Ohio Vegetable & Small Fruit Research & Development Program

Final Report

2017

Project Title: Development of Fungicide Programs for Phytophthora Blight of Summer Squash

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Why was this project funded? Squash and pumpkins are highly susceptible to Phytophthora blight, and losses are high in infested fields under warm rainy conditions. The new fungicide oxathiapiprolin (OXTP: trade name Orondis) has good activity against Phytopthora blight, but there is little information available on how to best use the product in squash or pumpkins. Our results in 2016 under very high disease pressure showed significant reductions in squash plant wilting and death for four treatments, although the maximum control was 30%. We requested a second year of funding to repeat the study, focusing on the more effective treatments. We also proposed to test Orondis Gold and Orondis Ultra premix formulations (co-packs tested in 2016), with reduced Phytophthora inoculum applied to simulate natural infection sources. We will set up the field trial on the OARDC North Central Agricultural Experiment Station (NCARS).

Project outline. The experiment was conducted at the Ohio Agricultural Research and Development Center's North Central Agricultural Research Station in Fremont, OH on Rimer loamy fine sandy soil. Roundup PowerMax (1 qt/A) and Choice® (8 fl oz/A) were applied on 12 Apr to kill the cover crop and weeds. On 17 Apr the test field was plowed, disked and potassium (300 lb/A K2O), phosphorous (78 lb/A P2O5), nitrogen (107 lb/A NH4NO3), and boron (7 lb/A) were incorporated. Raised beds were prepared on 5-ft centers on 19 Apr and reshaped on 15 May. 'Autumn Delight' squash seeds were sown on 10 May into 72-cell plug trays containing Metro-Mix 360 seedling mix. The herbicides Dual II Magnum (1.0 pt/A), Command 3ME (0.5 pt/A), Roundup PowerMax (22.0 fl oz/A), Choice® (8.0 fl oz) and

InterLock (6.0 fl oz/A) were applied and incorporated into the test field on 23 May. Squash seedlings were transplanted on 30 May. Starter fertilizer (N-P-K 10-34-0; 0.7 qt/50 gal) was applied in the transplant water. Plots were arranged in a randomized complete block design with four replications. Each plot consisted of 13 plants spaced 2 ft apart with 5 ft between rows. Treated rows were alternated with non-treated border rows. Seven treatments containing Orondis Gold 200 (14 fl oz/A) were drenched at transplant by pouring 8 fl oz of diluted product around the base of each plant. The insecticides Assail 30SG (4.0 fl oz/A), Admire Pro SC (7 fl oz/A) plus Brigade 2EC (6.1 fl oz/A), Hero (6.0 fl oz/A), Sevin 50W (2.0 lb/A), Warrior II with Zeon Technology (1.9 fl oz/A) and Mustang Maxx (4.0 fl oz/A), were applied on 14 Jun and 26 Jul; 21 Jun; 28 Jun; 5 Jul; 19 Jul; and 9 Aug, respectively. Treatments were applied using a tractor-mounted CO_2-pressurized sprayer (55 psi, 43.8 gal/A, 3 mph) beginning 16 Jul and ending 21 Aug for a total of six applications. The field was cultivated on 16 Jun and hand weeded and hoed on 20 Jun. Plants were overhead irrigated with 1.0 in. water on 21 Jun. Inoculum of *Phytophthora capsici* was produced by placing a 0.4 in. disc, cut with a #4 cork borer, of an actively growing colony of *P. capsici* produced on V8 medium into a 0.4 in. diameter hole cut through the rind of a mature zucchini fruit. The rind was replaced after inoculation. Fruits were incubated at room temperature with a 12 hr photoperiod for 7 days. Squash plants were exposed to the *P. capsici*-infected zucchini fruit on 18 Jul by placing one fruit in the middle of each treated and non-treated control row. On 25 Jul and 1, 8, 15, 22 and 29 Aug, the number of healthy plants, plants with Phytophthora blight on fruits, plants wilted due Phytophthora blight and plants killed by Phytophthora blight were counted. Squash fruits from the middle 7 plants in each treatment row were harvested, counted and weighed on 29 Aug. Average maximum temperatures for 30-31 May, Jun, Jul and 1-29 Aug were 76.1, 82.2, 82.2 and 79.9°F; average minimum temperatures were 56.4, 60.6, 63.7 and 58.5°F; and rainfall amounts were 0.0, 3.6, 4.5 and 3.2 in., respectively. Analysis of variance was performed using the GLIMMIX procedure and means were separated by Fisher's least significant difference test with SAS software.

