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Efficacy of fungicides for managing cucurbit powdery mildew and treatment impact on pathogen sensitivity to fungicides, 2008.

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 20 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 areas on 22 Jun followed by 0.5 inches of overhead irrigation used for activation. During the season, subsequent 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 22 Jun and applying Asana XL (9.6 fl oz/A) to foliage on 31 Jul, 14 Aug, and 21 Aug. 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): Ranman 400 SC (2.75 fl oz/A) on 20 Jul, 14 Aug, 21 Aug, 30 Aug, and 21 Sep; Forum 4.16SC (6 oz/A) on 5 Aug, 12 Sep, and 24 Sep; and Curzate 60 DF (3.2 oz/A) on 31 Jul. Kocide 3000 (1-1.25 lb/A) was applied for bacterial leaf spot on 5 Aug and 12 Sep. Plots were three 15-ft rows spaced 68 in apart. The plots were 18 ft apart. A randomized complete block design with four replications was used. Plots were inspected for powdery mildew symptoms weekly beginning on 22 Jul. Initially 50 older leaves were examined per plot. The examined leaves were selected from the oldest third of the foliage based on leaf physiological appearance and position in the canopy. On 30 Jul the IPM threshold of one affected leaf out of 50 old leaves (Plant Dis. 80:910-916) was found to have been reached in most plots (50 of 64). Treatments were started on 30 Jul with subsequent applications made weekly on 5, 13, 19, and 27 Aug, 5 Sep, and 11 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. Additional powdery mildew assessments were made on 4, 11, 18, and 26 Aug; 2 Sep and 13 Sep on upper and lower leaf surfaces. Starting on 11 Aug, fewer than 50 leaves were examined in plots with a high percentage of symptomatic leaves. Mid-aged leaves were also assessed beginning on 18 Aug and young leaves on 28 Aug. Five leaves of each age group were rated starting on 2 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 30 Sep, 8 Oct, and 23 Oct. Handles were considered good if they were green, solid, and not rotting. 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 CO2-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 18 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 13 Aug in a nontreated section of the field beyond where the experiment being reported was conducted. Isolates were collected on 18 Aug from nontreated plants in part of the field not used for experiments and on 16 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 (°F) were 80/63 in Jun, 84/67 in Jul, 79/63 in Aug, 75/61 in Sep, and 63/47 in Oct. Rainfall (in.) was 3.88, 3.67, 3.76, 8.34, and 3.18 for these months, respectively.

Powdery mildew was first observed on 22 Jul on 0.7% of leaves examined. Treatments were started on 30 Jul when powdery mildew infection had reached the IPM threshold in most plots (50 of 64 plots; 6% of leaves). All treatments suppressed powdery mildew on both leaf surfaces. Differences in efficacy were mostly evident on lower leaf surfaces. Quintec applied weekly at the lowest label rate was the most effective treatment, providing 100% and 99% control on upper and lower leaf surfaces, respectively, based on AUDPC values. This is not a labeled use pattern. Similar control was achieved with labeled use patterns consisting of Quintec alternated with Procure or Rally, following a simple or 2-spray block alternation. The Quintec treatment with Rally also included sulfur each week, and thus had both components of a recommended fungicide resistance management program (alternation of at-risk fungicides tank-mixed with a protectant fungicide). This treatment started with sulfur alone thus there was one less spray of a mobile fungicide. Procure or Quintec alternated with LEM17 was numerically but not significantly less effective than the treatments with Quintec and Procure. Procure at 8 fl oz, the highest label rate, was significantly more effective than Inspire Super at the low rate tested but not the high rate. Pristine at 18.5 oz, the highest label rate, was not significantly more effective than LEM17 at either rate tested. Quadris Top was the least effective treatment, but it did not differ significantly from QFA61, Inspire Super at the low rate, or LEM17 at the low rate. The QoI component of Quadris Top and Pristine likely contributed little to control considering that 60% of the isolates collected on 18 Aug and 92% of those collected on 16 Sep were QoI-resistant. None of the 18 Aug isolates or 16 Sep isolates from nontreated plots tolerated 80 ppm myclobutanil (active ingredient in Rally) or 125 ppm boscalid (an active ingredient in Pristine). In contrast, 80% of the 16 Sep isolates from plots treated with Pristine or LEM17 alone tolerated 125 ppm boscalid, and 50% of the 16 Sep isolates from plots treated with Procure alone tolerated 80

ppm myclobutanil (both are FRAC code 3 fungicides). Fungicide use during a growing season appears to be selecting for less sensitive isolates. Dose in the spray tank for these treatments applied at 96 gpa was 156 ppm myclobutanil, 274 ppm triflumizole (ai in Procure), and 364 ppm boscalid. Degree of control of powdery mildew was inversely related to defoliation and directly related to fruit quality in terms of handle condition. No significant differences were detected among treatments in number of good or rotting fruit.

