

**TOMATO:** *Lycopersicon esculentum* Miller

**EVALUATION OF BIOPESTICIDES FOR FOLIAR DISEASE CONTROL IN TOMATO PRODUCTION IN FLORIDA, SPRING 2008**

Gary E. Vallad  
University of Florida,  
Gulf Coast Research & Education Center  
14625 CR 672  
Wimauma, FL 33598  
Phone: 813-633-4121  
Fax: 813-634-0001  
Email: gvallad@ufl.edu

*Xanthomonas axonopodis* pv. *vesicatoria*; *Alternaria solani*; *Corynespora cassiicola*, *Sclerotium rolfsii*

On 29 Feb. 2008, plots were established at the University of Florida's Gulf Coast Research and Education Center in Balm, FL to assess the effect of several biopesticides applied through drip irrigation on the incidence and severity of foliar diseases typical of tomato in Florida. Transplants of the TYLC resistant cultivar Tygress were transplanted at 18" spacing to 21 ft plots along 300 ft long, raised beds with 5 ft center-to-center bed spacing. Beds were covered with silver virtually impermeable mulch and irrigated with a drip system. Treatments (Table 1) were applied with a CO<sub>2</sub> back pack sprayer calibrated to deliver 60 gal/A for the first six applications, and 90 gal/A for the subsequent applications, both at 40 psi. Foliar applications of the standard treatment of Cuprofix Ultra 40D (2 lb/A) + Penncozeb 75 DF (3 lbs/A) or Cuprofix Ultra 40D (2 lb/A) + Bravo Weatherstik (2pt/A) were rotated on a biweekly basis with the biopesticide treatments. An Actigard treatment was initially applied (0.32g/640 plants) to a subset of seedlings 4 days prior to transplanting and then at a weekly rate of 0.75 oz/A with the standard chemical treatment afterwards. A non-treated control was included to measure disease pressure. Treatments were arranged in a randomized complete block design with each treatment repeated 4 times. Experiment was inoculated 21 March with a suspension (10<sup>6</sup> cfu/ml) of *Xanthomonas campestris* pv. *vesicatoria*. Plots were monitored, and rated (23 Apr, 2 May, 7 May, 14 May) for several diseases, including bacterial leaf spot (caused by *X. c.* pv. *vesicatoria*), early blight (*Alternaria solani*), and target spot (caused by *Corynespora cassiicola*). Marketable yield was assessed from two separate harvests of the center 10 plants in each plot on 20 May 2008 and 30 May 2008.

Overall, the environmental conditions for this trial were not favorable for severe disease development. While plots received 2.33 in. of rain on March 6 to 8 and another 0.9 in. on March 20 to 23, which helped establish several foliar diseases, no appreciable rain occurred again until the 19 May. The bacterial leaf spot inoculation coincided with the rain event on 23 March. Early blight and late blight (caused by *Phytophthora infestans*) also occurred naturally in the following weeks. However, none of the foliar diseases ever reached epidemic levels, but persisted throughout the trial with heavy morning dews.

Bacterial leaf spot was rated 23 April, 54 days after transplant (DAT). The severity ranged from 1 to 3 on the Horsfall-Barratt scale. The next three disease severity ratings at 63, 68 and 75 DAT included early blight, target spot and bacterial leaf spot, since separating the diseases was impractical. Disease severity in the last three ratings ranged from 2 to 5 on the Horsfall-Barratt scale. No significant effect of treatment on individual foliar disease ratings was observed (Table 3). Foliar disease data was further analyzed by calculating the area under disease progress curve (AUDPC) for each treatment and through the use of ranked treatment means over time; however, no treatment effect was observed with either analysis (Table 2). Based on ranked treatment means, a significant increase in disease occurred with time ( $P < 0.0001$ ), but no interaction with treatment was detected ( $P = 0.5361$ ). However, some promising trends were observed. Actigard and Serenade Max both reduced AUDPC scores by 17% relative to the untreated control and standard fixed copper and mancozeb treatment, whereas actinovate increased AUDPC scores by 25% (Table 4).

Fruit yield was assessed in two separate harvests on 20 May and 30 May. The first harvest was of medium sized fruit and larger, while the second was a complete harvest of all fruit. A combined analysis of both harvests failed to detect a significant effect of treatment on marketable yield of extra large ( $P = 0.1484$ ) and total fruit ( $P = 0.3875$ ; Table 4), or on the total number or weight of culls, small, medium or large sized fruit (data not shown). However, a significant treatment effect was found for the total number of total ( $P = 0.0147$ ) and extra large fruit ( $P = 0.0461$ ) harvested per plot, and in the percentage of marketable fruit that were extra large ( $P = 0.0559$ ; Table 4). In the case of total marketable fruit/plot, the standard fungicide treatment gave the highest yields, while the biopesticide treatments yields were similar to the control. No significant effect treatment was observed on the percentage of fruit culled for bacterial spot or for fungal roset associated with *Corynespora cassiicola* and *Alteranaria alternate*.

