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

M. T. McGrath and C. T. Downing
Plant Pathology & Plant-Microbe Biology Section
SIPS, Cornell University, LIHREC
3059 Sound Avenue, Riverhead, NY 11901

Efficacy of fungicide programs with a biopesticide and conventional fungicides 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. One objective was to evaluate programs with a biopesticide (Theia) applied in place of conventional fungicides for some applications. There were six treatments with only conventional fungicides. 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. The herbicides 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 and 15 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 infected 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 eight times on a 7-day schedule beginning on 20 Jul using a backpack boom sprayer equipped with one TwinJet (TJ60-8004VS) nozzle that delivered 30.2 gal/A at 55 psi and 2.37 mph. For the last five applications, two passes were made treating each plot side separately because plants had grown too large to obtain complete coverage with one pass. The sixth and last applications had to be delayed one day due to heavy rain earlier in the week. Severity of downy mildew was assessed weekly from 22 Jul through 19 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. The values of the area under disease progress curve (AUDPC) were calculated from 25 Jul through 19 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 was assessed by estimating the percent of foliage lost due to downy mildew on 13 and 19 Sep. Fruits were harvested and counted when time permitted (12, 19, and 26 Aug; and 1-2, 9, and 19 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 (ºF) 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 in this experiment on one to five leaves in eight of the 36 plots on 8 Aug, which was 19 days after the first application. Symptoms were first observed on 5 Aug in an adjacent cucumber experiment. The first 3 applications were preventive because no symptoms were seen. Applications of conventional fungicides for several treatments were started on 2 Aug because symptoms were found that day in the nearby sentinel plots for monitoring occurrence of cucurbit downy mildew, and there were high risk forecasts for successful spread of the pathogen to Long Island on 25 and 28 Jul, and 2 Aug. All treatments controlled downy mildew by 46 to 99% based on AUDPC values compared to the untreated control. The last assessment was made 12 days after the last application. The most effective treatments were the five with at least four applications of a targeted fungicide for downy mildew (92-99% control). Among those, the numerically most effective treatment was the program with the targeted fungicides Ranman, Orondis Ultra, and Previcur Flex applied in alternation, and the least effective treatment was the one with the experimental (BCS-CS55621) applied on a 14-day schedule with the contact fungicide Bravo Weather Stik applied weekly. The experimental applied weekly was more effective. This documents the importance of mobile fungicides able to move to the lower leaf surface. The fungicide program with a biopesticide and conventional fungicides did not improve control over that achieved with the conventional fungicides applied on the same days. The number of fruit per plant was numerically greater than the control for all treatments, and significantly better for four treatments. There were no significant differences in marketable yield among treatments. No phytotoxicity was observed. Photographs are posted at https://blogs.cornell.edu/livegpath/research/cucurbit-downy-mildew/fungicide-evaluations-biopesticides-in-programs-with-conventional-fungicides-for-cucurbits-downy-mildew/.

Treatment and rate (application dates) [y]	Canopy severity (%) [z, x]				Defoliation (%) [z, x]	Fruit/plant [z]	
	1 Sep	7 Sep	13 Sep	AUDPC	19 Sep	No.	Marketable (%)
Untreated control	30.7 a	63 a	73 a	1289 a	91 a	27.6 c	79
Theia 3 lb (1, 2, 5, 7, 8) [w]; Ranman 2.1 fl oz (3, 6) [w]; Orondis Ultra 8 fl oz (4) [w]	0.3 b	4 c	29 b	288 c	28 bcd	38.1 a	76
Theia 3 lb (1, 2, 6, 7, 8) [w]; Ranman 2.1 fl oz (3, 5) [w]; Orondis Ultra 8 fl oz (4) [w]	0.8 b	27 b	56 a	618 b	60 ab	31.3 abc	81
Ranman 2.1 fl oz (3, 5) [w]; Orondis Ultra 8 fl oz (4) [w]	2.8 b	37 b	53 a	698 b	57 abc	28.7 bc	80
Ranman 2.1 fl oz (3, 6) [w]; Orondis Ultra 8 fl oz (4, 8) [w]; Previcur Flex 1.2 pt (5, 7) [w]	0.0 b	0 d	1 d	11 e	24 cde	37.6 ab	77
BCS-CS55621 13.7 fl oz (1-8) [v]	0.0 b	0 d	1 d	25 de	9 de	35.7 abc	82
BCS-CS55621 13.7 fl oz + Previcur Flex 1.2 pt (1, 2, 4, 6, 8) [v]; Bravo Weather Stik 1.5 pt (3, 5, 7)	0.0 b	2 cd	1 d	24 de	9 de	39.4 a	79
Orondis Ultra 8 fl oz (1, 2, 4, 6, 8) [v]; Bravo Weather Stik 1.5 pt (3, 5, 7)	0.0 b	2 cd	2 d	31 de	6 e	35.6 abc	79
BCS-CS55621 13.7 fl oz (1, 3, 5, 7); Bravo Weather Stik 1.5 pt (1-8)	0.1 b	3 cd	10 c	110 d	11 de	38.8 a	77
P-value (treatment)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0003	0.3351

[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. Application dates were 1=20 Jul, 2=26 Jul, 3=2 Aug, 4=9 Aug, 5=16 Aug, 6=23 Aug, 7=30 Aug, and 8=7 Sep.

[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.

[v] Treatment applied with the nonionic surfactant Induce at 0.12% v/v.