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

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Evaluation of biopesticides and conventional fungicides for managing powdery mildew on pumpkin, 2022.

An experiment with field-grown pumpkins was conducted at the Long Island Horticultural Research and Extension Center (LIHREC) in Riverhead, NY, in a field with Haven loam soil. The objective was to evaluate programs with biopesticides applied in place of conventional fungicides for some applications. The field was moldboard plowed on 22 Mar. Phytophthora blight, caused by *Phytophthora capsici*, was managed through biofumigation and weekly applications of targeted fungicides on a preventive schedule. Urea fertilizer (46-0-0) was applied at 80 lb/A N on 23 Mar, then mustard biofumigant cover crop cv. Rojo Caliente was seeded at 10 lb/A by drilling. On 3 Jun the mustard was flail chopped, immediately incorporated by disking, and followed by a cultipacker to seal the soil surface; the field could not be irrigated to initiate biofumigation as recommended and usually done, but the soil was moist. Pumpkins were planted with a vacuum seeder at approximately 24-in. plant spacing on 21 Jun after disking. Controlled-release fertilizer (N-P-K, 19-10-9) was used at 525 lb/A (101 lb/A N) and applied with the seeder in two bands about 2 in. to the side of the seed. The herbicides Strategy 3 pt/A, Sandea 0.5 oz/A, and Curbit EC 1 pt/A were applied immediately after planting using a tractor-mounted sprayer. During the season, weeds were managed by cultivating and hand weeding as needed. Drip tape was laid along each row of pumpkin seedlings on 29 Jun. Irrigation was run as needed to supplement rainfall to achieve 1 in. water each week. The following fungicides with targeted activity for Phytophthora blight were applied throughout the season to foliage (except the first application which was a directed spray to soil): Omega 24 fl oz/A was applied on 10 Jul, Omega 16 fl oz/A on 15 Jul, Ranman 2.75 fl oz/A on 20 Aug and 3 Sep, Orondis Ultra 7 fl oz/A on 13 and 27 Aug and 9 Sep, Presidio 4 fl oz/A on 23 Jul and 6 Aug, and Revus 8 fl oz/A on 30 Jul. No foliar or fruit symptoms of *P. capsici* were seen until mid-October, about one month after the last fungicide application. Plots were three 15-ft rows spaced 68 in. apart with a 15-ft in-row untreated area between plots. The 15-ft area between plots was also planted to pumpkin. A randomized complete block design with four replications was used. The primary source of initial inoculum for powdery mildew in this area is considered to be long-distance wind-dispersed spores from affected plants. Treatments were applied eight times on a preventive schedule using a tractor-mounted boom sprayer equipped with twinjet (TJ60-11004VS) nozzles spaced 17 in. apart that delivered 72 gal/A at 55 psi and 2.3 mph. The sixth application scheduled for 24 Aug had to be delayed one day due to heavy rain earlier in the week. The last application scheduled for 7 Sep was applied two days late due to large amounts of rain earlier in the week. Plants were inspected for powdery mildew symptoms on upper and lower leaf surfaces from 20 Jul through 21 Sep. Initially only old leaves were examined: 20 in each plot on 20 and 26 Jul and on 2 Aug. Old, mid-aged and young leaves (usually five of each selected based on their physiological appearance and position in the canopy) were examined in each plot on 9, 15, 24 and 29 Aug, and 7, 14 and 21 Sep. Colonies of powdery mildew were counted, and 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 to count. Colony counts were converted to severity values using the conversion factor of 30 colonies/leaf = 1% severity. Average severity for the entire canopy was calculated from the individual leaf assessments. Area under disease progress curve (AUDPC) values were calculated from 26 Jul through 7 Sep using the formula: $\sum_{i=1}^{n}[(R_{i+1} + R_i)/2]\,[t_{i+1} - t_i]$, where R = disease severity rating (% of leaf surface affected) at the *i*th observation, t_i = time (days) since the previous rating at the *i*th observation, and n = total number of observations. Defoliation, which was mainly due to powdery mildew, was assessed on 8, 14, 20 and 27 Sep; and 3 Oct. Quality of each fruit was evaluated in terms of handle (peduncle) condition for mature fruit without rot on 23 and 28 Sep; and 3 and 10 Oct. Handles were considered good if they were green, solid, and not rotting. Data were analyzed with one-way ANOVA and Tukey's HSD to separate means using JMP statistical software. Average monthly high and low temperatures (°F) were 85.3 and 68.9 in Jul, 85.4 and 68.7 in Aug, 76.3 and 60.3 in Sep, and 64.7 and 48.1 in Oct. Rainfall (in.) was 4.1, 2, 4.3 and 6.1 for these months, respectively.

