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

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Evaluation of fungicides for managing powdery mildew in pumpkin, 2007.

The primary objective of this study was to evaluate the efficacy of several individual fungicides and a fungicide program for the control of cucurbit powdery mildew in an area where in previous years strains of the pathogen with QoI resistance and moderate DMI resistance were detected before fungicide use. The fungicides were currently registered products, new products, and 'alternative' products. The fungicide program included the three currently-registered mobile fungicides thought to have the greatest activity for this disease. A field experiment was conducted at LIHREC on Haven loam soil. The field was plowed on 10 May and tilled on 11 Jun. Fertilizer (N-P-K 10-10-10) at 400 lb/A was broadcast on 18 Jun. Seeds were planted at approximately 24-in. plant spacing within rows with a vacuum seeder on 21 Jun. The seeder applied fertilizer at 30 lb/A N in a band about 2 in. away from the seed. Additional fertilizer (N-P-K 34-0-0) at 88 lb/A was side-dressed on 2 Aug. Red clover at 10 lb/A was planted with a grain drill to establish driveways on 12 Jul. During the season, weeds were controlled by applying Strategy (2 pt/A) over the seeded rows on 22 Jun, and cultivating, roto-tilling between plots, and hand weeding were performed as needed. Cucumber beetles were managed with insecticides, applying Admire 2 F (20 fl oz/A) over the planted rows with Strategy on 22 Jun and Asana XL (9.6 fl oz/A) as a foliar treatment on 16 Jul. To manage Phytophthora fruit and crown rot (*Phytophthora capsici*), Ridomil Gold EC (1 pt/A) was broadcast over the field and incorporated mechanically on 19 Jun, and the field was subsoiled between rows on 25 Jul to improve drainage. The following fungicides were applied to foliage preventively for downy mildew (*Pseudoperonospora cubensis*) and Phytophthora blight (*Phytophthora capsici*): Forum 4.16SC (6 oz/A) on 16 Jul, Ranman 400 SC (2.75 fl oz/A) on 12 Aug and 14 Sep, Acrobat 50 WP (6.4 oz/A) on 19 Aug, and Previcur Flex 6 F (1.2 pt/A) on 30 Aug. Symptoms of neither disease were observed before the end of this experiment. Plots were three 15-ft rows spaced 68 in apart. The plots were 10 ft apart. A randomized complete block design with four replications was used. On 30 Jul, 15-20 old leaves per plot were inspected for powdery mildew symptoms, which revealed that the IPM threshold of one affected leaf out of 50 old leaves (Plant Dis. 80:910-916) had been reached in all plots scouted. The examined leaves were selected then from the oldest third of the foliage based on leaf physiological appearance and position in the canopy. Treatments were started on 31 Jul with subsequent applications made weekly on 7 Aug, 14 Aug, 23 Aug, 29 Aug, and 5 Sep with a tractor-mounted boom sprayer equipped with D5-25 hollow cone nozzles spaced 17 in. apart that delivered 86 gal/A at 100 psi. Upper and lower surfaces of 15 old leaves per plot were examined to assess powdery mildew severity on 6 and 13 Aug. Eight old leaves, mid-aged leaves, and young leaves were assessed in each plot on 20 and 27 Aug. Five leaves of each age group were rated on 4 Sep. Mid-aged to young leaves were examined on 13 Sep, as most old leaves had senesced then. Powdery mildew colonies were counted; severity was assessed by visual estimation of percent leaf area infected when colonies could not be counted accurately because they had coalesced and/or were too numerous. Average severity for the entire canopy was calculated from the individual leaf assessments. A square root transformation was used when needed prior to analysis to achieve homogeneity of variance. Canopy condition including defoliation was assessed on 29 Aug and 12 Sep. Fruit quality was evaluated in terms of handle (peduncle) condition for mature fruit without rot on 25 Sep and on 2, 9, 16, and 24 Oct. Handles were considered good if they were green, solid, and not rotting. Mature fruit were harvested and weighed when the handle had rotted. All remaining fruit were weighed on 24 Oct. Fungicide sensitivity of pathogen strains in the experiment was examined by conducting an in-field seedling bioassay and by testing isolates in the laboratory. The seedling bioassay was conducted on 26 Jul in a nearby experiment where powdery mildew had already started to develop to determine resistance frequency at LIHREC before fungicide treatments were started. The assay was conducted in plots treated with Pristine, Procure, Quintec, and Endura on 13 Aug and 9 Sep. These fungicides at several concentrations were applied with a backpack CO_2 pressurized sprayer to pumpkin seedlings in the greenhouse. The next day these plus nontreated seedlings were placed in the plots for about 4 hours. Afterwards they were maintained in a greenhouse for 7 to 10 days, and then powdery mildew severity was assessed. Additionally isolates were collected for fungicide sensitivity testing on 18 Sep from nontreated plots and plots treated with Pristine, Procure, Quintec, or Endura. Their sensitivity to fungicides was assessed using a leaf disk bioassay (Plant Dis. 80:633-639). Isolates able to grow and sporulate on leaf tissue treated with 50 ppm trifloxystrobin (a.i. in Flint 50 WDG) were considered resistant to QoIs and those tolerating 40 ppm myclobutanil (a.i. in Nova 40 WP) were considered moderately resistant to DMIs. Resistance to QoIs is qualitative, thus resistant strains are completely resistant and only one concentration is needed in the assay to characterize resistant strains. Whereas resistance is quantitative to DMIs, and likely also to the other at-risk fungicides, thus multiple concentrations are used in assays and field efficacy data is needed along with assay results to identify dose tolerated by a resistant strain. Strains tolerating 40 ppm myclobutanil are resistant to the old DMI Bayleton. Average monthly high and low temperatures (°F) were 79/61 in Jun, 82/66 in Jul, 82/65 in Aug, 77/60 in Sep, and 70/56 in Oct. Rainfall (in.) was 3.37, 3.63, 2.60, 1.51, and 1.84 for these months, respectively.

