

Evaluation of biopesticides and conventional fungicides for managing powdery mildew of pumpkin, 2023.

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 the biopesticide Theia in programs with three applications of targeted, conventional fungicides for managing powdery mildew (FRAC 3 and 50) made early in disease development. Additional objectives were to evaluate Regev, a hybrid fungicide with tea tree extract plus difenoconazole, and to compare two FRAC 50 fungicides (Prolivo and Vivando). The field was moldboard plowed on 4 Apr. *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 5 Apr, then mustard biofumigant cover crop cv. Rojo Caliente was seeded at 10 lb/A by drilling. On 15 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 23 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 2 pt/A and Sandea 0.5 oz/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 28 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: Omega (16 fl oz/A) was applied on 13 Jul, Ranman (2.75 fl oz/A) on 19 Jul, 4 and 19 Aug, and 8 Sep, Orondis Ultra (7 fl oz/A) on 26 Jul, 11 Aug and 1 Sep, and Forum (6 fl oz/A) on 17 Sep. The following protectant fungicides were also applied to foliage for general disease management: Bravo Weather Stik (1.5 pt/A) on 13, 19 and 26 Jul and 4 and 27 Aug, Cueva (2 qt/A) on 19 Jul, and Kocide 3000 (1.25 lb/A) on 4, 11 and 19 Aug. 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. 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 eight times on a 7-day preventive schedule beginning on 28 Jul 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 date applications were made was adjusted as needed due to weather. 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, 1 Aug, and 14 Aug. Old, mid-aged and young leaves (five of each selected based on their physiological appearance and position in the canopy) were examined in each plot on 23 and 29 Aug, and 6, 12, 21, and 27 Sep. Colonies of powdery mildew were counted, and disease 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 14 Aug through 21 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 21 and 27 Sep and 3 and 11 Oct. Fruit quality was evaluated in terms of the condition of the handle (peduncle) for mature fruit without rot on 27 Sep and 3, 11 and 18 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. Data for two plots were excluded because once they received the wrong treatment. Average monthly high and low temperatures (°F) were 85.4 and 69.4 in Jul, 81.1 and 65.6 in Aug, 76.0 and 62.7 in Sep, and 68.6 and 51.2 in Oct. Rainfall (in.) was 7.0, 4.8, 5.1 and 3.0 for these months, respectively.

Powdery mildew was first observed in this experiment on 14 Aug in all 36 plots on 181 of the 720 leaves examined (25%). The IPM action threshold recommended to growers for initiating fungicide applications is one out of 50 old leaves with symptoms (2%). Therefore, the first two applications in this experiment are preventive applications because they were before the threshold and before symptoms typically would be found through routine scouting. Likely, powdery mildew had started to develop when the third application was made on 11 Aug. Based on comparison with the untreated control, all treatments numerically improved control of powdery mildew on upper leaf surfaces over what was achieved by the general disease maintenance management program implemented. All treatments were effective based on the 29 Aug assessment (data not shown). The three fungicide programs with Theia were not significantly better than the parallel program with two applications of a FRAC 50 fungicide (Vivando) and one application of a FRAC 3 fungicide (Prolivo): 61-72% vs 72% control based on AUDPC values. Regev was ineffective after the 29 Aug assessment. Vivando was significantly more effective than Prolivo based on AUDPC values: 86% vs 59% control; however, there were no significant differences in defoliation or fruit handle quality. The numerically most effective treatment was the grower-recommended program of Vivando applied in alternation with a FRAC 3 fungicide from powdery mildew onset through mid-September (6 applications): 96% control on lower leaf surfaces based on AUDPC values. This program also had one of the highest percentages of fruit with good handles, significantly better than the untreated control. No phytotoxicity was observed. Effective control on lower leaf surfaces, where powdery mildew develops best, is critical for successful management and thus was used to assess treatment efficacy.

Treatment and rate (application dates) ^{x, w}	Powdery mildew severity (%) ^{z, y}					Defoliation (%) ^z	Fruit quality (% good handles) ^z		
	Upper leaf surface		Lower leaf surface				27 Sep	3 Oct	18 Oct
	21 Sep	AUDPC	6 Sep	12 Sep	AUDPC				
Untreated Control	14.3 a	71 a	30.7 a	29.6 a	875 a	97 a	61 b	36 bc	
Regev 8.5 fl oz (3-8)	0.6 bc	3 bc	14.3 ab	29.8 ab ^v	546 ab	86 ab	57 b	27 c	
Theia 1.5 lb (1-8); Prolivo 5 fl oz (3, 5); Rhyme 7 fl oz (4)	3.9 ab	18 abc	2.5 bc	13.1 abcd	340 bc	68 ab	76 ab	55 abc	
Theia 1.5 lb (1-8); Vivando 15.4 fl oz (3, 5); Proline 5.7 fl oz (4)	2.0 bc	9 bc	0.2 c	10.5 bcde	287 bc	44 bc	94 a	83 a	
Theia 3 lb (1-8); Vivando 15.4 fl oz (3, 5); Proline 5.7 fl oz (4)	1.2 bc	6 bc	0.8 c	7.2 cde	245 bc	49 bc	85 ab	62 abc	
Vivando 15.4 fl oz (3, 5); Proline 5.7 fl oz (4)	5.6 ab	25 ab	1.4 c	6.6 cde	246 bc	57 b	94 a	74 ab	
Prolivo 5 fl oz (3-8)	1.2 bc	7 bc	5.7 bc	16.2 abc	362 b	69 ab	83 ab	55 abc	
Vivando 15.4 fl oz (3-8)	0.2 bc	1 bc	0.6 c	3.4 de	125 cd	47 bc	92 a	68 abc	
Vivando 15.4 fl oz (3, 5, 7); Proline 5.7 fl oz (4, 6); Procure 8 fl oz (8)	0.0 c	0 c	0.3 c	2.2 e	37 d	18 c	95 a	79 a	
<i>P-value (treatment)</i>	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0009	0.0028	

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

^x Rate of formulated product/A. Application dates were 1=28 Jul, 2=3 Aug, 3=11 Aug, 4=17 Aug, 5=24 Aug, 6=1 Sep, 7=7 Sep, and 8=14 Sep.

^w All treatments were applied with the nonionic surfactant Dyne-Amic at 0.38% v/v.

^v Mean separation letters reflect there being only 3 plots in the analysis for this treatment.