Table 1. Chemical application schedule for the 2008 spring IR-4 trial in Wimauma, FL.

|                                 |                    | Spray applications: |        |        |       |       |        |        |       |       |        |        |
|---------------------------------|--------------------|---------------------|--------|--------|-------|-------|--------|--------|-------|-------|--------|--------|
| Treatment                       |                    | 12 Mar              | 20 Mar | 25 Mar | 1 Apr | 8 Apr | 15 Apr | 22 Apr | 30Apr | 6 May | 13 May | 22 May |
| - Formulation                   | Rate               |                     |        |        |       |       |        |        |       |       |        |        |
| Actigard                        | 0.75 oz            | X                   | X      |        | X     | X     | X      |        | X     |       | X      |        |
| Actinovate                      | 12 oz/A            |                     | X      |        | X     |       | X      |        | X     |       | X      |        |
| Citrex                          | 1 ml/L             |                     | X      |        | X     |       | X      |        | X     |       | X      |        |
| HMO736                          | 14 oz/A            |                     | X      |        | X     |       | X      |        | X     |       | X      |        |
| Omega Grow Plus                 | 2% v/v             |                     | X      |        | X     |       | X      |        | X     |       | X      |        |
| SeaCide                         | 1% v/v             |                     | X      |        | X     |       | X      |        | X     |       | X      |        |
| Serenade Max                    | 1.5 lb/A           |                     | X      |        | X     |       | X      |        | X     |       | X      |        |
| Sporan                          | 3 pt/A             |                     | X      |        | X     |       | X      |        | X     |       | X      |        |
| Taegro                          | 3.5 oz/A           |                     | X      |        | X     |       | X      |        | X     |       | X      |        |
| Tiadanil                        | 500 ppm            |                     | X      |        | X     |       | X      |        | X     |       | X      |        |
| <b>Standard:<sup>z</sup></b>    |                    |                     |        |        |       |       |        |        |       |       |        |        |
| Cuprofix40D +<br>Penncozeb 75DF | 3 lb/A +<br>3 lb/A | X                   | X      | X      | X     |       | X      | X      |       | X     |        |        |
| Cuprofix 40D +<br>Bravo         | 3 lb/A +           |                     |        |        |       |       | X      |        | X     |       | X      | X      |
| Weatherstik                     | 2 pt/A             |                     |        |        |       |       |        |        |       |       |        |        |

<sup>z</sup> Standard treatment was also applied in a biweekly rotation with other products to non-standard treatment plots.

Table 2. Statistical analyses of variance based on the effect of treatment and time on the severity of bacterial leaf spot (BLS) and early blight (EB), in the 2008 spring trial.

| Effect                        | ANOVA-type statistic (ATS)             |            |          |                |
|-------------------------------|--|------------|----------|----------------|
|                               | $df_{Num}$                             | $df_{Den}$ | ATS      | <i>P</i> value |
| BLS+ EB severity:             |  |            |          |                |
| Treatment (Trt)               | 9.80                                   | 143        | 0.91     | 0.5241         |
| Time                          | 2.69                                   | $\infty$   | 33.40    | < 0.0001       |
| Trt x Time                    | 14.70                                  | $\infty$   | 0.92     | 0.5361         |
|                               | ANOVA <i>F</i> -statistic ( <i>F</i> ) |            |          |                |
|                               | $df_{Num}$                             | $df_{Den}$ | <i>F</i> | <i>P</i> value |
| BLS + EB AUDPC <sup>y</sup> : | 11                                     | 33         | 1.14     | 0.3454         |

Table 3. Mean, median (Med.) and relative effect (RE) of treatment on the severity of bacterial leaf spot, early blight and target spot in the 2008 spring trial.