Powdery mildew was first seen on 30 Jul on 48% of leaves examined (average of 10.5 colonies per symptomatic leaf). All treatments suppressed powdery mildew on upper leaf surfaces. V-10118, the Fungicide Program, and Quintec 2.08 SC were the most effective based on AUDPC values for both upper and lower leaf surfaces. Genica BP 300, a product containing liquid concentrate derived from the microbial digestion of food waste, did not control powdery mildew on lower surfaces. The biopesticide Polyoxin provided good control on upper leaf surfaces, which was not significantly different from that obtained with Procure and Pristine, two widely-used conventional products tested. There were no significant differences between the two rates of Procure and Pristine evaluated, which are the intermediate and highest label rates. The pathogen has exhibited reduced sensitivity to DMI fungicides (FRAC Group 3) and to boscalid (Group 7), the active ingredients in these fungicides, respectively; thus there was concern that the intermediate rates might no longer be as effective as the highest label rates. Endura was as effective as Pristine, as occurred in 2005 and 2006. This confirms that boscalid, the common active ingredient in these products, is the effective component in Pristine. The seedling bioassay performed on 26 Jul before fungicides were applied revealed that most of the pathogen population was resistant to Group 11 fungicides. Thus it is not surprising that pyraclostrobin, the other component in Pristine, was not contributing to control. Most of the pathogen population also was moderately resistant to DMIs. Some powdery mildew developed on seedlings treated with 120 ppm myclobutanil, 175 ppm boscalid, the highest concentration tested, but not on 5 ppm quinoxyfen the active ingredient in Quintec (Group 13). Strains were detected in subsequent assays able to tolerate 5 ppm quinoxyfen. The highest concentrations tolerated by individual isolates tested with the leaf disk bioassay were 80 ppm myclobutanil, 125 ppm boscalid, and 15 ppm quinoxyfen. Degree of control of powdery mildew was inversely related to defoliation and directly related to fruit quality in terms of handle condition. There were no significant differences among treatments in number of fruit per plot or average weight of fruit.

