Tomato (*Solanum lycopersicum* 'Sebring')
Bacterial speck; *Pseudomonas syringae pv. tomato*

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Efficacy of biopesticides for managing bacterial speck in tomato seedlings, 2020.

An experiment was conducted at the Long Island Horticultural Research and Extension Center (LIHREC) in Riverhead, NY. The study was conducted in a greenhouse with seedlings to screen products for controlling bacterial speck in seedlings being grown as transplants in the greenhouse, but destined for field production, and also to obtain a preliminary screen to identify products to subsequently test on plants grown to maturity under field conditions. A randomized block design was used with four replications. The experimental unit was a 48-cell tray with 40 treatment seedlings and eight inoculated seedlings serving as pathogen source plants in the center two of the 12 rows of cells. Seedlings to be used as the inoculated source plants in the treatment trays were seeded in 48-cell trays on 10 Jan. Starting 2 weeks after seeding, when seedlings were at the 1-leaf stage, they were brush inoculated twice per week for two weeks using seedlings that were previously inoculated while testing the inoculation procedure. A copper-sensitive isolate of *Pseudomonas syringae pv. tomato* from a New York farm was used (isolate NYT1). On Tuesday and Thursday each week, infected seedlings and those being inoculated were spritzed with water around 4 pm, then the trays were covered with a tall plastic propagation dome. The following morning the dome was removed, then a narrow PVC pipe was gently moved across the leaves of the infected seedlings which were still wet and then across the leaves of the seedlings to be inoculated a few times. The inoculation procedure was repeated the next week on the inoculated seedlings to spread bacteria to new leaves. The trays were also overhead watered daily. Treatment trays for the experiment were seeded on 20 Jan with the center eight cells covered while filling the trays with growing medium (Premier Pro-Mix BX) so these cells remained empty. Two treatments started with a soil drench application four or seven days after seeding. Emergence was reduced and delayed in trays treated with Nobactra on 24 Jan, therefore these trays were switched with those that had been assigned to the noninoculated control so that the foliar Nobactra applications were applied to trays with seedlings of similar size and number as the other treatments. Weekly foliar treatments were started 14 days after seeding. Treatments were made using a CO_2-pressurized backpack sprayer with a boom that has a single TeeJet TwinJet Even Flat Spray nozzle (TJ60-4004EVS). Just before the second treatment, inoculated seedlings with symptoms were placed in the center eight cells of each tray. Bacterial spread in the treatment trays was promoted by overhead watering daily and brushing a PVC pipe across the plants from the inoculated seedlings outward in both directions twice a week for three weeks. Bacterial speck was assessed on every leaf of every treatment seedling before the third and fourth (last) foliar applications, and 7 days later. Leaf spots were counted and severity estimated for three leaves since few symptoms were observed on the fourth leaf of each plant. The number of spots per leaf of each of the treated plants was recorded at each evaluation and used to calculate the proportion of seedlings with symptoms, severity of bacterial speck was estimated as a percentage of leaf area affected on seedlings, and area under disease progress curve (AUDPC) was calculated using the formula: $\sum n_{i=1}[(R_{i+1} + R_i)/2]\,[t_{i+1} - t_i]$, where R = seedling disease severity rating at the ith observation, t_i = time (days) since the previous rating at the ith observation, and n = total number of observations. At the last assessment, ten of the 40 plants in each tray were randomly selected, cut at the soil line and fresh weights determined to find out if treatments affected plant growth. The percentage of source plants with low severity of speck in each tray was calculated to find out if treatments suppressed development of speck on the inoculated source plants. Temperature in the greenhouse during the experiment ranged from 70 to 89 F and averaged 77 F. Supplemental lighting from sodium vapor lighting was provided from 0630 to 1130 and 1600 to 2100 every day. Light intensity averaged 26.7 LIU. Data were analyzed with one-way ANOVA and Tukey's HSD to separate means using JMP statistical software.