Powdery mildew was first observed in this experiment on 26 Jul in 7 of the 36 plots on only 7 of the 720 leaves examined (0.97%). The first fungicide treatment was applied on 22 Jul. The first two applications were considered to be preventive because they were before symptoms would be found through routine scouting. The IPM action threshold recommended to growers for initiating fungicide applications is 1 out of 50 old leaves with symptoms (2%). On 2 Aug symptoms were found in 35 of the 36 plots on 70 of 720 leaves examined (9.7%). All treatments tested provided effective control of powdery mildew on both leaf surfaces. The grower standard fungicide program consisting of weekly applications of targeted, conventional fungicides provided the best control based on last defoliation ratings on 27 Sep and 3 Oct (data not shown). However, this treatment was rarely significantly better than the other treatments. The main integrated program evaluated consisted of a biopesticide or Microthiol Disperss, an organic (OMRI-listed) sulfur, applied two times very early in powdery mildew development (before the action threshold), then three applications of targeted fungicides, then three applications of the organic product. Another treatment (first in table) was a block rotation among the biopesticide and the conventional fungicides. For the two programs with biopesticides and conventional fungicides, there was a matching treatment with just the targeted fungicides applied at the same time for comparison, which is in the table below the corresponding treatments with biopesticides to facilitate comparing. The first comparison conventional fungicide treatment was highly effective (99% control based on AUDPC values for powdery mildew on upper leaf surfaces), thus there was no opportunity for detecting benefit provided by the biopesticide (Theia) included in that program. The other comparison conventional fungicide treatment, with the three applications of targeted fungicides applied in succession on 3, 10, and 17 Aug, was no longer effective at the 7 Sep severity rating. Control of powdery mildew on upper leaf surfaces was improved significantly when Theia or sulfur was applied before and after (five applications total) these three consecutive applications of targeted fungicides (95% and 99% versus 68% control based on AUDPC values for powdery mildew on upper leaf surfaces). AUDPC values for the other integrated programs were numerically lower. AUDPC values for powdery mildew on lower leaf surfaces did not differ significantly among treatments. No phytotoxicity seen. Photographs are posted at https://blogs.cornell.edu/livegpath/research/cucurbit-powdery-mildew-research/evaluation-of-biopesticides-in-programs-with-conventional-fungicides/

Treatment and rate (application dates)[y]	Powdery mildew severity (%)[z, x]					Defoliation (%)[z]	Fruit quality (% good handles)[z]	
	Upper leaf surface		Lower leaf surface					
	7 Sep	AUDPC	29 Aug	7 Sep	AUDPC	20 Sep	23 Sep	10 Oct
Untreated control	42.5 a	301 a	31.2 a	50 a	489 a	93 a	56 b	13 b
Theia 3 lb (1, 2, 5, 7, 8)[w]; Proline 5.7 fl oz (3, 6)[w]; Vivando 15.4 fl oz (4)[w];	0.8 c	4 c	4.8 b	7 b	73 b	34 bc	99 a	75 a
Proline 5.7 fl oz (3, 6)[w]; Vivando 15.4 fl oz (4)[w]	0.5 c	3 c	4.4 bc	3 b	49 b	38 bc	99 a	80 a
Theia 3 lb (1, 2, 6, 7, 8)[w]; Proline 5.7 fl oz (3, 5)[w]; Vivando 15.4 fl oz (4)[w];	3.3 c	15 c	1.6 bcd	14 ab	82 b	44 bc	100 a	75 a
Serifel 10 oz (1, 2, 6, 7, 8)[w]; Proline 5.7 fl oz (3, 5)[w]; Vivando 15.4 fl oz (4)[w];	4.8 c	22 bc	1.8 bcd	11 b	66 b	61 ab	94 a	61 a
Timorex ACT 20 fl oz (1,2,6,7,8)[w]; Proline 5.7 fl oz (3, 5)[w]; Vivando 15.4 fl oz (4)[w];	5.9 bc	27 bc	0.7 cd	15 ab	78 b	45 bc	96 a	66 a
Microthiol Disperss 5 lb (1,2,6,7,8)[w]; Proline 5.7 fl oz (3, 5)[w]; Vivando 15.4 fl oz (4)[w];	0.7 c	3 c	0.4 d	7 b	38 b	32 bc	95 a	73 a
Proline 5.7 fl oz (3, 5)[w]; Vivando 15.4 fl oz (4)[w]	21.4 ab	97 b	1.0 bcd	17 ab	85 b	63 ab	96 a	58 a
Proline 5.7 fl oz (3, 5)[w]; Vivando 15.4 fl oz (4, 6, 8)[w]; Procure 8 fl oz (7)[w]	0.5 c	2 c	0.8 cd	9 b	50 b	24 c	99 a	79 a
P-value (treatment)	<0.0001	<0.0001	<0.0001	0.0028	<0.0001	<0.0001	<0.0001	<0.0001

[z] Numbers in each column with a letter in common or no letters are not significantly different from each other (Tukey's HSD, P=0.05).

[y] Rate of formulated product/A. Application dates were 1=22 Jul, 2=27 Jul, 3=3 Aug, 4=10 Aug, 5=17 Aug, 6=25 Aug, 7=31 Aug, and 8=9 Sep.

[x] Values were square root transformed before analysis because raw data were not distributed normally. Table contains de-transformed values.

[w] Treatment applied with the nonionic surfactant Dyne-Amic at 0.38% v/v.