SQUASH (*Cucurbita pepo* 'Honey Bear')
Powdery mildew; *Podosphaera xanthii*

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Efficacy for powdery mildew on acorn squash of conventional and organic fungicide programs with biopesticides that induce systemic resistance, 2018.

An experiment with field-grown squash 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 of this experiment was to assess benefits of adding a biopesticide that triggers an induced systemic resistance (ISR) response in plants (Regalia or LifeGard) to a conventional fungicide rotation for powdery mildew on cucurbits. There was a parallel treatment with Serifel, another biopesticide, and a treatment with only organic-approved fungicides. The cultivar selected has intermediate resistance to powdery mildew. The field was plowed on 29 May. Controlled-release fertilizer (N-P-K, 15-5-15) at 675 lb/A (101 lb/A N) was broadcast over the bed area and incorporated on 1 Jun. Beds were formed with drip tape and covered with black plastic mulch also on 1 Jun. A waterwheel transplanter was used to make planting holes in the beds and apply starter fertilizer. Two seeds were placed in each opening in the plastic mulch by hand on 27 Jun, and emerging seedlings were then thinned to one plant per hole on 3 Jul. Weeds were managed between the mulched beds by applying Strategy 3 pt/A, Sandea 0.5 oz/A, and Roundup PowerMax 22 oz/A prior to seedling emergence on 29 Jun using a tractor mounted sprayer. During the season, weeds were managed by cultivating and hand weeding as needed. The following fungicides were applied throughout the season to manage Phytophthora blight: Presidio 4 fl oz/A on 25 Jul, Ranman 2.75 fl oz/A on 30 Jul, Orondis Ultra 7 fl oz/A on 4 Aug, Revus 8 fl oz/A on 7 Aug, Omega 1.5 pt/A on 13 Aug, Orondis Ultra 7 fl oz/A on 23 Aug, Orondis Ultra 7 fl oz/A on 30 Aug, Omega 1.5 pt/A on 6 Sep, and Ranman 2.75 fl oz/A on 15 Sep. The primary source of initial inoculum of *Podosphaera xanthii* in this area is considered to be long-distance wind-dispersed spores from affected plants. Plots were three 15-ft rows spaced 68 in. apart, 12 plants per plot. A randomized complete block design with four replications was used. Treatments were applied on a 7-day schedule using a tractor-mounted boom sprayer equipped with twinjet (TJ60-11004VS) nozzles spaced 17 in. apart that delivered 72 gal/A at 50 psi and 2.3 mph. Applications of Regalia, LifeGard, and Serifel were begun on 19 Jul, at least two weeks before plants were anticipated to begin producing fruit, which is when powdery mildew typically starts to develop. Plots were inspected for powdery mildew symptoms on upper and lower leaf surfaces on 24 Jul; 1, 7, 16, 24 and 31 Aug; and 17 Sep. For each assessment 5 old to middle age leaves and 5 young leaves were evaluated per plot. 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. 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 1 Aug through 17 Sep using the formula: $\sum n_{i=1}[(R_{i+1} + R_i)/2]\,[t_{i+1} - t_i]$, where R = disease severity rating (% of leaf surface affected) at the ith observation, t_i = time (days) since the previous rating at the ith observation, and n = total number of observations. Plots were also evaluated for canopy health using a hand-held GreenSeeker crop sensor, which measured canopy greenness using the Normalized Difference Vegetation Index (NDVI) spectral reflectance index. Plots were measured for canopy greenness on the same day as powdery mildew disease ratings when light conditions were appropriate (full sunlight). Two measurements were taken per plot and averaged. Mature fruit were harvested on 19 and 20 Sep. All fruit was taken from each plot and counted (excluding rotten fruit caused by Phytophthora blight). Fruit was sorted based on marketability criteria: larger than 3.5 inches in diameter, fully ripe, and no large surface defects. Marketable fruit was weighed. Yield per healthy plant in each plot was calculated and used in analysis. Five representative fruit from each plot were analyzed for sugar content (Brix) using a refractometer. Data was analyzed with one-way ANOVA and Tukey's HSD to separate means using JMP statistical software. Average monthly high and low temperatures (^{o}F) were 85/70 in Jul, 84/72 in Aug, and 77/66 in Sep. Rainfall (in.) was 3.76, 6.04, and 5.81 for these months, respectively. Due to the atypically high amounts of rainfall in Aug, Sep, and Oct, Phytophthora blight was prevalent in the experiment despite efforts to control it. As the growing season progressed multiple plots were completely killed by Phytophthora blight and other plots were heavily impacted by the disease. As a result, one treatment had to be left out of statistical analysis because it did not have enough replications. Means from this treatment are presented from an observational context. Yield data was also heavily impacted by Phytophthora blight, rotten fruit was excluded from all yield measurements in an attempt to limit the impact of the disease on yield estimations.