What was discovered? Phytophthora blight incidence was high in this trial, with 76% of the plants dead or wilting in the non-treated control at the final evaluation date on 29 Aug. Although the trial site was naturally infested with *P. capsici*, no symptoms were observed until after plants were exposed to *P. capsici* inoculum on 18 Jul, 7 weeks after transplanting. All treatments significantly increased the percentage of plants remaining symptomless and decreased the percentage of plants wilted or dead at the end of the experiment (Figure 1, Table). The numerically highest percentage of surviving symptomless plants (92.3%) at the end of the season was observed in plots treated with foliar applications of Orondis Ultra alternated with Presidio 4SC. This was statistically similar to the percentage of symptomless plants at the end of the season in plots treated with Orondis Gold 200 as a drench at transplanting followed by foliar applications of Ranman 400SC + Activator 90SL alternated with Presidio 4SC; Presidio 4SC alternated with Zampro + Activator 90SL; Revus 2.09SC + Kocide 3000 + Activator 90SL alternated with Presidio 4SC (with or without Kocide 3000); or Revus 2.09SC + Kocide 3000 +

Activator 90SL alternated with Ranman 400SC + Activator 90SL; or with two foliar applications only of Orondis Ultra alternated with Ranman 400SC + Activator 90SL, or Tanos + Kocide 3000 + Activator 90SL. Addition of Kocide 3000 to the foliar treatments did not significantly affect the percentage of surviving symptomless plants compared to similar treatments without Kocide 3000. Marketable yield was significantly increased by all treatments except Orondis Gold 200 drench at transplanting followed by foliar applications of Ranman 400SC + Activator 90SL alternated with Zampro + Activator 90SL, compared to the non-treated control (Figure 2, Tables). All programs significantly reduced the yield of fruit with Phytophthora blight symptoms at harvest compared to the non-treated control. With exception of plots treated with Orondis Gold 200 drench at transplanting followed by foliar applications of Ranman 400SC + Activator 90SL alternated with Zampro + Activator 90SL, or foliar applications alone of Orondis Ultra alternated with Presidio 4SC + Kocide 3000, all treatments increased the percentage of marketable fruits compared to the non-treated control.

Take-home message. Effectively managing Phytophthora blight in squash and pumpkins will require an integrated approach that combines cultural practices such as water management and site selection (fields with low populations of the pathogen) and fungicides. Phytophthora blight control overall was similar for treatments including Orondis Gold as a drench at transplanting followed by other foliar fungicides, and for foliar treatments including Orondis Ultra alternated with fungicides including Presidio, Ranman, Zampro and Tanos. Since Phytophthora blight usually develops in early- to mid-July in Ohio, it may not be advantageous to apply soil treatments of an Orondis product for crops planted/transplanted in late May/early June. For these plantings, foliar treatments including Orondis Ultra alternated with effective fungicides may be preferable. Further, there was no advantage to including Kocide 3000 to the foliar fungicides in terms of disease control and marketable yield.