| Treatments      | Rating dates:                      |     |                          |                       |     |                    |                       |     |                    |                        |     |                    |
|-----------------|------------------------------------|-----|--------------------------|-----------------------|-----|--------------------|-----------------------|-----|--------------------|------------------------|-----|--------------------|
|                 | <u>23-Apr (54 DAT)<sup>z</sup></u> |     |                          | <u>2-May (63 DAT)</u> |     |                    | <u>7-May (68 DAT)</u> |     |                    | <u>14-May (75 DAT)</u> |     |                    |
|                 | Mean                               | Med | RE (95% CI) <sup>z</sup> | Mean                  | Med | RE (95% CI)        | Mean                  | Med | RE (95% CI)        | Mean                   | Med | RE (95% CI)        |
| Actigard        | 2.3                                | 2.5 | 0.28 (0.05 - 0.52)       | 3.3                   | 3.5 | 0.53 (0.21 - 0.85) | 3.0                   | 3.0 | 0.68 (0.59 - 0.76) | 2.3                    | 2.0 | 0.56 (0.37 - 0.75) |
| Actinovate      | 3.8                                | 4.0 | 0.79 (0.61 - 0.97)       | 3.5                   | 3.5 | 0.61 (0.39 - 0.83) | 3.3                   | 3.0 | 0.75 (0.61 - 0.89) | 2.5                    | 2.5 | 0.66 (0.44 - 0.87) |
| Citrex          | 3.3                                | 3.5 | 0.60 (0.26 - 0.94)       | 3.8                   | 4.0 | 0.71 (0.52 - 0.91) | 3.0                   | 3.0 | 0.64 (0.35 - 0.92) | 2.3                    | 2.0 | 0.50 (0.16 - 0.84) |
| Standard        | 3.0                                | 3.0 | 0.50 (0.22 - 0.79)       | 3.5                   | 3.5 | 0.61 (0.39 - 0.83) | 2.8                   | 3.0 | 0.56 (0.34 - 0.78) | 2.5                    | 2.5 | 0.66 (0.44 - 0.87) |
| HMO736          | 3.3                                | 3.0 | 0.41 (0.22 - 0.59)       | 3.3                   | 3.0 | 0.43 (0.16 - 0.70) | 2.5                   | 2.5 | 0.45 (0.20 - 0.69) | 2.3                    | 1.5 | 0.28 (0.08 - 0.47) |
| Omega Grow      | 2.8                                | 2.5 | 0.41 (0.07 - 0.75)       | 3.0                   | 3.0 | 0.43 (0.16 - 0.70) | 2.5                   | 2.5 | 0.45 (0.20 - 0.69) | 1.8                    | 1.5 | 0.38 (0.04 - 0.71) |
| SeaCide         | 2.8                                | 3.0 | 0.60 (0.41 - 0.78)       | 3.0                   | 3.5 | 0.53 (0.21 - 0.85) | 2.5                   | 2.5 | 0.45 (0.20 - 0.69) | 1.5                    | 2.0 | 0.56 (0.37 - 0.75) |
| Serenade Max    | 2.5                                | 2.5 | 0.31 (0.11 - 0.51)       | 3.3                   | 3.5 | 0.53 (0.21 - 0.85) | 2.0                   | 2.0 | 0.28 (0.02 - 0.54) | 1.5                    | 1.0 | 0.28 (0 - 0.64)    |
| Sporan          | 3.0                                | 3.0 | 0.50 (0.22 - 0.79)       | 3.0                   | 3.0 | 0.41 (0.30 - 0.52) | 2.5                   | 2.5 | 0.45 (0.20 - 0.69) | 1.8                    | 2.0 | 0.37 (0.19 - 0.54) |
| Taegro          | 3.3                                | 3.0 | 0.60 (0.41 - 0.78)       | 2.8                   | 3.0 | 0.41 (0.11 - 0.71) | 2.8                   | 2.5 | 0.52 (0.18 - 0.86) | 2.5                    | 2.5 | 0.66 (0.44 - 0.87) |
| Tiadanil        | 2.8                                | 3.0 | 0.41 (0.22 - 0.59)       | 3.0                   | 3.0 | 0.43 (0.16 - 0.70) | 2.5                   | 2.5 | 0.45 (0.20 - 0.69) | 2.0                    | 2.0 | 0.46 (0.37 - 0.55) |
| <b>Control</b>  | 3.3                                | 3.0 | 0.60 (0.41 - 0.78)       | 2.8                   | 2.5 | 0.36 (0.05 - 0.67) | 2.3                   | 2.0 | 0.33 (0.12 - 0.55) | 2.5                    | 2.5 | 0.66 (0.44 - 0.87) |
| <i>P &gt; F</i> |                                    |     | 0.2988                   |                       |     | 0.8328             |                       |     | 0.3682             |                        |     | 0.2781             |

<sup>y</sup> DAT = days after transplant.

<sup>z</sup> The 95% confidence intervals (CI) are in parenthesis.

