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

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Evaluation of biopesticides and conventional fungicides for managing powdery mildew on a resistant variety of 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 main objective was to evaluate recently developed biopesticides suitable for organic production. Second objective was to evaluate Cevya, a new FRAC 3 fungicide, and Prolivo (FRAC 50). 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 and 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 consisted of 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 except that there were only three plots of the treatment with Prolivo due to space constraints. The primary source of initial inoculum for powdery mildew in this area is thought to be long-distance wind-dispersed spores from affected plants. Treatments were applied nine 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 first application was done over two days, 21 and 22 Jul. 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 symptoms of powdery mildew on upper and lower leaf surfaces. Twenty old leaves were examined in each plot on 25 Jul and 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 8, 15, 24, and 29 Aug, and 8, 14 and 21 Sep. Powdery mildew colonies 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 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. The values of area under the disease progress curve (AUDPC) were calculated from 25 Jul through 8 Sep using the formula: $\sum_{i=1}^{n}[(Ri+1 + Ri)/2] [ti+1 – ti]$, where R = disease severity rating (% of leaf surface affected) at the *i*th observation, ti = 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. Fruit quality 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, 2.0, 4.3 and 6.1 for these months, respectively.

Powdery mildew was first observed in this experiment on 25 Jul in seven of the 51 plots on only eight of the 1,020 leaves examined (0.78%). The IPM action threshold recommended to growers for initiating fungicide applications is one out of 50 old leaves with symptoms (2%). Therefore, the first and second applications in this experiment are considered to be preventive applications because they were before the threshold and before symptoms typically would be found through routine scouting. On 2 Aug, symptoms were found in 47 of the 51 plots on 100 of 1,020 leaves examined (9.8%). Severity was low throughout August especially on upper leaf surfaces, which may be partly due to some contact activity for powdery mildew of the fungicides applied for Phytophthora blight, which was documented in a nearby experiment that had the same Phytophthora blight fungicide program as a treatment (PDMR 17:V063) to determine if this was the reason for limited powdery mildew development during August on upper leaf surfaces in previous experiments (PDMR 16:V110). On 24 Aug, one day before the sixth application, severity in the untreated control plots averaged 0.6% on upper leaf surfaces and 1% on lower surfaces (data not shown). All biopesticides were effective for powdery mildew on upper leaf surfaces but not lower leaf surfaces reflecting their contact activity. There was numerically less defoliation and more pumpkin fruit with good handles in plots treated with only biopesticides; defoliation was significantly different from the control only on 8 Sep (other data not shown). Sulfur (Microthiol Disperss), the organic non-biopesticide standard included for comparison, was more effective than the biopesticides: 99% versus 64-76% control based on AUDPC values for powdery mildew on upper leaf surfaces. It provided some control of powdery mildew on lower leaf surface (33%) perhaps partly due to sulfur's volatility enabling some product to redistribute to lower leaf surfaces. The two programs consisting of biopesticide (Stargus + Regalia or Theia) applied in alternation with sulfur were as effective as sulfur applied weekly (96% and 35-37% control). Effective control was achieved with the program consisting of a biopesticide (Serifel) applied in block alternation with conventional, mobile fungicides (biopesticide applied early season when incidence of affected leaves below 1% and late season): 92% and 86% control on upper and lower leaf surfaces, respectively. The two conventional fungicides tested, Cevya and Prolivo, effectively controlled powdery mildew. Cevya was not as effective for powdery mildew on lower leaf surfaces (54% control), which confirms previous results. Some mean separation letters for Prolivo for some variables are not what would be expected based on the mean for it and other treatments; this is due to there being three rather than four replicate plots. While this experiment was conducted with a resistant variety, it provided limited suppression based on a comparison to severity data for the untreated control plots in an adjacent experiment conducted with 'Gold Challenger', a powdery mildew susceptible pumpkin variety (PDMR 17:V062). No phytotoxicity was observed. Photographs are posted at https://blogs.cornell.edu/livegpath/research/evaluation-of-a-phytophthora-blight-fungicide-program-for-powdery-mildew-and-phytophthora-blight-2022/.

Treatment and rate (application dates) [y]	Powdery mildew severity (%) [z]					Defoliation (%) [z]	Fruit quality (% with good handles) [z]	
	Upper leaf surface		Lower leaf surface					
	8 Sep	AUDPC	29 Aug [x]	8 Sep	AUDPC	8 Sep	23 Sep	10 Oct
Untreated control	50 a	324 a	22.8 a	55 a	457 a	83 a	47 d	16 e
Berezi 3 lb (1-8)	15 b	84 bc	9.5 abcd	49 a	323 abc	26 bcdef	85 abc	62 abcd
Berezi 5 lb (1-8)	16 b	118 b	19.1 ab	54 a	419 ab	48 b	72 abc	33 de
Serifel 10 oz (1-8) [w]	18 b	101 b	11.1 abcd	47 a	334 abc	40 bcd	75 abc	33 de
Stargus 87 fl oz + Regalia 63 fl oz (1-8)	17 b	94 bc	13.7 abcd	52 a	378 ab	39 bcd	68 bcd	38 cde
Trillium 1% (1-8)	16 b	88 bc	11.3 abcd	52 a	348 abc	36 bcde	78 abc	43 bcde
Theia 3 lb (1-8) [w]	12 bc	79 bc	14.3 abc	47 a	345 abc	45 bc	65 cd	32 de
Microthiol Disperss 5 lb (1-8)	1 d	4 d	7.7 bcd	47 a	305 bc	15 def	88 abc	69 abc
Stargus 87 fl oz + Regalia 63 fl oz (1, 3, 5, 7); Microthiol Disperss 5 lb (2, 4, 6, 8)	3 cd	14 d	8.4 abcd	45 a	295 bc	13 def	80 abc	51 abcd
Theia 3 lb (1, 3, 5, 7); Microthiol Disperss 5 lb (2, 4, 6, 8)	2 d	12 d	4.2 cde	48 a	286 bc	18 cdef	83 abc	57 abcd
Serifel 10 oz (1, 2, 6, 7, 8) [w]; Proline 5.7 fl oz (3, 5) [w]; Vivando 15.4 fl oz (4) [w]	6 bcd	29 cd	0.3 e	12 b	66 e	6 f	97 a	73 ab
Cevya 5 fl oz (1-8)	1 d	4 d	3.2 de	37 a	212 cd	14 def	90 abc	61 abcd
Prolivo 5 fl oz (1-8) [w]	2 cd	10 d	0.4 e	10 b	60 de	5 ef	94 ab	82 a
P-value (treatment)	<0.0001	<0.0001	<0.0001	<0.0001	<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 unless otherwise noted. Application dates were 1=21 and 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.