting.

Powdery mildew was first seen on 31 Jul on 36% of leaves examined. All treatments had numerically lower powdery mildew severities on both leaf surfaces than the untreated control on the 16 Aug evaluation, but values were not statistically significant. Powdery mildew was controlled on upper leaf surfaces by all biopesticides and biocompatible products tested based on the AUDPC value for severity. On the lower leaf surface, Actinovate (0.0371% *Streptomyces lydicus* WYEC 108), Milstop (85% potassium bicarbonate), GC-3, Proud 3 (5.6% thyme oil), Genica BP 300, and Organocide (5% sesame oil) did not control powdery mildew based on AUDPC. Therefore, Prev-Am and AgriLife were the only biocompatible products, and Eco E-Rase (97.5% jojoba oil) was the only biopesticide that provided full season control on both leaf surfaces. Performance of Genica BP 300 might have been better if a surfactant was used. Only Prev-Am and AgriLife controlled powdery mildew on the lower leaf surface at the same statistical level as the conventional protectant fungicide Bravo Ultrex. All biocompatibles and biopesticides controlled powdery mildew on the lower leaf surface at the same level as Microthiol Disperss (sulfur). Two treatments using the conventional fungicide Nova alternated with Prev-Am provided a similar level of control of powdery mildew on the upper and lower leaf surfaces based on AUDPC, however, when Nova was applied three times consecutively before Prev-Am, control on the lower leaf surface on 23 Sep was significantly better than when Prev-Am was applied first. The 'conventional grower standard program' provided excellent control of powdery mildew on upper and lower leaf surfaces as anticipated because of mobility of these fungicides. Severity and AUDPC values for this treatment was numerically lower than all other treatments and significantly lower than all treatments on the lower leaf surface. A variation of this conventional program, with 1 application each of Quintec 2.08 SC and Procure 50 WS combined with weekly applications of Microthiol Disperss 80 W, was as effective as the grower standard program for managing powdery mildew on upper and lower leaf surfaces. Canopy condition and fruit quality generally corresponded to level of powdery mildew control with the notable exception of the Milstop treatment, which resulted in significantly less defoliation than the nontreated control and also significantly more fruit with solid handles, although AUDPC values did not differ significantly from the control. There was also 93% fruit with solid handles with the Genica BP 300 treatment. All other treatments with a biopesticide or biocompatible product had less than 90% fruit with good handles. No phytotoxicity was observed.

Treatment and rate (application date) [y]	Powdery mildew severity (%) [z]								Good handles		Defol-iation	
	Upper leaf surface				Lower leaf surface							
	16 Aug	23 Aug		AUDPC	16 Aug	23 Aug		AUDPC	18 Sep		18 Sep	
Nontreated (control) …….....	13.4 [x]	67.8	a	102 a	11.5	68.5	a	102 a	60	d	90	ab
Organocide 2 oz/gal (1-5)……..	1.8	8.8	cde	13 cde	6.4	47.3	abc	64 abc	81	abc	94	a
Eco E-Rase 0.5% (1-5)……..	0.8	19.2	bcd	24 bcd	2.9	43.7	abcd	55 bc	81	abc	90	ab
GC-3 Organic Fungicide 1% + Natural Wet 8 fl oz (1-5)…..	1.3	23.8	bc	31 bc	4.3	60.0	ab	75 ab	72	cd	88	ab
Proud-3 4 qt (1-5)……..	1.3	32.5	b	41 b	4.8	48.3	abc	62 abc	73	bcd	79	abc
Actinovate SP 6 oz (1-5)……....	2.2	35.4	b	46 b	2.7	58.6	ab	72 ab	82	abc	89	ab
Milstop 2.5 lb (1-5)……	0.5	30.3	b	36 b	6.3	60.3	ab	78 ab	93	ab	56	cd
Prev-Am (1-5)……	0.0	11.4	cde	13 cde	3.0	40.4	abcde	52 bcd	84	abc	68	bcd
AgriLife 3% (1-5)……..	1.0	20.4	bcd	26 bcd	2.9	26.7	cde	36 cd	88	abc	71	abcd
Genica BP 300 2.27% (1-5)…...	2.1	28.2	b	37 b	4.5	45.3	abcd	60 abc	93	ab	80	abc
Microthiol Disperss 80W 4 lb (1-5)…..……..	0.6	11.0	cde	14 cde	1.8	37.9	bcde	48 bcd	92	abc	58	cd
Bravo Ultrex 82.5 WG 2.7 lb (1-5)…..……..	0.0	5.8	ef	7 ef	0.5	20.3	e	25 d	83	abc	79	abc
Prev-Am 0.8% (1-3), Nova 40 W 5 oz (4-5)……..	0.2	8.2	de	10 de	3.0	47.0	abc	59 bc	91	abc	51	d
Nova 40 W (1-3), Prev-Am (4-5)……	1.0	5.6	ef	9 def	4.2	22.8	de	35 cd	96	a	74	abcd
Qunitec 2.08 SC 4 fl oz + Microthiol Disperss (1,3,5) alt Procure 50W 6 oz + Microthiol Disperss (2,4)[w]…...	0.0	3.1	ef	4 ef	0.1	2.2	f	3 e	97	a	11	e
Quintec 2.08 SC + Microthiol Disperss (1), Procure + Microthiol Disperss (2), Microthiol Disperss (3-5)……	0.0	0.6	f	1 f	0.2	3.6	f	5 e	94	ab	20	e
P-value	0.0802	0.0001		0.0001	0.2169	0.0001		0.0001	0.0404		0.0001	

[z] Exact colony counts were made when possible and severity was estimated using the conversion factor of 30 colonies/leaf = 1%. Severity data is for old leaves on 16 Aug and mid-aged leaves on 23 Aug. AUDPC was calculated for 16 Aug to 23 Aug.

[y] Rate of formulated product/A. All treatments were on an IPM schedule with threshold of 1 affected leaf out of 50 older leaves. Application dates were 1=3 Aug, 2=10 Aug, 3=17 Aug, 4=23 Aug, and 5=1 Sep. Where rate or formulation is not specified product was applied at the same rate and formulation as listed for the previous treatment with this product.

[x] Numbers in each column with a letter in common are not significantly different according to Fisher's Protected LSD ($P = 0.05$).

[w] Conventional fungicide program.