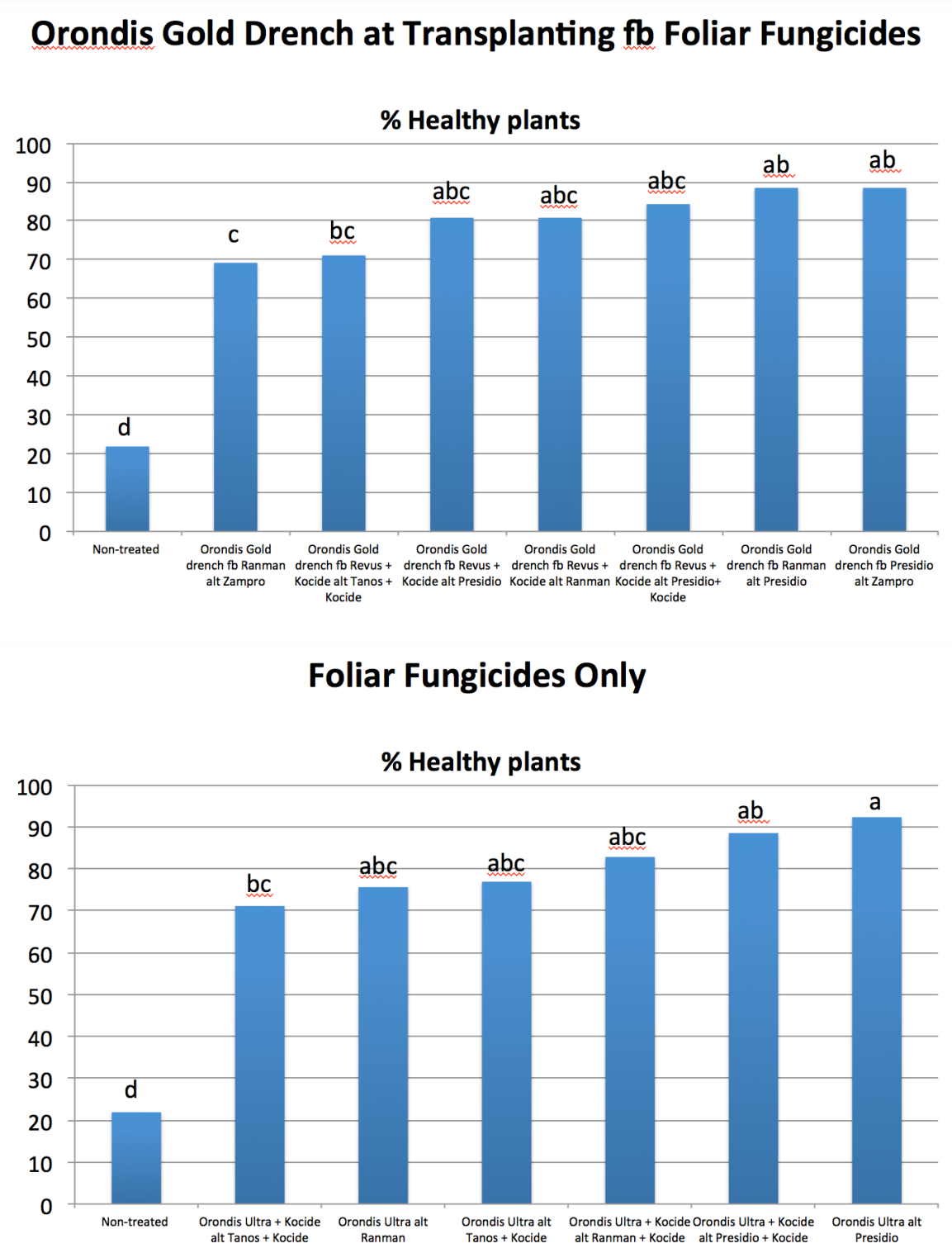
