CUCUMBER, SLICER (*Cucumis sativus,* 'Marketmore 76')
Downy mildew; *Pseudoperonospora cubensis*

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**Efficacy of biopesticides applied alone or alternated with copper for managing downy mildew in cucumber, 2022.**

A field experiment was conducted at the Long Island Horticultural Research and Extension Center (LIHREC) in Riverhead, NY, on Haven loam soil. The main objective was to evaluate recently developed biopesticides suitable for organic production for their control of downy mildew. Phytophthora blight, caused by *Phytophthora capsici*, was managed through biofumigation and weekly applications of targeted fungicides on a preventive schedule. The field was moldboard plowed, urea fertilizer (46-0-0) was applied at 80 lb/A N, then mustard biofumigant cover crop cv. Rojo Caliente was seeded at 10 lb/A by drilling on 23 Mar. On 8 Jun the mustard was flail chopped and immediately incorporated by disking, and followed by a cultipacker to seal the soil surface. The field could not be irrigated to initiate biofumigation as recommended and usually done, but the soil was moist. Controlled-release fertilizer (N-P-K, 19-10-9) at 525 lb/A (101 lb/A N) was broadcast over the bed area and incorporated on 5 Jul. Strategy 3 pt/A, Sandea 0.5 oz/A, and Curbit EC 1 pt/A were applied for weed control on 13 Jul using a tractor-mounted sprayer. The following fungicides were applied to foliage to manage Phytophthora blight: Revus 8 fl oz/A applied on 14 and 26 Jul, and Presidio 4 fl oz/A applied on 19 Jul and 2 Aug. They were selected because they were ineffective for downy mildew in recent seedling bioassays assumed due to fungicide resistance in *Pseudoperonospora cubensis* (PDMR 16:V103). No foliar or fruit symptoms of *P. capsici* were seen. Beds were formed with drip tape and covered with black plastic mulch on 12 Jul. Seeds were sown on 27 Jun in the greenhouse. A waterwheel transplanter was used to make planting holes in the beds and apply starter fertilizer (9-18-9). All plants were placed outdoors to harden for a few days and then transplanted by hand into the holes in the beds on 14 Jul. During the season, water was provided as needed via drip irrigation lines. Weeds were managed between the mulched beds by covering the soil with landscape cloth and by hand weeding. The primary source of initial inoculum of *Pseudoperonospora cubensis* in this area is long-distance wind-dispersed spores from affected plants. Plots were single 18-ft rows with nine plants at 2-ft spacing. Rows were 4 ft apart. The plots were 6 ft apart within the row initially until plants began to vine partly filling the area. Vines were moved as needed to maintain plot separation. A randomized complete block design with four replications was used. Treatments were applied seven times on a weekly schedule beginning on 20 Jul using a backpack boom sprayer equipped with one TwinJet (TJ60-8004VS) nozzle that delivered 30.4 gal/A at 55 psi and 2.35 mph. For the last four applications, two passes were made treating each plot side separately because plants had grown too large to obtain complete coverage with one pass. The third application was re-applied two days later due to heavy rain within 6 hours of applying the treatments on 2 Aug. The sixth application had to be delayed one day due to heavy rain earlier in the week. Downy mildew severity was assessed weekly from 22 Jul through 7 Sep by estimating incidence of symptomatic leaves in each plot and rating severity on nine representative affected leaves. Canopy severity was calculated by multiplying incidence by average severity. Values of the area under the disease progress curve (AUDPC) were calculated from 25 Jul through 7 Sep using the formula: $\sum n_{i=1}[(R_{i+1} + R_i)/2]\ [t_{i+1} - t_i]$, where R = disease severity rating (% of leaf surface with symptoms) at the *i*th observation, $t_i$ = time (days) since the previous rating at the *i*th observation, and n = total number of observations. Defoliation, which was due to downy mildew, was assessed on 1 and 7 Sep. Fruit were harvested and counted when time permitted (11, 18, and 26 Aug and 1 and 8 Sep), rather than more frequently as fruit reached marketable size, because experiment focus was disease control. Misshapen fruits, but not over-sized fruits, were considered unmarketable. Average monthly high and low temperatures (°F) were 85.3 and 68.9 in Jul, 85.4 and 68.7 in Aug, and 76.3 and 60.3 in Sep. Rainfall (in.) was 4.1, 2, and 4.3 for these months, respectively. Data was analyzed with one-way ANOVA and Tukey's HSD to separate means using JMP statistical software.