Treatment and rate/A[y]	Powdery mildew severity (%) [z]						Defoliation	Good handles
	Upper leaf surface			Lower leaf surface				
	13-Aug	4-Sep	AUDPC	13-Aug	4-Sep	AUDPC	12-Sep	16-Oct
Fungicide program [x]……..	0.03 e [w]	1.8 ef	50 ef	0.12 ef	11.5 f	297 g	19.4 efg	63.4 a
Quintec 2.08 SC 4 fl oz ……	0.35 bcde	2.3 def	87 def	0.68 cdef	13.4 f	279 g	12.2 g	51.2 a
V-10118 0.41 EC 9.4 fl oz …	0.04 e	1.1 f	32 f	0.09 f	18.4 ef	377 fg	14.4 fg	59.8 a
A16001A 20 fl oz (wks 1,2,4,5); Bravo (3,6) [v]……	0.06 de	3.3 cdef	119 cde	0.27 ef	33.4 cde	806 cde	51.6 abcd	43.8 ab
A7402 7 fl oz (wks 1,2,4,5); Bravo 1.8 lb (3,6)[v] …..…..	0.10 de	6.5 c	154 cd	0.48 def	42.7 bcd	977 bcd	24.2 defg	50.3 ab
Procure 480 SC 6 fl oz ……	0.94 bcd	7.6 bc	157 cd	1.14 bcde	22.7 ef	368 fg	12.7 g	53.6 a
Procure 480 SC 8 fl oz ……	0.71 bcde	4.2 cde	129 cd	0.96 bcdef	13.6 f	324 g	29.6 cdefg	49.7 ab
Pristine 38 WG 14.5 oz ……	1.23 bc	5.5 cd	177 cd	1.94 abcd	30.7 de	694 de	24.6 cdefg	47.9 ab
Pristine 38 WG 18.5 oz ……	0.29 cde	4.4 cde	112 cde	0.54 cdef	29.1 de	615 e	37.8 bcdef	56.8 a
Endura 70W 6.66 oz …….	0.50 bcde	6.8 c	190 c	0.69 cdef	25.5 ef	581 ef	23.0 defg	50.0 ab
Polyoxin 2.5% 28. oz ……	1.36 bc	5.4 cd	188 c	2.59 ab	47.3 bc	1066 bc	55.4 abc	27.1 bc
Polyoxin 2.5% 71. oz ……	0.37 bcde	5.6 cd	158 cd	0.48 def	49.6 b	989 bcd	46.1 bcde	27.0 bc
Genica BP 300[u] ……	1.63 b	13.6 b	531 b	2.20 abc	54.3 ab	1226 ab	64.6 ab	18.3 c
Nontreated control ……	5.35 a	40.6 a	1317 a	3.48 a	66.8 a	1453 a	88.5 a	13.1 c
P-value	<0.0001	<0.0001	0.0001	0.0024	<0.0001	0.0001	0.0002	0.0008

[z] Exact colony counts were made when possible and severity was estimated using the conversion factor of 30 colonies/leaf = 1%. Severity data is for old leaves on 16 Aug and mid-aged plus young leaves on 13 Sep. AUDPC was calculated for 10 Aug to 13 Sep.

[y] Rate of formulated product/A. All treatments were on an IPM schedule with threshold of 1 affected leaf out of 50 older leaves. Application dates were 31 Jul, 7 Aug, 14 Aug, 23 Aug, 29 Aug, and 5 Sep.

[x] Fungicide program consisted of Microthiol Disperss 4 lb/A (applied on weeks 1-6), Quintec 2.08 SC 4 fl oz/A (weeks 1, 4), Procure 480 SC 6 fl oz/A (weeks 2, 5), Pristine 38 WG 18.5 oz/A (weeks 3, 6).

[w] Numbers in each column with a letter in common are not significantly different according to Fisher's Protected LSD ($P = 0.05$).

[v] Experimental fungicide applied on 31 Jul, 7 Aug, 23 Aug, and 29 Aug. Bravo Ultrex (1.8 lb/A) applied on 14 Aug and 5 Sep.

[u] Applied with nuFilm P at 6 oz/100 gal.