Bacterial speck was successfully established on the inoculated seedlings and the pathogen spread throughout the trays. Some symptoms were observed in the non-treated, non-inoculated trays indicating pathogen spread occurred by water-splash from overhead watering as well as mechanically by brushing with the PVC pipe. Only the conventional grower standard treatment, copper plus mancozeb alternated with streptomycin, successfully suppressed pathogen spread compared to other treatments and the controls. Disease incidence for the conventional treatment was significantly lower than all other treatments on 25 Feb and 2 Mar. At the last assessment, symptoms were observed on only 41% of these seedlings versus 93-100% of seedlings receiving biopesticide treatments. Disease severity for the conventional treatment on 25 Feb and 2 Mar was significantly lower than some biopesticide treatments and numerically lower than all. CranProtect was the most effective biopesticide treatment: disease incidence for CranProtect on 25 Feb was significantly lower than other biopesticide treatments and it was the only biopesticide treatment with disease severity at all assessments that did not differ significantly from the conventional treatment. Based on disease severity, Zinkicide and the treatment including Regalia, TerraGrow, and Stargus performed similarly to CranProtect. The other biopesticide treatments were ineffective. Conditions for testing product efficacy were rigorous with a high percentage of infected source plants in each tray (17%) and actions taken to promote bacterial spread (brushing) and infection (leaf wetness maintained overnight 2 days/week). The treatment including Regalia, TerraGro, and Stargus stunted plant growth: at the end of the experiment, these plants weighed 0.45 oz/100 plants, which was significantly less than all other treatments except one (data not shown). Plants receiving the conventional treatment were significantly larger than others based on weight (2.19 oz/100 plants). Weights of plants that received the other treatments ranged from 0.76 to 1.16 oz/100 plants. At the end of the experiment, the percentage of inoculated source plants with lower bacterial speck than the untreated inoculated control (47%) was not significantly lower among any of the treatments except SP8010 + Mastercop (16%), which was statistically lower than six other treatments (64-78%).

Treatment and rate/A (application dates) **	Bacterial speck incidence (%)*			Bacterial speck severity (%)*			
	17 Feb	25 Feb	2 Mar	17 Feb	25 Feb	2 Mar	AUDPC
Untreated uninoculated control	15 de	58 b	58 b	0.22 c	3.1 de	3.5 cd	33 c
Untreated inoculated control	38 bcde	100 a	100 a	0.60 bc	19.6 a	20.6 a	201 a
SP8010 0.13% + Silwet L-77 0.1% (5-8)	75 a	98 a	98 a	1.54 a	18.9 ab	21.3 a	203 a
SP8010 + Silwet L-77 (5,7); Mastercop 1 qt (6,8)	61 abc	99 a	99 a	1.06 ab	14.6 abc	17.4 ab	159 ab
Nobactra AN10 + AN21 (5-8)	45 abcd	100 a	100 a	0.74 bc	14.0 abc	16.0 ab	149 ab
AOMMA 1 gal (5-8)	69 ab	100 a	100 a	1.47 a	12.4 abcd	14.1 ab	135 ab
Regalia 4 qt (1,3); TerraGrow 2 oz/100 gal (2,4); Stargus 4 qt + Nu-Film P 0.25% (5-8)	9 e	93 a	97 a	0.11 c	9.7 bcde	10.2 bc	99 bc
Zinkicide 2 qt (5-8)	31 cde	95 a	99 a	0.71 bc	9.0 cde	10.6 bc	98 bc
CranProtect, undiluted (5-8)	25 de	62 b	93 a	0.28 c	1.7 e	3.3 cd	23 c
Mastercop 1 qt + Manzate Pro-Stick 2 lb (5,7); Harbour 1 lb (6,8)	38 bcde	37 c	41 c	0.50 bc	0.5 e	0.9 d	7 c
P-value (treatment)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

* Numbers in each column with a letter in common are not significantly different from each other (Tukey's HSD, P=0.05).

** Rate of formulated product. Soil drench application dates were 1=27 Jan, 2=3 Feb, 3=10 Feb, and 4=17 Feb. Foliar application dates were 5=3 Feb, 6=10 Feb, 7=17 Feb, and 8=24 Feb.