Ohio Vegetable & Small Fruit Research & Development Program

Final Report

2020

Project Title: Integrated Management of Phytophthora Blight Using Grafted Peppers and Fungicides

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Why was this project funded? Phytophthora blight is very difficult to manage in peppers, despite the availability of partially resistant pepper varieties and Phytophthora-specific fungicides, and OVSFRDP members suggested research on improving Phytophthora control. An integrated approach including disease resistance, cultural practices, and fungicides is necessary to achieve adequate control. Recently two *Phytophthora*-resistant pepper rootstocks were identified by Clemson University and USDA ARS. These rootstocks have been successfully grafted with various commercial pepper varieties (scions). These and several Phytophthora-resistant pepper varieties were tested in field trials. Similar trials were conducted in 2019, but diseases incidence was low and the study was repeated, with some changes, in 2020.

Project outline: We worked with Dr. Richard Hassel of Clemson University, who provided grafted peppers (two rootstocks, one scion variety) for 1) a one acre on-farm demonstration trial in Sandusky County (scion variety was chosen by the grower (SV3255)) and 2) a replicated trial on the OSU North Central Agricultural Research Station (NCARS) in Fremont. In the replicated trial at NCARS, we established a split plot trial with four replications in a field with a history of *Phytophthora*. Plots were also inoculated with *Phytophthora capsici* by placing and infected squash fruit in each row in the NCARS trial only. One main plot included grafted and non-grafted peppers that received foliar fungicide applications; the other main plot had the same pepper varieties, grafted and non-grafted, but was not

sprayed with foliar fungicides. Varieties were: SV3255 + rootstock 1, SV3255 + rootstock 2, four partially resistant pepper varieties (Aristotle, Intruder, Nitro and Sequoia), and one susceptible bell variety (non-grafted SV3255). The fungicide program included a rotation of Orondis Ultra, Ranman, and Presidio, which we have found to be most effective among the various fungicides for Phytophthora management. Plots were evaluated for Phytophthora blight weekly once symptoms appeared. Marketable yield and Phytophthora fruit rot were evaluated at harvest.

Take-home messages:

- Under low-moderate Phytophthora blight disease pressure, a fungicide program consisting of foliar applications of Orondis Gold, Ranman and Presidio provided excellent disease control.
- The varieties Nitro, Intruder and Aristotle demonstrated good but not complete resistance to Phytophthora blight.
- Grafted plants were not resistant to Phytophthora blight, regardless of rootstock. This is likely because the rootstock/scion junction was low and too close to the soil line, exposing the susceptible scion to *Phytophthora*. Future efforts will focus on grafting higher on the rootstock stem.
- Higher yields of SV3255 grafted onto E1 in the non-fungicide-treated plots is related to lower fruit infection. Additional studies are needed to determine if this unexpected outcome is consistent.

Impacts: Losses in peppers to Phytophthora blight can be greatly reduced by using disease-resistant varieties and effective fungicides. Additional research is needed to determine if grafted plants can play a role in Phytophthora blight management.

What was discovered?

- in the NCARS trial, Phytophthora blight disease pressure was moderate (incidence of 20% diseased plants of susceptible SV3255 in non-fungicide treated plots).
- Varieties Nitro, Intruder and Aristotle had significantly fewer plants killed by *Phytophthora* than the susceptible control SV3255 in the non-fungicide treated plot.
- Grafting SV3255 onto either disease-resistant rootstock – E1 or E3 – did not significantly reduce the incidence of plants killed by *Phytophthora* in non-fungicide treated plots.
- Marketable yield was significantly higher in SV3255 + E1 than SV3255 alone, and percent marketable fruit was significantly higher in both SV3255 + E1 and SV3255 + E3 than SV3255 alone in non-fungicide treated plots.
- There was no effect of grafting or variety on marketable yield or percent marketable fruit in fungicide-treated plots.

- Fruit infection was low (6.3% in SV3255) and only Nitro and Intruder had significantly less *Phytophthora* fruit infection than SV3255 in non-fungicide treated plots.
- In the grower trial there was no difference in the percentage of plants with Phytophthora blight on 13 August among the non-grafted scion SV3255 (5.4%), SV3255 grafted onto E1 rootstock (5%) and SV3255 grafted onto E3 rootstock (5.8%). It should be noted that these peppers received Orondis Gold via chemigation and a foliar application of Ranman.

PEPPER (*Capsicum annuum*)
Phytophthora blight; *Phytophthora capsici*

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Integrated management of Phytophthora blight using grafted peppers and fungicides, 2020.