Powdery mildew was first observed on 1 Aug at very low levels in a few plots in this experiment. The conventional fungicide rotation was started two days later. All four treatments with conventional fungicides were highly effective for managing powdery mildew on both leaf surfaces through the last assessment, which was ten days after the last application. Adding biopesticides to the rotation did not improve control; however, there was negligible room for improvement. The organic program appeared to be effective until the last assessment. Due to loss of half of these plots, this treatment was not included in data analysis. The Greenseeker did not detect differences in canopy health between treatments until 31 Aug when powdery mildew was well established in the untreated plots, therefore it does not appear to be a useful tool for detecting infection before symptoms are readily visible or ISR response. NDVI values averaged 0.86 or 0.87 for all treatments on 24 Aug. On 31 Aug they were 0.66 for control plots (only treatment significantly different from others), 0.82 and 0.83 for conventional fungicide rotations that included Regalia or LifeGard, 0.78 and 0.79 for the other conventional fungicide treatments, and 0.73 for the organic program. No significant differences were detected among treatments in number or weight of marketable fruit or average fruit weight (data not shown). Brix was lowest for fruit from the untreated plots (8.3), 10 for the organic program, and 10.16 to 10.92 for the four treatments that included conventional fungicides, with 10.92 for the program with LifeGard being the only one significantly different from untreated.

Treatment and rate (application dates) [x]	Powdery mildew severity (%) [y,z]							
	Upper leaf surface				Lower leaf surface			
	24 Aug	31 Aug	17 Sep	AUDPC	24 Aug	31 Aug	17 Sep	AUDPC
Untreated Control	2.52 a	17.98 a	13.87 a	348.2 a	1.13 a	10.69 a	34.3 a	398.2 a
Regalia 2 qt/A (1-8) Vivando 15.4 fl oz/A (3,6) Quintec 4 fl oz/A (4,7) Luna Experience 6 fl oz/A (5,8)	0.00 b	0.10 b	1.79 ab	8.7 b	0.00 b	0.06 b	6.5 ab	37.5 b
LifeGard 4.5 oz/100 gal (1-8) Vivando 15.4 fl oz/A (3,6) Quintec 4 fl oz/A (4,7) Luna Experience 6 fl oz/A (5,8)	0.00 b	0.08 b	0.63 ab	7.5 b	0.00 b	0.03 b	2.0 b	14.9 b
Serifel 8 oz/A (1-8) Vivando 15.4 fl oz/A (3,6) Quintec 4 fl oz/A (4,7) Luna Experience 6 fl oz/A (5,8)	0.00 b	0.01 b	0.71 ab	6.2 b	0.01 b	0.06 b	1.8 b	16.0 b
Vivando 15.4 fl oz/A (3,6) Quintec 4 fl oz/A (4,7) Luna Experience 6 fl oz/A (5,8)	0.00 b	0.15 b	0.34 b	9.4 b	0.00 b	0.25 b	1.8 b	15.6 b
P-value (treatment)	<0.0001	<0.0001	0.0288	<0.0001	0.0007	<0.0001	0.0116	0.0006
LifeGard 4.5 oz/100 gal (1,2) [w] Milstop 3 lbs/A (3,6) Serifel 8 oz/A (4,7) Suffoil-X 1% v/v (5,8)	0.59	2.38	34.40	324.8	1.04	0.41	21.4	205.1

[z] Values in each column with a letter in common are not significantly different from each other (Tukey's HSD, *P*=0.05).
[y] When data were not distributed normally, values were square root transformed before analysis. Table contains back-transformed values.
[x] Rate of formulated product. LifeGard rate was 3.25 oz/A. Application dates were 1=19 Jul, 2=27 Jul, 3=3 Aug, 4=10 Aug, 5=17 Aug, 6=24 Aug, 7=31 Aug, and 8=7 Sep.
[w] Data not included in statistical analysis because two plots were lost to Phytophthora blight. Table contains means for two surviving plots.