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

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Fungicide sensitivity of cucurbit powdery mildew pathogen population on Long Island, 2019.

Fungicide resistance can be a major constraint to effectively managing powdery mildew in cucurbit crops. Fungicides that are most effective for managing powdery mildew (because they are mobile and thus can redistribute from deposition sites on upper leaf surfaces to the lower surfaces where powdery mildew develops best) are also more prone to the pathogen developing resistance (as a result of their single site mode of action). In this study a seedling bioassay was used to obtain site-specific information about resistance in cucurbit powdery mildew pathogen populations. Two bioassays were conducted in commercial and research plantings during the growing season. Pumpkin seeds were sown in 48-cell trays. Seedlings at about the cotyledon stage were transferred individually to 4-in. pots. At approximately the 3-leaf stage, the growing tip with unexpanded leaves was removed, and then plants were sprayed to coverage with a fungicide dose. Fungicides were tested at highest label rate; some were also tested at lower doses. Applications were made with a backpack sprayer using a TJ60-4004EVS nozzle delivering 50 gal/A operated at 55 psi. The following morning the seedlings were organized into replications each with one plant of each treatment plus two untreated control plants. Each replication was placed in a different field location next to, but not touching leaves of, plants naturally affected by powdery mildew, with up to five replications in the same planting. Seedlings remained there for the rest of the day (5-8 hours) to be exposed to spores dispersed by wind, then the seedlings were returned to the greenhouse until symptoms developed. Seedlings regularly received water with 20-20-20 fertilizer applied to the top of the pot so leaves stayed dry and any new growth was removed. There was no supplemental lighting. Severity of powdery mildew was assessed as percent coverage with symptoms on the upper surface of each leaf. In bioassay 1, treated on 31 Jul, the nine replications of plants were put at two farms in commercial spring plantings of summer squash on which powdery mildew-targeted fungicides had not been applied (Location A and B). Few symptoms developed on seedlings placed at one location (Location A) perhaps due to reduced spore production on affected crop plants caused by high density of spider mites (data not shown). In bioassay 2, treated on 19 Sep, four replications with all of the fungicide doses were placed in a cucurbit powdery mildew field experiment that had been treated with Quintec, Vivando, and Luna Privilege (Location C). Three replications with fungicides at highest dose were placed in a research squash planting also at LIHREC that had been treated with a rotation of Vivando, Procure, and Quintec (Location D). Similar sets of 3 replications were put in commercial pumpkin plantings at two farms. At Location E the planting was treated with a rotation of Vivando, Proline, and Quintec. Only protectant fungicides (sulfur and chlorothalonil) were applied for managing powdery mildew at Location F. Data were analyzed with one-way analysis of variance (ANOVA) and Tukey's honest significance test (HSD) to separate means using JMP statistical software.

Results from the early season bioassay (bioassay 1) provided clear evidence of resistance to Topsin M (FRAC 1), Endura (FRAC 7), and Torino (FRAC U6) all being at high frequencies in the pathogen population: severity of powdery mildew on treated seedlings was not significantly less than on the untreated control. These fungicides had not been used in this commercial crop, therefore resistance occurrence is not due to selection from fungicide use in the crop. Quintec (FRAC 13) was not effective at the lowest rate (0.75 fl oz). Rally (FRAC 3) was highly effective at the tested rate, which is the highest label rate. In the late season bioassay (bioassay 2), results varied by location suggesting that fungicides applied during the season affected resistance development in those pathogen populations. Topsin M was ineffective at all locations, suggesting that resistance to this fungicide is very well established although it is not being used for powdery mildew. Endura and Flint (FRAC 11) were ineffective at the label rate at two of the four locations tested. These fungicides also have not been recommended for powdery mildew management for several years. Another FRAC 7 fungicide, Luna Privilege, was used at Location C which was near Location D. Use of one fungicide in a FRAC group typically can select for resistance to other fungicides in the group; however, the binding site for fluopyram (AI in Luna fungicides) differs from that for boscalid (AI in Endura). Unlike the early season bioassay, in bioassay 2 Torino was effective in all locations at the label rate, but not at half label rate where tested, suggesting occurrence of an intermediate level of resistance. In NY, Torino was recommended to be used no more than once early in the season in 2019, if used at all, because resistance was detected late in the 2018 season using the bioassay. Rally, Luna Privilege, and Vivando (FRAC 50) were extremely effective at all rates tested in all locations; these chemistries remain the best options for managing powdery mildew.

	Powdery mildew severity (%) [z,y]									
	Bioassay 1		Bioassay 2							
	Location B		Location C		Location D		Location E		Location F	
Treatment and rate/A [x]	13 Aug		2 Oct		2 Oct		2 Oct		2 Oct	
Control	22.5	a	50.0	a	30.9	a	61.7	a	48.6	a
Topsin M 8 oz	15.7	a	48.6	a	34.9	a	45.2	a	53.9	a
Flint 2 oz			38.0	ab	16.2	ab	16.4	b	20.5	b
Endura 6.5 oz	15.5	a	42.3	ab	22.2	ab	13.9	b	6.4	c
Endura 3.25 oz			35.4	ab						
Torino 3.4 fl oz	7.0	abc	0.1	e	0.3	c	0.1	c	0.1	d
Torino 1.7 fl oz	16.3	a	34.6	abc						
Torino 0.85 fl oz	8.6	abc	40.4	ab						
Quintec 6 fl oz	0.8	c	19.9	bcd	10.6	b	2.5	c	2.1	cd
Quintec 3 fl oz	2.0	bc	34.6	abc						
Quintec 1.5 fl oz	1.2	c	41.7	ab						
Quintec 0.75 fl oz	6.3	abc								
Bravo Ultrex 2 lb			13.9	cd						
Rally 5 oz	0.8	c	0.5	e	0.3	c	0.2	c	0.1	d
Rally 2.5 oz			5.4	de						
Luna Privilege [w] 6.8 fl oz			0.5	e	0.0	c	0.1	c	0.2	d
Luna Privilege 3.4 fl oz			1.4	e						
Luna Privilege 1.7 fl oz			5.1	de						
Vivando 15.4 fl oz			0.0	e	0.0	c	0.2	c	0.0	d
Vivando 7.7 fl oz			0.0	e						
Vivando 3.85 fl oz			1.8	e						
P-value (treatment)	<0.0001		<0.0001		<0.0001		<0.0001		<0.0001	

[z] Numbers in each column with a letter in common are not significantly different from each other (Tukey's HSD, P=0.05).

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

[x] Rate of formulated product applied at 50 gal on 31 Jul for bioassay 1 and 19 Sep for bioassay 2, which were one day prior to plant exposure to naturally-occurring inoculum under field conditions.

[w] Luna Privilege was used rather than Luna Experience or Luna Sensation, which are labeled for cucurbit powdery mildew, because they contain a second active ingredient (FRAC code 3 or 11, respectively) which would confound results.