The experiment was conducted at The Ohio State University's North Central Agricultural Research Station in Fremont, OH on Rimer loamy fine sand. Aristotle seeds were sown on 1 Apr, SV3255 on 3 Apr and Intruder, Nitro, and Sequoia on 8 Apr into 200-cell plug trays containing Baccto Professional Growers Mix. Seeds of rootstocks E1 and E3 and scion SV3255 were sown on 24 Apr and grafted on 12 May at Clemson University. The herbicides Roundup PowerMAX (32 fl oz/A) and Choice Weather Master (8 fl oz/A) were applied to the test field on 23 Apr. On 4 May, the fertilizers 46-0-0 (N-P-K; 250 lb/A), 10-52-0 (100 lb/A), 0-0-60 (500 lb/A) and 10% granular boron (10 lb/A) were broadcast and then the field was disked to incorporate the fertilizers. On 6 May the field was tilled and beds were prepared on 5 ft centers. The herbicides Dual II Magnum (16 fl oz/A), Command 3ME (8 fl oz/A), Roundup PowerMAX (22 fl oz/A) and Choice Weather Master (8 fl oz/A) were applied on 26 May. Pepper seedlings were transplanted on 9 Jun using a row transplanter. Starter fertilizer solution (N-P-K 10-34-0; 0.7 qt/50gal water) was applied in the transplant water. The experiment was arranged as a split plot in a randomized compete block design with four replications. Main plots were a foliar fungicide program or no fungicides. Sub-plots were grafted and non-grafted peppers. Sub-plots consisted of one row of 25 plants spaced 1 ft apart with 5 ft between rows and were alternated with non-treated border rows. Insecticides were applied as needed: Asana XL (9.6 fl oz/A; 26 Jun), Assail 30SG (3.5 oz/A; 1 and 22 Jul), Warrior II with Zeon Technology (1.92 fl oz/A; 9 Jul), Radiant SC (8 fl oz/A; 9 Jul), Exirel (13.5 fl oz/A; 17 Jul and 25 Sep), Baythroid XL (2.8 oz/A; 30 Jul), Arctic 3.2EC (8 oz/A; 6 Aug and 11 Sep), Actara (5 oz/A; 12 Aug), Coragen (5 fl oz/A; 12 Aug and 18 Sep), Beleaf 50 SG (2.8 oz/A; 21 Aug), Avaunt (3.5 oz/A; 21 Aug), Mustang Maxx (4 fl oz/A; 28 Aug) and Carbaryl 4L (1qt/A; 4 Sep). Cover applications of fungicides were applied to prevent anthracnose: Quadris Top (8 fl oz/A; 17 and 30 Jul, 12 and 28 Aug and 11and 25 Sep), Bravo Weather Stik (1.5 pt/A; 22 Jul, 6 and 21 Aug and 4 and 18 Sep) and Quintec (6 fl oz/A, 11 Sep). The field was hoed and hand weeded on 22 Jun and 1, 13 and 23 Jul, and cultivated on 15 Jun and 10, 21 and 30 Jul. Foliar treatments for Phytophthora blight were applied using a tractor-mounted CO_2-pressurized sprayer (55 psi, 41.5 gal/A, 3 mph) beginning 9 Jul and ending 25 Sep for a total of 12 applications. On 9 Jul, plants were inoculated with *Phytophthora capsici.* Inoculum of *Phytophthora capsici* was produced by placing a 0.4 inch disk, cut with #4 cork borer, of an actively growing colony of *P. capsici* produced on non-clarified V8 agar medium into a 0.4 inch diameter hole cut through the rind of a mature zucchini fruit. The rind was replaced after placing the inoculum in the hole. Zucchini fruits were incubated at room temperature for 24 hr in a moist chamber. Pepper plants were exposed to the *P. capsici*-infected zucchini fruit by placing two zucchini fruits on the soil in each plot, one at plant #8 and the other at plant #16. Plants were irrigated with 1.2, 1.35, 1.30 and 2.3 inches of water on 7, 14 and 24 Jul and 14 Aug, respectively. Incidence of Phytophthora blight was evaluated weekly from 13 Jul to 1 Oct. Peppers were harvested from 10 plants from each row on 25 Aug, 10 Sep and 1 Oct. Pepper fruits were evaluated and weights were recorded for the following categories: healthy, diseased (Phytophthora), blossom end rot and other minor fruit rots. Average maximum temperatures for 28-31 May, Jun, Jul and 1-26 Aug were 73.4, 82.7, 88.7, and 83.8°F; average minimum temperatures were 57.6, 60.9, 66.5 and 60.6°F; and rainfall amounts were 0.2, 1.7, 1.6, and 1.1 in., respectively. Analysis of variance was performed using the GLM procedure and means were separated by Fisher's least significant difference test with SAS software.