Table 4. Effect of treatments on the LS Mean (95% confidence interval) tomato yield by market class, culled fruit, and disease.

| Treatment                  | Marketable yield (25 lb cartons/A) |                 | Marketable yield (fruit/plot) |               | Extra large        | Culls             | BLS             | Fruit Rot     | AUDPC <sup>z</sup>    |
|----------------------------|------------------------------------|-----------------|-------------------------------|---------------|--------------------|-------------------|-----------------|---------------|-----------------------|
|                            | Total                              | Extra large     | Total                         | Extra large   | (% by number)      | (% by weight)     | (% by number)   | (% by number) |                       |
| Actigard                   | 1080 (818 - 1341)                  | 366 (221 - 512) | 289 (225 - 352)               | 56 (36 - 75)  | 19.4 (12.1 - 26.7) | 7.3 (3.4 - 11.2)  | 0 (0 - 0.4)     | 0.2 (0 - 0.5) | 119.5 (90.8 - 148.2)  |
| Actinovate                 | 947 (685 - 1209)                   | 395 (250 - 541) | 229 (165 - 292)               | 63 (44 - 82)  | 27.0 (19.8 - 34.3) | 8.2 (4.3 - 12.1)  | 0.3 (0 - 0.6)   | 0 (0 - 0.3)   | 170.9 (142.1 - 199.6) |
| Citrex                     | 1052 (790 - 1314)                  | 471 (326 - 616) | 235 (171 - 298)               | 67 (48 - 86)  | 27.8 (20.5 - 35.1) | 7.8 (3.9 - 11.7)  | 0 (0 - 0.4)     | 0.2 (0 - 0.5) | 154.5 (125.8 - 183.2) |
| Standard                   | 1305 (1043 - 1567)                 | 518 (373 - 664) | 384 (320 - 448)               | 79 (60 - 99)  | 22.1 (14.8 - 29.3) | 8.1 (4.2 - 12)    | 0 (0 - 0.4)     | 0.1 (0 - 0.4) | 144.3 (115.5 - 173)   |
| HMO736                     | 1074 (813 - 1336)                  | 435 (289 - 580) | 269 (205 - 333)               | 67 (48 - 86)  | 26.4 (19.2 - 33.7) | 8.9 (5.0 - 12.8)  | 0.1 (0 - 0.4)   | 0.2 (0 - 0.5) | 127.9 (99.1 - 156.6)  |
| OmegaGrow                  | 988 (726 - 1250)                   | 337 (192 - 483) | 237 (173 - 301)               | 49 (29 - 68)  | 20.4 (13.2 - 27.7) | 12.0 (8.1 - 15.9) | 0 (0 - 0.4)     | 0 (0 - 0.3)   | 128.8 (100.0 - 157.5) |
| SeaCide<br>Serenade<br>MAX | 992 (730 - 1254)                   | 368 (222 - 513) | 240 (176 - 303)               | 55 (35 - 74)  | 23.0 (15.7 - 30.3) | 11.5 (7.6 - 15.4) | 0 (0 - 0.4)     | 0.3 (0 - 0.6) | 148.0 (119.3 - 176.7) |
|                            | 990 (728 - 1251)                   | 392 (246 - 537) | 235 (171 - 298)               | 60 (40 - 79)  | 25.7 (18.5 - 33.0) | 10.4 (6.5 - 14.3) | 0 (0 - 0.4)     | 0.2 (0 - 0.5) | 118.8 (90.0 - 147.5)  |
| Sporan                     | 1321 (1059 - 1583)                 | 506 (360 - 651) | 243 (179 - 306)               | 74 (54 - 93)  | 30.4 (23.2 - 37.7) | 9.4 (5.5 - 13.4)  | 0.3 (0 - 0.7)   | 0 (0 - 0.3)   | 136.6 (107.9 - 165.4) |
| Taegro                     | 1046 (784 - 1308)                  | 408 (262 - 553) | 250 (186 - 313)               | 61 (42 - 80)  | 24.3 (17.1 - 31.6) | 8.2 (4.3 - 12.1)  | 0 (0 - 0.4)     | 0.1 (0 - 0.4) | 146.9 (118.1 - 175.6) |
| Tiadanil                   | 1223 (961 - 1485)                  | 547 (402 - 693) | 263 (199 - 327)               | 82 (62 - 101) | 32.0 (24.7 - 39.2) | 9.3 (5.4 - 13.2)  | 0.3 (0 - 0.7)   | 0.1 (0 - 0.4) | 129.6 (100.9 - 158.4) |
| <b>Control</b>             | 1212 (951 - 1474)                  | 565 (420 - 710) | 270 (206 - 334)               | 82 (63 - 101) | 30.5 (23.3 - 37.8) | 9.6 (5.7 - 13.5)  | 0.5 (0.1 - 0.9) | 0 (0 - 0.3)   | 143.9 (115.1 - 172.6) |
| <b><i>P &gt; F</i></b>     | 0.3875                             | 0.1484          | 0.0578                        | 0.0461        | 0.0559             | 0.8307            | 0.4790          | 0.6956        | 0.3454                |

<sup>z</sup> Area under the disease progress curve (AUDPC) for foliar diseases (bacterial leaf spot, early blight and target spot) on 23 April, 2 May, 7 May, and 14 May using the Horsfall-Barratt scale.