| _ | Powdery mildew severity (%) ^z | | | | | | | | | | | | | |
|----------------------------------|--|----------------|----------|----|--------------------|-------|--------|-----|--------|------|------------------|------|--------|----|
| Treatment and rate/A | Upper leaf surface | | | | Lower leaf surface | | | | | | Good handles (%) | | | |
| (application dates) ^y | 26-Aug | | AUDPC | | 26-Aug | | 2-Sep | | AUDPC | | 30-Sep | | 8-Oct | |
| Nontreated | 25.3307 | a ^x | 310.5 | а | 41.26 | а | 51.4 | а | 507.6 | а | 75.7 | а | 66.4 | а |
| Quadris Top 10 fl oz | 3.0255 | b | 35.3 | b | 11.12 | b | 21.8 | b | 169.3 | b | 79.9 | ab | 76.3 | ab |
| QFA61 34 fl oz | 0.2218 | с | 3.0 | с | 4.99 | cde | 16.0 | bcd | 98.0 | bcd | 94.4 | cde | 87.5 | cd |
| Pristine 38 WG 18.5 oz | 0.0530 | c | 1.6 | с | 1.89 | defgh | 4.0 | de | 31.3 | defg | 98.5 | defg | 89.2 | cd |
| LEM17 16.8 fl oz | 0.6225 | с | 17.2 | bc | 5.23 | cd | 12.9 | bcd | 91.6 | bcde | 96.2 | cdef | 89.0 | cd |
| | | | | | | | | bcd | | | | cdef | | |
| LEM17 24 fl oz | 0.1045 | с | 2.2 | с | 3.87 | cdef | 7.4 | e | 58.5 | cdef | 96.6 | g | 89.2 | cd |
| Inspire Super 14 fl oz | 0.2115 | с | 4.2 | c | 8.13 | bc | 20.4 | bc | 139.1 | bc | 91.1 | bc | 74.9 | а |
| | | | | | | | | bcd | | | | | | |
| Inspire Super 20 fl oz | 0.4195 | с | 4.4 | с | 4.36 | cde | 6.9 | e | 61.9 | cdef | 95.4 | cdef | 86.2 | bc |
| Procure 480 SC 8 fl oz | 0.1409 | с | 3.4 | с | 2.06 | defgh | 5.1 | cde | 35.9 | defg | 93.3 | cd | 86.4 | bc |
| Procure 480 SC 8 fl oz alt | | | | | | | | bcd | | | | | | |
| LEM17 16.8 fl oz | 0.3413 | с | 4.1 | с | 2.65 | defg | 5.7 | e | 42.2 | defg | 96.2 | cdef | 89.2 | cd |
| LEM17 16.8 fl oz alt | | | | | | | | bcd | | | | | | |
| Quintec 2.08 SC 4 fl oz | 0.1713 | с | 14.0 | bc | 1.50 | efghi | 8.3 | e | 47.8 | defg | 99.9 | g | 97.4 | d |
| Quintec 2.08 SC 4 fl oz | 0.0166 | с | 0.7 | с | 0.37 | hi | 1.0 | e | 6.6 | g | 99.3 | efg | 89.2 | cd |
| Procure 480 SC 8 fl oz alt | | | | | | | | | | - | | - | | |
| Quintec 2.08 SC 4 fl oz | 0.2615 | с | 4.0 | с | 0.76 | ghi | 1.2 | e | 10.8 | fg | 98.6 | defg | 90.1 | cd |
| Quintec 2.08 SC 4 fl oz | | | | | | C | | | | C | | U | | |
| (1,2,5,6), Procure 480 | | | | | | | | | | | | | | |
| SC 8 fl oz (3,4,7) | 0.0447 | с | 1.5 | с | 0.68 | ghi | 1.6 | e | 11.7 | fg | 99.4 | fg | 89.7 | cd |
| Quintec 2.08 SC 4 fl oz + | | | | | | | | | | | | | | |
| Procure 480 SC 8 fl oz | 0.0007 | с | 9.0 | bc | 0.05 | i | 5.5 | cde | 21.0 | fg | 98.4 | defg | 93.3 | cd |
| Microthiol Disperss 4 lb | | | | | | | | | | | | | | |
| (1-7), Quintec 2.08 SC | | | | | | | | | | | | | | |
| 4 fl oz (2,4,6), Rally | | | | | | | | | | | | cdef | | |
| 40WSP 4 oz (3,5,7) | 0.1372 | с | 4.8 | с | 1.06 | fghi | 4.5 | de | 25.8 | efg | 97.0 | g | 87.9 | cd |
| <i>P</i> -value (treatment) | < 0.0001 | | < 0.0001 | | < 0.0001 | | 0.0002 | | <.0001 | | <.0001 | | 0.0002 | |

^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 30 Jul to 2 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. All treatments were on an IPM schedule with threshold of 1 affected leaf out of 50 older leaves. Application dates were 1=30 Jul, 2=5 Aug, 3=13 Aug, 4=19 Aug, 5=27 Aug, 6=5 Sep, and 7=Sep 11. Where not noted, treatment applied on all dates.

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