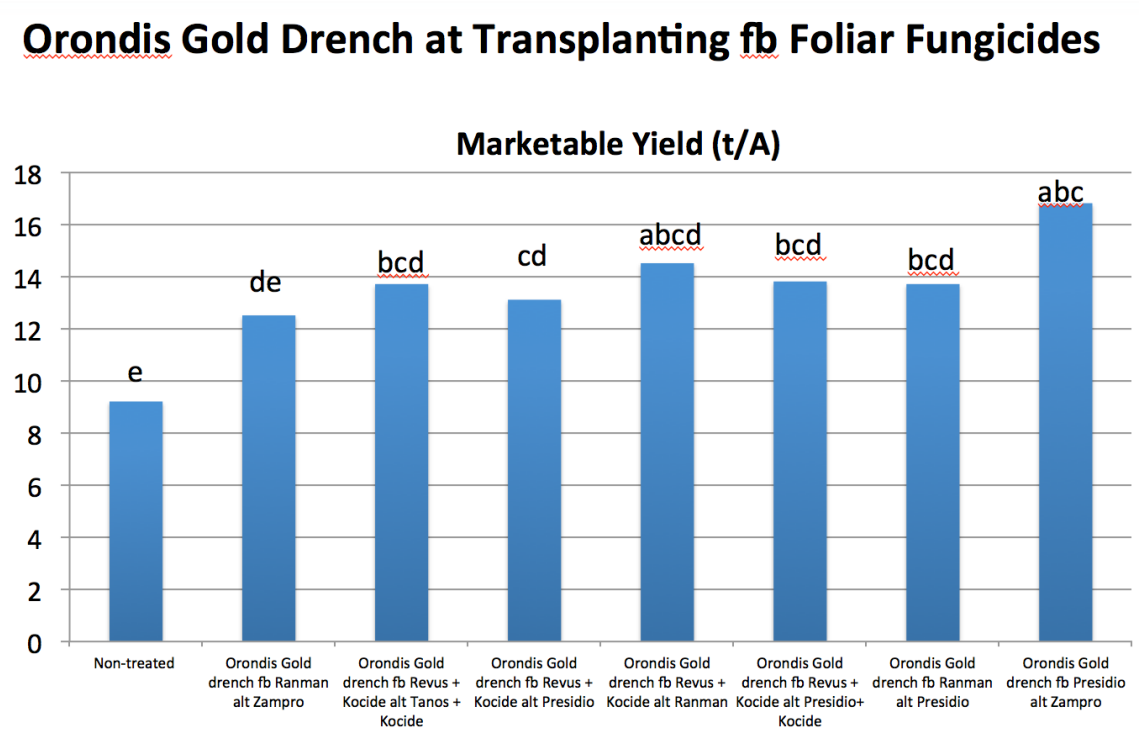


