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

M. T. McGrath and G. M. Fox
Dept of Plant Pathology & Plant-Microbe Biology
Cornell University, LIHREC
3059 Sound Avenue, Riverhead, NY 11901

**Efficacy of fungicides for managing cucurbit powdery mildew and treatment impact on pathogen sensitivity to fungicides, 2009.**

The primary objective of this study was to evaluate the efficacy of several individual fungicides and fungicide alternations for the control of cucurbit powdery mildew. Both new and currently registered products were tested in an area where in previous years strains of the pathogen with QoI resistance and moderate DMI resistance were detected before fungicide use. The field experiment was conducted at the Long Island Horticultural Research and Extension Center on Haven loam soil. The field was plowed on 10 May and tilled on 11 Jun. Seeds were planted at approximately 24-in. plant spacing within rows with a vacuum seeder on 16 Jun. The planter applied fertilizer in a band about 2 in. away from the seed. A blend of controlled release fertilizers, consisting of 300 lb/A 15-18-12 and 100 lb/A ESN, was used. The herbicides Strategy (3 pt/A) and Sandea (0.5 oz/A) were applied over the entire plot area on 17 Jun, which was followed by 1.1 inches of rain. During the season, weeds were controlled by cultivating, roto-tilling between plots, and hand weeding as needed. Red clover at 10 lb/A was planted with a grain drill to establish driveways on 12 Jul. Cucumber beetles were managed by applying the insecticide Admire 2 F (20 fl oz/A) in a narrow band over the planted rows immediately after the herbicide application on 17 Jun and applying Asana XL (9.6 fl oz/A) to foliage on 1 Jul. To manage damping-off, Ridomil Gold EC (1 pt/A) was broadcast over the field and incorporated mechanically on 10 Jun. A soil penetrant to increase water penetration, SprayHandler (0.5 pt/A), was applied with Ridomil. The following fungicides were applied to foliage preventively for downy mildew (*Pseudoperonospora cubensis*) and Phytophthora blight (*Phytophthora capsici*): ProPhyt (4 pts/A) on 24 Jun; Forum 4.16SC (6 oz/A) on 27 Jul, 8 Aug, 27 Aug, 13 Sep, and 24 Sep; and Ranman 400 SC (2.75 fl oz/A) on 17 Jul, 1 Aug, 16 Aug, 4 Sep, 18 Sep, 1 Oct. Plots were three 15-ft rows spaced 68 in apart. The plots were 18 ft apart initially until plants began to vine. Vines were moved as needed to maintain plot separation. A randomized complete block design with four replications was used. Plots were inspected for powdery mildew symptoms on upper and lower leaf surfaces weekly beginning on 23 Jul. Initially the examined leaves were selected from the oldest third of the foliage based on leaf physiological appearance and position in the canopy. Additional powdery mildew assessments were made on 31 Jul; 4, 14, 21, and 28 Aug; and 4 and 8 Sep. Ten leaves per age group were examined in plots. Mid-aged leaves were also assessed beginning on 14 Aug and young leaves on 4 Sep. 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 17 and 24 Sep. Fruit quality was evaluated in terms of handle (peduncle) condition for mature fruit without rot on 30 Sep; and 6, 14, 20, and 26 Oct. Handles were considered good if they were green, solid, and not rotting. Treatments were started on 12 Aug when the IPM threshold of one affected leaf out of 50 old leaves (Plant Dis. 80:910-916) was suspected to have been reached in most plots; this was confirmed on 14 Aug. Subsequent applications were made weekly on 19 Aug, 26 Aug, 2 Sep, and 9 Sep using a tractor-mounted boom sprayer equipped with D5-25 hollow cone nozzles spaced 17 in. apart that delivered 96 gal/A at 100 psi. Fungicide sensitivity of pathogen strains in the experiment was examined by conducting an in-field seedling bioassay and by testing isolates in the laboratory on treated leaf disks. For the bioassay, pumpkin seedlings were produced in a growth chamber and then greenhouse, treated with various doses of different fungicides applied with a $CO_2$-pressurized backpack sprayer, then next day put in the field for at least 4 hours, then kept in a greenhouse for about 10 days until mildew developed. Severity of powdery mildew on leaves of treated seedlings was compared to non-treated ones to estimate the proportion of the pathogen population able to tolerate each fungicide dose tested. The bioassay was conducted on 30 Jul in a nearby experiment where powdery mildew had already started to develop to determine resistance frequency at LIHREC before fungicide treatments for powdery mildew were started. The assay was conducted on 24 Sep in plots that had been treated weekly with Pristine, Procure or Quintec and in a near-by experiment where a fungicide program with these fungicides was applied to the same pumpkin cultivar. Isolates were collected on 30 Sep from several plots. 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 (FRAC code 11) and those tolerating 40 ppm myclobutanil (a.i. in Nova 40 WP) were considered moderately resistant to DMIs (FRAC code 3). 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. Strains tolerating 40 ppm myclobutanil are resistant to the old DMI Bayleton. Average monthly high and low temperatures ($^oF$) were 73/58 in Jun, 80/64 in Jul, 83/68 in Aug, 74/58 in Sep, and 62/47 in Oct. Rainfall (in.) was 6.43, 4.82, 2.01, 2.39, and 5.78 for these months, respectively.

