CUCUMBER (*Cucumis sativus* 'Dasher II')
Downy mildew; *Pseudoperonospora cubensis*

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Efficacy of biopesticides for managing downy mildew in organically-produced cucumber, 2009.

The goals of this study were to evaluate biopesticides and fungicides approved for organic production using a cucumber cultivar that has exhibited relatively low susceptibility to downy mildew compared to other cultivars in cucumber evaluations conducted at North Carolina State University since 2005. This integrated approach was taken because downy mildew is considered a difficult disease to manage organically. K-Phite was the only biopesticide evaluated that is not approved for organic production. The biopesticides were compared to an organic standard treatment, the copper fungicide NuCop, and a conventional fungicide program of Manzate Pro-Stick during the vegetative period followed by Bravo during the harvest period. Only protectant fungicides were used for the conventional fungicide standard because the organic fungicides also lack targeted activity and mobility. Most biopesticides were tested alone. Organocide was tested at a low label rate tank-mixed with NuCop at a low label rate. Cucumber was seeded on 17 Jul and transplanted on 29 Jul into beds with black plastic mulch and drip irrigation in a field with Haven loam soil at the Long Island Horticultural Research and Extension Center in Riverhead. A late planting date was used to increase the likelihood of downy mildew developing during the experiment. Organic production practices were used. A blend of Pro-Gro 5-3-4 organic fertilizer at 1000 lb/A plus peanut meal at 625 lb/A was spread on 23 Jul over the rows to be planted and then incorporated by disking before laying plastic mulch. Neptune's Harvest hydrolyzed fish emulsion fertilizer (0.094 fl oz in 6 fl oz water) was poured into the transplant hole before planting. Weeds were controlled by hand weeding. Plots consisted of single 27-ft rows spaced 11 or 17 ft apart with 18 plants at 18-in spacing. The plots were 10 ft apart in the row. A randomized complete block design with four replications was used. Fungicides were applied weekly for 7 weeks beginning on 25 Aug, one day after symptoms were first observed, using a backpack CO_2-pressurized sprayer equipped with an 8002E nozzle that delivered 74 gal/A at 50 psi. It was intended that the treatments be applied on a preventive schedule. Therefore, to obtain some initial suppression of downy mildew, a conventional fungicide with some curative activity but limited residual activity, Curzate 60DF (2.75 oz/A), was applied early on 26 Aug to the entire experiment. Downy mildew severity was assessed on 24 and 31 Aug; 8, 15, and 23 Sep; and 8 Oct by estimating incidence of symptomatic leaves in each plot and rating severity on nine representative affected leaves. Incidence and average severity for symptomatic leaves were used to estimate canopy severity. Marketable fruit and culls were harvested on 5 and 13 Oct. Average monthly high and low temperatures (^{o}F) were 83/68 in Aug, 74/58 in Sep, and 62/47 in Oct. Rainfall (in.) was 2.01, 2.39, and 5.78 for these months, respectively.

Symptoms of downy mildew were first observed in this experiment before expected based on environmental conditions; consequently treatment applications had not begun. Conditions in Aug were warm and dry before 24 Aug when symptoms were first seen. There were only 5 days that rain occurred, and total rainfall was only 0.83 in.: 0.45 in. on 1 Aug, 0.07 in. on 2 Aug, 0.04 in. on 10 Aug, 0.09 in. on 13 Aug. and 0.18 in. on 22 Aug. Downy mildew was uniform in the experiment at disease onset as there were no significant differences at the 24 Aug assessment. Conditions were favorable for downy mildew during the experiment. There were four consecutive days of rain, with a total of 1.18 in., starting 2 days after the first treatment application. Subsequently rain fell on 6 Sep (0.01 in.), 9 Sep (0.05 in.), 11-13 Sep (0.66, 0.17, and 0.14 in.), 16 Sep (0.17 in.), 24 Sep (0.06 in.), 27 Sep (0.97 in.), and 29 Sep (0.16 in.). Six biopesticides controlled downy mildew based on both the 8 Sep and the 23 Sep canopy severity values, providing 43-82% and 26-51% control, respectively: Actinovate, K-Phite, Organocide + NuCop, Sonata, Taegro, and Timorex Gold. These were as effective as the organic standard based on at least one of these assessments. The other three biopesticides were effective based on one of these assessments. K-Phite, Organocide + NuCop, and Sporatec had the lowest severity values at the last three assessments. These treatments provided 39-45% control based on AUDPC, which was as effective as the conventional standard (53% control).