Figure 1. Percentage of healthy squash plants remaining at the end of the experiment after treatment with fungicides effective against Phytophthora blight. Bars sharing the same letter are not significantly different at $P \leq 0.05$.



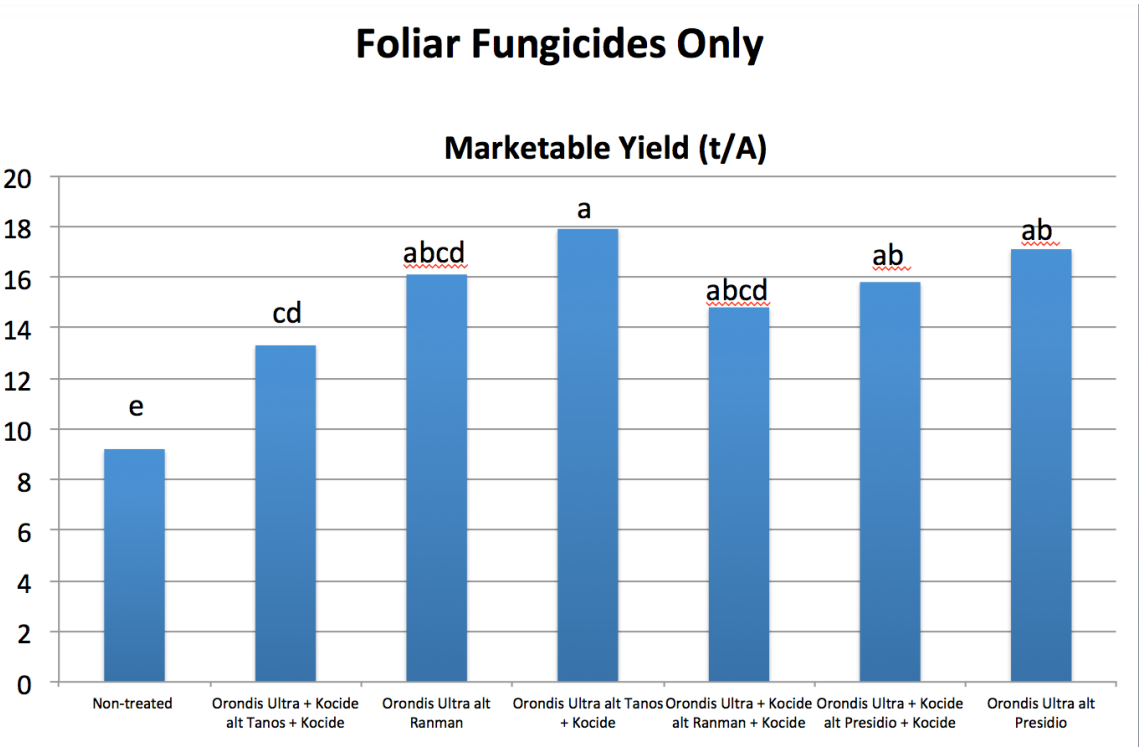


Figure 2. Marketable yield of squash plants after treatment with fungicides effective against Phytophthora blight. Bars sharing the same letter are not significantly different at $P \leq 0.05$.

Treatment application and rate (application timing[z])	% plants w/out symptoms[y] (29 Aug)	% wilted plants[x] (29 Aug)	AUDPC[w] wilted plants	% dead plants[v] (29 Aug)	AUDPC dead plants
Orondis Gold 200[u] 14 fl oz/A (drench at transplanting)[t] Ranman 400SC 2.75 fl oz/A + Activator 90SL 0.25% v/v (1,3,5) alt Presidio 4SC 4 fl oz/A (2,4,6)	88.5 ab[s]	3.9 bc	40.4 d	3.9 cd	40.4 c
Orondis Gold 200[u] 14 fl oz/A (drench at transplanting)[t] Ranman 400SC 2.75 fl oz/A + Activator 90SL 0.25% v/v (1,3,5) alt Zampro 14 fl oz/A + Activator 90SL 0.25% v/v (2,4,6)	69.2 c	13.5 bc	195.2 cbd	9.6 bcd	87.5 bc
Orondis Gold 200[u] 14 fl oz/A (drench at transplanting)[t] Presidio 4SC 4 fl oz/A (1,3,5) alt Zampro 14 fl oz/A + Activator 90SL 0.25% v/v (2,4,6)	88.5 ab	7.7 bc	67.3 cd	1.9 cd	6.7 c
Orondis Gold 200[u] 14 fl oz/A (drench at transplanting)[t] Revus 2.09SC 8 fl oz/A + Kocide 3000 1 lb/A + Activator 90SL 0.25% v/v (1,3,5) alt Presidio 4SC 4 fl oz/A (2,4,6)	80.8 abc	11.6 bc	175.0 bcd	7.7 bcd	107.7 bc
Orondis Gold 200[u] 14 fl oz/A (drench at transplanting)[t] Revus 2.09SC 8 fl oz/A + Kocide 3000 1 lb/A + Activator 90SL 0.25% v/v (1,3,5) alt Tanos 10 oz/A + Kocide 3000 1 lb/A + Activator 90SL 0.25% v/v (2,4,6)	71.1 bc	9.6 bc	141.4 cbd	7.7 bcd	80.8 c