Powdery mildew was first observed on 31 Jul on 3% of leaves examined. All treatments suppressed powdery mildew on upper leaf surfaces (82-100% control based on AUDPC values). The most effective treatments were the 2 experimental formulations, Quintec, and the two fungicide programs (86-94% control based on AUDPC values). Rally and Inspire were ineffective on lower surfaces based on AUDPC values. However, ineffectiveness of Rally did not affect the efficacy of the fungicide program that included two applications of Rally. In contrast with previous experiments, degree of control of powdery mildew was not closely related to defoliation and fruit quality expressed as handle condition. Based on the results of the 30 Jul bioassay conducted in an adjacent experiment, which was before use of fungicides targeting powdery mildew that are at-risk for resistance development, 69% of the *Podosphaera xanthii* population was QoI resistant, 31% tolerated 80 ppm triflumizole (a.i. in Procure), 15% tolerated 175 ppm boscalid (an a.i. in Pristine), and 5% tolerated 10 ppm quinoxyfen (Quintec). The 24 Sep bioassay documented that using Pristine alone can result in greater selection of boscalid-resistant strains than using a fungicide program: 100% of the population was estimated to be resistant to boscalid (able to tolerate 500 ppm) after 5 applications, while 17% of the population was resistant where a fungicide program was used, and less than 1% of the population in plots treated weekly with Procure or Quintec. The increase in proportion of boscalid resistant strains occurred slowly enough that control of powdery mildew did not appear to be compromised. Sensitivity to the other fungicides did not vary much among the populations. Proportion tolerating 40 ppm triflumizole was 36% for the Procure plot and 12-19% for the other treatments. Proportion tolerating 10 ppm quinoxyfen was 1% for the Quintec plot and 0.1-1% for the other treatments. Boscalid resistance was only detected in isolates collected from plots treated weekly with Pristine.

| Treatment and rate/A (application dates) [y] | Powdery mildew severity (%) [z] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Upper leaf surface | | | | Lower leaf surface | | | | Defoliation | | Good handles (%) | |
| | 4-Sep | | AUDPC | | 4-Sep | | AUDPC | | 24-Sep | | 30-Sep | 6-Oct |
| Nontreated control …….. | 52.6 | a [x] | 682.0 | a | 60.5 | a | 789.0 | a | 93.8 | a | 24.6 b | 23.4 c |
| Rally 40WSP 5 oz (1-5) ……. | 12.1 | b | 122.8 | b | 44.5 | ab | 497.1 | ab | 66.3 | bc | 67.4 a | 61.4 c |
| Inspire 20 fl oz (1-5) ……. | 3.8 | bc | 35.5 | bc | 44.2 | ab | 473.9 | abc | 88.8 | ab | 63.6 a | 38.9 bc |
| Pristine 38 WG 18.5 oz (1-5) …… | 0.9 | c | 13.5 | c | 25.8 | ab c | 216.9 | bc d | 70.0 | abc | 91.3 a | 82.8 a ab |
| Procure 8 fl oz (1-5) ……. | 1.5 | c | 16.9 | c | 20.8 | c | 161.2 | cd | 67.5 | bc | 75.0 a | 62.0 c |
| USF2017B 4.8 oz (1-5) …… | 0.6 | c | 7.5 | c | 11.8 | bc | 113.7 | d | 76.3 | abc | 88.7 a | 75.4 ab |
| Quintec 6 fl oz (1-5) ……. | 0.1 | c | 6.7 | c | 7.8 | c | 112.8 | d | 67.5 | bc | 77.3 a | 62.4 ab c |
| USF2015A 3.0 oz (1-5) …… | 0.0 | c | 0.9 | c | 10.4 | c | 79.1 | d | 63.8 | c | 88.3 a | 60.0 ab c |
| Microthiol Disperss 4 lb (1-5), Quintec (1,2,5), Rally (3,4) …… | 0.2 | c | 7.3 | c | 7.7 | c | 70.1 | d | 67.5 | bc | 86.1 a | 57.6 c |
| Procure + Microthiol Disperss (1,3,5) alt Pristine + Bravo Ultrex 2.7 lb (2,4) ……..…. | 0.4 | c | 5.0 | c | 3.6 | c | 50.2 | d | 66.3 | bc | 85.7 a | 73.8 ab |
| *P*-value (treatment) | <.0001 | | <.0001 | | <.0001 | | <.0001 | | 0.0017 | | <.0001 | 0.0018 |

[z] Exact colony counts were made when possible and severity was estimated using the conversion factor of 30 colonies/leaf = 1%. AUDPC was calculated for 4 Aug to 8 Sep. Data were transformed from percentages by a square root transformation when needed to obtain normality of variance before analysis of variance was performed. The table has de-transformed means.

[y] Rate of formulated product/A. Where rate not noted it was the same as for other treatments. All treatments were started after disease detection. Application dates were 1=14 Aug, 2=19 Aug, 3=26 Aug, 4=2 Sep, and 5=9 Sep.

[x] Numbers in each column with a letter in common are not significantly different according to Tukey's HSD ($P = 0.05$).