Treatment and rate/A (application dates) [y]	Downy mildew canopy severity (%) [z] 24-Aug	31-Aug	8-Sep	15-Sep	23-Sep	8-Oct	AUDPC
Nontreated …….	0.23	2.53	17.5 ab [w]	43.9	43.2 a	93 a	1651 a
Serenade MAX 3 lb (1-7) …….	0.07	0.05	8.6 cd	40.1	36.4 ab	85 ab	1399 abc
Regalia 0.5% (1-7) ……..……..	0.34	1.65	15.4 abc	39.5	31.9 bc	93 a	1461 ab
Sporatec AG 1 qt + Biolink 2 fl oz/gal (1-7) …	0.32	0.14	10.5 abcd	29.0	16.7 fg	61 cde	910 ef
Actinovate 12 oz (1-7) ……..	0.03	1.94	6.4 d	36.0	32.2 bc	78 abc	1236 abcde
Sonata ASO 4 qt (1-7) ……..	0.13	0.12	5.9 d	37.4	30.6 bcd	88 a	1319 abcde
Timorex Gold 0.75% (1-7) ……...	0.12	1.63	7.5 d	40.4	28.4 bcde	88 a	1351 abcd
Taegro 3.5 oz/100 gal (1-7) ……..…	1.36	1.70	10.0 bcd	34.4	27.8 bcde	88 a	1291 abcde
Organocide 1 oz/gal + NuCop HB 1 lb (1-7) ..	0.07	1.40	8.4 cd	28.8	21.9 def	69 bc	1002 cdef
K-Phite 2 qt (1-7) ……..	0.04	2.09	3.1 d	28.4	21.1 efg	49 e	959 def
NuCop HB 2 lb (1-7) ……..……..	0.63	0.13	5.3 d	35.1	21.4 efg	68 bcd	1025 bcdef
Manzate Pro-Stik 3 lb (1,2), Bravo 1.8 lb (3-7)..	0.12	0.03	17.7 a	27.0	12.8 g	68 bcd	777 f
Actinovate (1-7) + systemic fungicides [x]……	0.09	0.03	15.7 abc	37.5	26.2 cde	50 de	905 ef
P-value (treatment)	0.5305	0.0193	0.002	0.078	< 0.0001	< 0.0001	<0.0001

[z] Percent leaf tissue with symptoms of downy mildew was estimated and severity was assessed for the affected leaves. Canopy severity was calculated from these values.

[y] Rate of formulated product/A. Sporatec was mixed in deionized water. Treatments were started after disease detection. Applications dates were 1=25 Aug, 2=31 Aug, 3=8 Sep, 4=16-17 Sep, 5=22 Sep, 6=28 Sep, and 7=6 Oct. Rain occurred on 16 Sep before the treatments had time to dry, therefore they were reapplied on 17 Sep.

[x] The systemic fungicides tank-mixed with Actinovate were Curzate 60DF (3.2 oz/A) on week 1, Ranman 300SC (2.75 oz/A) on weeks 2 and 5, Previcur Flex (1.5 pt/A) on weeks 3 and 6, and Forum 500SC (6 fl oz/A) on weeks 4 and 7.

[w] Means followed by the same letter or no letter are not statistically different from each other (Tukey's HSD, P=0.05).