Orondis Gold 200[u] 14 fl oz/A (drench at transplanting)[t] Revus 2.09SC 8 fl oz/A + Kocide 3000 1 lb/A + Activator 90SL 0.25% v/v (1,3,5) alt Ranman 400SC 2.75 fl oz/A + Activator 90SL 0.25% v/v (2,4,6)	80.8 abc	11.6 bc	67.3 cd	1.9 cd	6.7 c
Orondis Gold 200[u] 14 fl oz/A (drench at transplanting)[t] Revus 2.09SC 8 fl oz/A + Kocide 3000 1 lb/A + Activator 90SL 0.25% v/v (1,3,5) alt Presidio 4SC 4 fl oz/A + Kocide 3000 1 lb/A (2,4,6)	84.3 abc	13.6 bc	101.5 cbd	0.0 d	0.0 c
Orondis Ultra[u] 8 fl oz/A (1,4) alt Ranman 400SC 2.75 fl oz/A + Activator 90SL 0.25% v/v (2,3,5,6)	75.6 abc	5.4 bc	237.0 b	19.1 b	227.4 ab
Orondis Ultra[u] 8 fl oz/A + Kocide 3000 1 lb/A (1,4) alt Ranman 400SC 2.75 fl oz/A + Kocide 3000 1 lb/A + Activator 90SL 0.25% v/v (2,3,5,6)	82.8 abc	11.4 bc	113.9 cbd	1.8 cd	44.7 c
Orondis Ultra[u] 8 fl oz/A (1,4) alt Presidio 4SC 4 alt fl oz/A (2,3,5,6)	92.3 a	1.9 c	80.8 cbd	5.8 bcd	74.1 c
Orondis Ultra[u] 8 fl oz/A + Kocide 3000 1 lb/A (1,4) alt Presidio 4SC 4 alt fl oz/A + Kocide 3000 1 lb/A (2,3,5,6)	88.5 ab	1.9 c	67.3 cd	5.8 bcd	60.6 c
Orondis Ultra[u] 8 fl oz/A (1,4) alt Tanos 10 oz/A + Kocide 3000 1 lb/A + Activator 90SL 0.25% v/v (2,3,5)	76.9 abc	9.6 bc	188.5 cbd	13.5 bc	101.0 bc
Orondis Ultra[u] 8 fl oz/A + Kocide 3000 1 lb/A (1,4) alt Tanos 10 oz/A + Kocide 3000 1 lb/A + Activator 90SL 0.25% v/v (2,3,5)	71.1 bc	17.3 b	208.7 bc	7.7 bcd	94.2 bc
Non-treated Control	21.9 d	42.2 a	592.9 a	33.8 a	351.8 a
P value	<0.0001	0.0002	<0.0001	0.0011	0.0014