Symptoms of downy mildew were first observed on one leaf in each of four plots on 5 Aug, which was 16 days after the first application, and were seen on one to three leaves in 13 plots on 8 Aug. The first two applications were preventive because no symptoms were seen. Incidence of leaves with symptoms remained very low through the fifth application (average treatment incidence on 18 Aug ranged from 0.5 to 2%; data not shown). Incidence ranged from 0.5% to 21% in untreated control on 23 Aug. Trillium was the only biopesticide treatment that significantly reduced AUDPC for incidence of leaves with symptoms, which was 932 compared to 1142 for the control (data not shown). Kocide 3000-O, an organic copper included as a non-biopesticide organic standard for comparison, was also effective based on this variable (959). The integrated program with a biopesticide (Serifel) applied in block alternation with targeted fungicides was the only treatment that provided meaningful control: 34% based on AUDPC for incidence of leaves with symptoms and 60% based on AUDPC values for canopy severity. It was the only treatment with significantly less defoliation and significantly greater yield than the untreated control. All treatments had numerically less defoliation than the untreated control except Kocide 3000-O. No phytotoxicity was seen. Photographs are posted at https://blogs.cornell.edu/livegpath/research/organic-disease-management/organic-disease-management-downy-mildew-in-cucurbit-crops/.

| Treatment and rate (application dates) [y] | Canopy severity (%) [z] | | | | Defoliation (%) [z] | Fruit/plant [z] | |
|---|---|---|---|---|---|---|---|
| | 23 Aug [x] | 1 Sep | 7 Sep | AUDPC | 1 Sep [x] | No. | Marketable (%) |
| Untreated control | 1.5 a | 71 a | 29 | 630 a | 42.4 ab | 15.8 b | 73.5 |
| Stargus 87 fl oz + Regalia 63 fl oz (1-7) | 1.4 ab | 68 a | 23 | 590 a | 3.7 bc | 16.8 ab | 74.6 |
| Serifel 10 oz (1-7) [w] | 0.7 abc | 64 a | 12 | 524 a | 27.0 abc | 16.3 b | 76.4 |
| Theia 3 lb (1-7) [w] | 0.7 abc | 63 a | 23 | 553 a | 23.0 abc | 16.5 b | 72.4 |
| Trillium 1% (1-7) | 0.1 c | 50 ab | 17 | 429 ab | 8.7 abc | 19.7 ab | 73.4 |
| Trillium 1% (1, 3, 5, 7); Kocide 3000-O 1.25 lb (2, 4, 6) | 0.1 bc | 56 ab | 38 | 539 a | 15.4 abc | 18.8 ab | 75.3 |
| Stargus 87 fl oz + Regalia 63 fl oz (1, 3, 5, 7); Kocide 3000-O 1.25 lb (2, 4, 6) | 0.1 c | 54 ab | 31 | 497 a | 12.0 abc | 17.0 ab | 74.0 |
| Kocide 3000-O 1.25 lb (1-7) | 0.2 abc | 49 ab | 18 | 419 ab | 49.9 a | 20.9 ab | 70.1 |
| Serifel 10 oz (1, 2, 6, 7) [w]; Ranman 2.1 fl oz (3, 5) [w]; Orondis Ultra 8 fl oz (4) [w] | 0.0 c | 25 b | 22 | 251 b | 0.5 c | 22.0 a | 70.1 |
| *P-value (treatment)* | 0.0005 | 0.0027 | 0.703 | 0.0004 | 0.0031 | 0.0045 | 0.4478 |

[z] Numbers in each column with a letter in common or no letters are not significantly different from each other (Tukey's HSD, P=0.05).

[y] Rate of formulated product/A unless otherwise noted. Application dates were 1=20 Jul, 2=26 Jul, 3=2 and 4 Aug, 4=9 Aug, 5=15 Aug, 6=24 Aug, and 7=30 Aug.

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

[w] Treatment applied with the nonionic surfactant Dyne-Amic at 0.38% v/v.