Despite very dry conditions in July, Phytophthora blight incidence reached 20.1% in the non-treated, susceptible (SV3255) scion variety in this trial. Spray program (fungicide application) had significant effects on disease incidence in pepper plants and fruits. Varieties significantly affected disease incidence in pepper plants and fruits, total and marketable yield, and percentage of marketable fruit. There was a marginally significant interaction between spray program and varieties in disease incidence in pepper plants.

In the main plots treated with the season-long spray program for Phytophthora blight management, incidence of the disease in plants (≤4.1%) and fruits (≤3%) was very low and there were no significant differences in disease incidence, total or marketable yield or percentage of marketable fruit between the susceptible scion variety SV3255 and the resistant varieties Nitro, Intruder, Sequoia, or Aristotle, or either scion/rootstock grafted combination (Table 2).

In the main plots not treated with the fungicide program, Phytophthora blight incidence was significantly lower in the varieties Nitro, Intruder and Aristotle than in the susceptible scion variety SV3255 (Table 3). Disease incidence in the two grafted combinations SV3255/E1 and SV3255/E3 and the variety Sequoia was statistically similar to incidence in SV3255. The relatively high incidence of Phytophthora blight in SV3255 grafted onto Phytophthora-resistant rootstocks E1 or E3 was unexpected. Examination of diseased grafted plants indicated scion infection resulting from low graft unions and exposure of the susceptible scions to *Phytophthora* at or near the soil line. The percentage of fruit harvested with Phytophthora symptoms was low (maximum 6.3% in SV3255) and only significantly lower in SV3255/E1, Nitro and Intruder than in SV3255. Total and marketable yields were significantly higher for SV3255/E1 and Aristotle than for SV3255. The percentage marketable fruit was significantly higher for both grafted combinations as well as Nitro, Intruder and Aristotle than from SV3255.

Table 1. Summary of P-values

Effects	Phytophthora blight incidence (%)		Total yield (t/A)	Marketable yield (t/A)	Marketable yield (%)
	Plants	Fruits			
Spray program	0.0353	0.0008	0.1226	0.2623	0.9875
Varieties	0.0087	0.0247	0.0006	0.0008	0.0080
Spray program × Varieties	0.0554	0.4599	0.6213	0.6107	0.6045

Table 2. Spray program: Fungicides[z]

Variety	Phytophthora blight incidence (%)[y]		Total yield (t/A)	Marketable yield (t/A)	Marketable yield (%)
	Plants	Fruits			
SV3255 + E1	0.0	2.1	14.2	12.4	87.1
SV3255 + E3	0.0	2.7	12.4	10.8	85.7
Nitro	3.8	0.6	12.1	10.8	89.8
Intruder	0.0	0.7	13.7	12.4	89.8
Sequoia	3.8	3.0	11.2	9.5	84.1
Aristotle	1.0	0.6	15.5	13.8	88.2
SV3255	4.1	1.6	13.5	11.4	84.6
P-value	0.2954	0.4465	0.2282	0.3332	0.6680

[z] Orondis Ultra (8 fl oz/A; 9 Jul and 6 Aug), Ranman + KPhite 7LP (2.75 fl oz/A, 1 gal/A; 17 and 30 Jul, 20 Aug, and 3 and 18 Sep), Presidio (4 fl oz/A; 22 Jul, 13 and 27 Aug, and 10 and 25 Sep).

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

Table 3. Spray program: No fungicides

Variety	Phytophthora blight incidence (%)[z]		Total yield (t/A)	Marketable yield (t/A)	Marketable yield (%)
	Plants	Fruits			
SV3255 + E1	12.8 ab	2.3 b	17.3 a	15.3 a	88.7 ab
SV3255 + E3	13.5 ab	3.8 ab	14.2 abc	12.5 ab	87.9 ab
Nitro	5.6 bc	1.9 b	12.5 bc	11.5 bc	92.9 a
Intruder	1.9 c	2.2 b	15.1 ab	13.9 ab	91.6 a
Sequoia	12.2 ab	6.2 a	10.4 c	8.6 c	82.4 bc
Aristotle	5.7 bc	3.4 ab	17.9 a	15.8 a	88.1 ab
SV3255	20.1 a	6.3 a	12.5 bc	10.2 bc	77.4 c
P-value	0.0240	0.0578	0.0092	0.0055	0.0159

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