

Evaluation of biofungicides for managing powdery mildew of pumpkin, 2004.

The objective of this study was to evaluate several biopesticides used alone and integrated in a program with conventional fungicides for powdery mildew in pumpkin. The focus was on 6 plant oil products because good control was achieved with a mineral oil (JMS Stylet-oil) in previous experiments conducted at LIHREC. Most are OMRI listed and/or exempt from EPA registration. A hydrogen dioxide product was also tested. Sulfur formulated as Microthiol Disperss and chlorothalonil were also included as conventional protectant fungicides for comparison. Combination fungicide programs were tested that included fungicides shown previously to provide excellent control on lower leaf surfaces: Procure is systemic and Quintec redistributes very well due to its high volatility. The 'conventional grower standard program' was Quintec tank-mixed with Microthiol Disperss and applied in alternation with Procure + Microthiol Disperss. A field experiment was conducted at LIHREC on Haven loam soil. Fertilizer (N-P-K 10-10-10) at 1000 lb/A was broadcast and incorporated on 10 May. A spring pea and triticum mix cover crop was seeded (100 lb/A) on 11 May, then mowed and disked under on 21 Jun. On 2 Jul, pumpkin seeds were planted at approximately 24-in. plant spacing within rows and 68-in. row spacing, then the herbicide Strategy (3 pt/treated A) was applied in a 10-in. band over the row. The insecticide Admire 2F (16 fl oz/ treated A) was applied for cucumber beetles on 6 Jul in a 10-inch band over the row, then the field was irrigated. During the season weeds were controlled by cultivation and hand weeding. To manage *Phytophthora* fruit and crown rot (*Phytophthora capsici*), Ridomil Gold EC (1 pt/A) was broadcast over the entire field then incorporated on 30 Jun and Phostrol (4-5 pt/A) was applied on 2 Aug, 12 Aug, 25 Aug, 4 Sep, and 17 Sep. Additionally, soil drainage was improved by subsoiling on 3 Aug between rows before vines grew over. Downy mildew was managed by applying Ridomil Gold (1/4 pt/A) with Phostrol on 12 and 25 Aug, Curzate (3.2 oz/A) on 14 Aug, 4 Sep, and 12 Sep, and Acrobat 50 WP (6.4 oz/A) on 20 Aug, 7 Sep and 14 Sep. These fungicides were selected because they were not expected to affect powdery mildew. Applications of Ridomil and Acrobat also may have been beneficial for managing *P. capsici*. Plots averaged 18 plants in three 15-ft rows. There was 10 ft between plots. A randomized complete block design with four replications was used. Average monthly high and low temperatures (F) were 77/59 in Jun, 82/65 in Jul, 82/66 in Aug, 78/60 in Sep, and 64/49 in Oct. Rainfall (in.) was 0.88, 3.33, 3.94, 6.97, and 2.04 for these months, respectively. Most treatments were started on 6 Aug after the IPM threshold of one leaf of 50 old leaves examined with powdery mildew symptoms (Plant Dis. 80:910-916) was reached in 31 of the 64 plots. Treatments were applied on 6-7 Aug, 12 Aug, 19 Aug, 25 Aug, 1 Sep, 6 Sep, and 12 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. The first Bugitol application was on 11 Aug due to delay in receiving the product, thus it was applied on two consecutive days. Applications were made more frequently than every 7 days due to forecasts for rain and/or windy weather. OxiDate also was applied following a curative schedule with 3 consecutive applications on 25, 26, and 27 Aug when powdery mildew reached a level of being easily seen but not severe (average severity on older leaves was 1% on upper surfaces and 2% on lower surfaces). Additional applications for this treatment were made along with the other treatments. Sporan was applied with the spreader/sticker NuFilm-P (6 fl oz/A). GC-3 was applied with Natural wet adjuvant (8 fl oz/A). Upper and lower surfaces of 5 to 50 leaves in each plot were examined weekly for powdery mildew beginning on 9 Aug when fruit were starting to enlarge. Initially, 50 older leaves were examined in each plot. The examined leaves were selected from the oldest third of the foliage based on leaf appearance and position in the canopy. As disease progressed, the number of leaves examined was adjusted based on the incidence of affected leaves in a plot. Mid-aged and young leaves were also examined beginning on 23 Aug and 3 Sep, respectively. Powdery mildew colonies were counted; severity was assessed 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 defoliation was assessed on 17 Sep. Fruit quality was evaluated in terms of handle (peduncle) condition for mature fruit without rot on 6 Oct. Handles were considered good if they were green, solid, and not rotting.