[z]Application dates: 1= 14 Jul; 2= 21 Jul; 3= 28 Jul; 4= 7 Aug; 5= 14 Aug; 6= 21 Aug.

[y]Percent healthy plants was calculated according to the formula: (# healthy plants (unaffected plants showing no symptom) ÷ total # plants)×100.

[x]Percent wilted plants was calculated according to the formula: (# plants wilted by Phytophthora blight ÷ total # plants)×100.

[w]Area under the disease progress curve values were calculated according to the formula: $\Sigma\ ([(x_i+x_{i-1})/2](t_i-t_{i-1}))$ where x_i the rating at each evaluation time and (t_i-t_{i-1}) is the number of days between evaluations.

[v]Percent dead plants was calculated according to the formula: (# plants killed by Phytophthora blight ÷ total # plants)×100.

[u]New formulated premixed

[t]Drench application at transplanting date: 1= 30 May.

[s]Values are the means of four replicate plots; means followed by the same letter within a column are not significantly different at P≤0.05. Means were separated using Fisher's least significant difference test.

Treatment application and rate (application timing[z])	Total yield (t/A)[y]	Marketable yield (t/A)[y]	% Marketable (lb/plot)	% Phytophthora (lb/plot)
Orondis Gold 200[x] 4 fl oz/A (drench at transplanting)[w] Ranman 400SC 2.75 fl oz/A + Activator 90SL 0.25% v/v (1,3,5) alt Presidio 4SC 4 fl oz/A (2,4,6)	15.0 bc[v]	13.7 bcd	90.6 bcd	0.9 b
Orondis Gold 200[x] 14 fl oz/A (drench at transplanting)[w] Ranman 400SC 2.75 fl oz/A + Activator 90SL 0.25% v/v (1,3,5) alt Zampro 14 fl oz/A + Activator 90SL 0.25% v/v (2,4,6)	14.3 cd	12.5 de	88.2 cde	1.2 b
Orondis Gold 200[x] 14 fl oz/A (drench at transplanting)[w] Presidio 4SC 4 fl oz/A (1,3,5) alt Zampro 14 fl oz/A + Activator 90SL 0.25% v/v (2,4,6)	17.0 abc	16.8 abc	99.1 a	0.8 b
Orondis Gold 200[x] 14 fl oz/A (drench at transplanting)[w] Revus 2.09SC 8 fl oz/A + Kocide 3000 1 lb/A + Activator 90SL 0.25% v/v (1,3,5) alt Presidio 4SC 4 fl oz/A (2,4,6)	14.0 cd	13.1 cd	91.7 abcd	1.8 b
Orondis Gold 200[x] 14 fl oz/A (drench at transplanting)[w] Revus 2.09SC 8 fl oz/A + Kocide 3000 1 lb/A + Activator 90SL 0.25% v/v (1,3,5) alt Tanos 10 oz/A+ Kocide 3000 1 lb/A + Activator 90SL 0.25% v/v (2,4,6)	14.7 bcd	13.7 bcd	93.0 abcd	1.5 b
Orondis Gold 200[x] 14 fl oz/A (drench at transplanting)[w] Revus 2.09SC 8 fl oz/A + Kocide 3000 1 lb/A + Activator 90SL 0.25% v/v (1,3,5) alt Ranman 400SC 2.75 fl oz/A + Activator 90SL 0.25% v/v (2,4,6)	16.1 abc	14.5 abcd	90.0 bcd	3.7 b
Orondis Gold 200[x] 14 fl oz/A (drench at transplanting)[w] Revus 2.09SC 8 fl oz/A + Kocide 3000 1 lb/A + Activator 90SL 0.25% v/v (1,3,5) alt Presidio 4SC 4 fl oz/A + Kocide 3000 1 lb/A (2,4,60)	15.3 abc	13.8 bcd	90.9 abcd	1.9 b
Orondis Ultra[x] 8 fl oz/A (1,4) alt Ranman 400SC 2.75 fl oz/A + Activator 90SL 0.25% v/v (2,3,5,6)	16.9 abc	16.1 abcd	95.5 abcd	0.0 b
Orondis Ultra[x] 8 fl oz/A + Kocide 3000 1 lb/A (1,4) alt Ranman 400SC 2.75 fl oz/A + Kocide 3000 1 lb/A + Activator 90SL 0.25% v/v (2,3,5,6)	15.3 abc	14.8 abcd	96.7 ab	0.3 b
Orondis Ultra[x] 8 fl oz/A (1,4) alt Presidio 4SC 4 alt fl oz/A (2,3,5,6)	17.7 abc	17.1 ab	96.4 abc	0.0 b
Orondis Ultra[x] 8 fl oz/A + Kocide 3000 1 lb/A (1,4) alt Presidio 4SC 4 alt fl oz/A + Kocide 3000 1 lb/A (2,3,5,6)	18.1 ab	15.8 abcd	87.5 de	1.8 b
Orondis Ultra[x] 8 fl oz/A (1,4) alt Tanos 10 oz/A + Kocide 3000 1 lb/A + Activator 90SL 0.25% v/v (2,3,5)	18.7 a	17.9 a	95.3 abcd	0.0 b
Orondis Ultra[x] 8 fl oz/A + Kocide 3000 1 lb/A (1,4) alt Tanos 10 oz/A + Kocide 3000 1 lb/A + Activator 90SL 0.25% v/v (2,3,5)	14.3 cd	13.3 cd	93.2 abcd	0.5 b
Non-treated Control	11.3 d	9.2 e	81.5 e	9.3 a
P value	0.0173	0.0042	0.0129	0.0089

[z]Application dates: 1= 14 Jul; 2= 21 Jul; 3= 28 Jul; 4= 7 Aug; 5= 14 Aug; 6= 21 Aug.
[y]Marketable yield and total yield (ton/A) values were calculated based on 4356 plants/A.
[x]New formulated premixed
[w]Drench application at transplanting date: 1= 30 May.
[v]Values are the means of four replicate plots; means followed by the same letter within a column are not significantly different at P≤0.05. Means were separated using Fisher's least significant difference test.