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

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Fungicide sensitivity of cucurbit powdery mildew pathogen population on Long Island, NY, 2020.

Fungicide resistance can be a major constraint to effectively managing powdery mildew in cucurbit crops. The most effective fungicides for this disease have mobility enabling redistribution from deposition sites on upper leaf surfaces to the lower surfaces where powdery mildew develops best. They are more prone to the pathogen developing resistance because they have single-site mode of action. Resistance to FRAC code 1, 3, 7, 11, and U6 fungicides has been documented in the U.S. 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. One or two days later the seedlings were organized into replications each with one plant of each treatment plus two (bioassay 2) or four (bioassay 1) 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 three or four 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 12-5-19 fertilizer applied to the top of the pot so leaves stayed dry and any new growth was removed. Severity of powdery mildew was assessed as percent coverage with symptoms on the upper surface of each leaf. In bioassay 1, treated on 4 Aug, four replications were put in a commercial spring planting of zucchini that had not been treated with any fungicides (Location A) and four replications were put in a research planting of zucchini that was treated with Procure on 9 Jul (Location B). In bioassay 2, treated on 24 Sep, four replications with all of the fungicide doses were placed in a cucurbit powdery mildew field experiment that had been treated with Procure and Vivando (Location C). Three replications with fungicides at highest dose were placed in commercial pumpkin plantings at two farms (Location D + E). At Location D the planting was treated with Vivando, Proline, and protectant fungicides (copper and chlorothalonil). Only protectant fungicides (sulfur, copper and chlorothalonil) were applied for managing powdery mildew at Location E. Locations B and C were near each other at LIHREC. Locations A, D, and E were different farms. 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) and Flint Extra (11) being at high frequencies in the pathogen populations: severity of powdery mildew on treated seedlings was not significantly less than on the untreated seedlings. These fungicides had not been used in either location, therefore resistance occurrence is not due to selection from fungicide use in the crops. More powdery mildew symptoms were observed on seedlings treated with Endura (7) and Torino (U6) than on seedlings treated with the most effective fungicide, Quintec (13), but at label rates (highest rate tested) they were both effective and not significantly different from Quintec. Quintec was highly effective at lowest rate tested while Torino was not. Rally (3) at low label rate (2.5 oz/A) was ineffective at Location B where another DMI fungicide had been applied once. In the late season bioassay (bioassay 2), resistance was again detected to FRAC 1 and 11 fungicides. Resistance was also detected to Endura and Torino, although these fungicides were not applied at any of these locations, which suggests resistant isolates are fit and able to compete. While three of the six seedlings treated with Endura or Torino were significantly less severely affected by powdery mildew than the untreated seedlings, two were significantly more severely affected than the most effective fungicides, Luna Privilege (7) and Vivando (50), which were very effective at labeled rate (highest rate tested). Endura and Torino previously were very effective. The binding site for fluopyram (active ingredient [AI] in Luna fungicides) differs from that for boscalid (AI in Endura), which explains lack of complete cross resistance between these FRAC 7 fungicides. Variable results among locations in powdery mildew severity on seedlings treated with Endura and Torino suggests frequency of resistance to these fungicides was not uniform in *P. xanthii* populations occurring on Long Island in 2020. Quintec at highest rate was slightly more effective in bioassay 1 than in bioassay 2: 100%, 99%, 79%, 90%, and 87% control for seedlings at Locations A-E, respectively. Results were similar for Rally: 86%, 97%, 71%, 84%, and 62% control, respectively. This suggests there might have been a small increase in frequency of resistance to these chemistries in *P. xanthii* populations during the growing season. These results combined with results from seedling bioassays conducted in 2018 and 2019 document that resistance to FRAC 1 and 11 chemistry is common early and late in the growing season while resistance to FRAC 7 (boscalid), 13 and U6 chemistry can be common, especially late in the growing season. Single-colony isolates were obtained from Locations C, D, and E to test for resistance using a laboratory leaf disk bioassay.

	Powdery mildew severity (%) [z]									
	Bioassay 1 [y]				Bioassay 2					
	Location A		Location B		Location C		Location D		Location E	
Treatment and rate/A [x]	19 Aug		19 Aug		12 Oct		12 Oct		12 Oct	
Untreated	54.0	a	38.1	a	81.5	ab	96.8	a	97.7	a
Topsin M 8 oz	56.8	a	45.3	a	88.5	a	79.0	abc	99.7	a
Flint Extra 2 oz	50.4	ab	31.8	ab	85.0	ab	90.3	ab	96.0	a
Endura 6.5 oz	11.3	bcd	9.3	bcd	68.2	abcd	63.3	bc	99.7	a
Endura 3.25 oz	2.6	d	7.5	bcd	81.2	ab				
Torino 3.4 fl oz	9.7	bcd	2.4	cd	30.0	def	51.7	cd	87.7	ab
Torino 1.7 fl oz	33.5	abc	7.9	bcd						
Torino 0.85 fl oz	41.8	abc	16.7	abc	67.5	abcd				
Quintec 6 fl oz	0.1	d	0.3	d	17.5	ef	9.7	e	12.3	c
Quintec 3 fl oz	0.1	d	0.5	d						
Quintec 1.5 fl oz	0.6	d	0.4	d	43.7	bcdef				
Quintec 0.75 fl oz	0.2	d	0.6	cd						
Rally 5 oz	7.5	cd	1.0	cd	24.0	ef	15.3	de	36.8	bc
Rally 2.5 oz	9.2	cd	11.8	abcd	52.5	abcde				
Luna Privilege 6.84 fl oz [w]					5.4	f	0.7	e	0.7	c
Luna Privilege 1.71 fl oz [w]					73.7	abc				
Vivando 15.4 fl oz					5.2	f	0.2	e	15.0	c
Vivando 3.85 fl oz					33.7	cdef				
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] 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 4 Aug for bioassay 1 and on 24 Sep for bioassay 2, which were two and one days prior, respectively, 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.