Powdery mildew was first seen earlier than expected based on crop phenology. On 6 Aug fruit had not started to set and the canopy had not closed between rows. First flowers were open. The 'conventional grower standard program' provided excellent control of powdery mildew on upper and lower leaf surfaces as anticipated. Severity on 16 Sep was numerically lower than all other treatments. AUDPC value for mildew on lower leaf surfaces was significantly lower than all other treatments. All botanical oils tested provided some control of mildew on upper leaf surfaces. GC-3 organic fungicide (cottonseed oil, corn oil, and garlic extract), Organocide (sesame oil) and Eco E-Rase (jojoba oil) were as effective as Microthiol Disperss, JMS Stylet-oil, (mineral oil) and Bravo Ultrex. GC-3 was the most effective product based on its AUDPC value for mildew on lower leaf surfaces being significantly lower than three other products (Trilogy, Sporan and Bugitol). Microthiol Disperss provided good control. Mildew severity on upper surfaces was not significantly different from the 'grower standard'; however, mildew was significantly more severe on lower surfaces beginning with the 3 Sep assessment. At the last assessment on 16 Sep, severity on lower surfaces was not significantly different from that on nontreated pumpkins. JMS Stylet-oil also provided good control. Mildew was often numerically more severe than on pumpkin treated with Microthiol Disperss; however, these differences were not significant. Bravo Ultrex also provided good control. Although mildew usually was numerically more severe than on pumpkin treated with Microthiol Disperss or JMS Stylet-oil, these differences were not significant. Trilogy and Bugitol effectively controlled mildew on upper leaf surfaces for the duration of the experiment. However, severity on lower surfaces was not significantly different from the nontreated control on 3 and 16 Sep or for the AUDPC value. Bugitol may have been more effective if the first application had been made 4-5 days earlier when most other treatments were started. Sporan and the hydrogen dioxide product, OxiDate, were effective against powdery mildew based on severity being significantly less than the nontreated for the IPM schedule on 23 Aug. However, the rate and treatment schedules used did not provide full season control. According to the Sporan label, addition of an approved adjuvant is required to improve spreading and sticking. Perhaps Sporan would be more effective when used with the recommended adjuvant, ThermX 70, which was not available when the experiment was conducted, rather than NuFilm P. Control of powdery mildew on lower leaf surfaces obtained with Microthiol Disperss, Trilogy, or OxiDate was improved by tank-mixing these products with Quintec or Procure for the first three applications. Improved control was evident through 3 Sep, 15 days after the last tank-mix application. Mildew was more effectively controlled on lower leaf surfaces with the 'conventional grower standard program' which included Quintec or Procure in all seven applications. Canopy condition generally corresponded to level of powdery mildew control. One notable exception is that Bravo-treated pumpkins had the least defoliation. This was likely due to additional control of downy mildew. There were no significant differences among treatments in fruit quality assessed based on handle quality.

Treatments and rate/A (application time) ^y	Powdery mildew severity (% leaf coverage) ^z						Defolia- tion (%)	% Solid handles
	Upper leaf surface			Lower leaf surface				
	23 Aug	16 Sep	AUDPC	23 Aug	16 Sep	AUDPC		
Nontreated	1.638 a ^x	45.9 a	371 ab	2.67 a	67.2 a	939 a	32.5 abcd	84
OxiDate Curative (128 fl oz/100 gal) (4,4a,4b,5,6,7)	0.738 ab	30.8 ba	298 abc	1.70 ab	52.8 abc	889 ab	32.5 abcd	85
OxiDate IPM (128 fl oz/100 gal)(1-3) (40 fl oz/100 gal)(4-7)	0.083 bc	40.1 a	486 a	0.81 bc	62.3 ab	958 a	42.5 a	83
Sporan (1.5 qt/A) + NuFilm P (6 oz/A)(1-7) ...	0.038 c	27.2 ba	237 bc	0.68 bc	55.4 abc	786 abc	36.3 abc	83
Trilogy (1%)(1-7)	0.013 c	16.8 cb	171 cd	0.45 bcd	52.8 abc	778 abc	26.3 bcd	86
Bugitol (96 fl oz/100 gal)(1b-7)	0.062 bc	17.5 cb	162 cd	0.53 bcd	57.9 abc	883 ab	31.3 abcd	88
Eco E-Rase (1%)(1-7)	0.026 c	11.0 cd	87 de	0.34 cd	48.3 abc	604 cd	28.8 abcd	88
Organocide (2 oz/gal)(1-7)	0.052 bc	6.9 cde	77 de	0.83 bc	42.8 bc	573 cd	30.0 abcd	88
GC-3 (1%)(1-7)	0.063 bc	7.9 cde	77 de	0.53 bcd	39.0 c	512 de	26.3 bcd	80
JMS Stylet-oil (5 qt/100 gal)(1-7)	0.050 bc	10.5 cd	87 de	0.50 bcd	46.9 abc	569 cd	23.8 bcde	96
Microthiol Disperss (4 lb/A)	0.000 c	3.7 def	39 ef	0.14 cd	53.0 abc	629 bcd	27.5 abcd	92
Bravo Ultrex (2.7 lb/A)	0.053 bc	11.2 cd	101 de	0.78 bc	55.1 abc	635 bcd	10.0 e	100
Quintec (4 oz/A) + OxiDate (1,3), Procure (6 oz/A) + OxiDate (2), OxiDate (4-7)	0.000 c	15.4 cb	101 de	0.02 d	44.1 bc	312 ef	35.0 abcd	84
Quintec + Trilogy (1,3), Procure + Trilogy (2), Trilogy (4-7)	0.004 c	7.6 cde	55 ef	0.07 cd	46.3 bc	435 def	37.5 ab	95
Quintec + Microthiol Disperss (1,3), Procure + Microthiol Disperss (2), Microthiol Disperss (4-7)	0.000 c	1.4 ef	9 f	0.01 d	43.3 bc	307 f	21.8 cde	100
Quintec + Microthiol Disperss (1,3,5,7), Procure + Microthiol Disperss (2,4,6)	0.003 c	0.5 f	5 f	0.08 cd	11.8 d	69 g	20.0 de	90
<i>P</i> value	0.0191	0.0001	0.0001	0.0014	0.0030	0.0001	0.0248	0.64

^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 23 Aug and all leaves on 16 Sep. Area under the disease progress curve (AUDPC) was calculated for severity from 6 Aug through 16 Sep.

^y Rate of formulated product/A. Application times were: 1=6-7 Aug, 1b=11 Aug, 2=12 Aug, 3=19 Aug, 4=25 Aug, 4a=26 Aug, 4b=27 Aug, 5=1 Sep, 6=6 Sep, and 7=12 Sep. Applications 3 and 5 were applied early due to forecasts for rain. Where rate is not specified product was applied at the same rate 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 ($P = 0.05$).