

Management of *Phytophthora capsici* in fresh peppers using foliar and chemigation treatments– Final Report

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Key Findings / Summary of Results

Summary of Greenhouse Screening:

Greenhouse trials were successfully completed in 2011 and 2012. EXP1 delayed the onset of Phytophthora crown and root rot in both years. Reason, V10208, and Presidio were all tested for the first time in 2012, and also delayed disease development. Drench applications of these products were more effective than foliar applications.

Pre-plant drenches with Revus (a currently registered use) were inconsistent at suppressing disease levels. Applications of Ranman, Zampro, Allegro and Acrobat rarely reduced disease severity below levels observed in the nontreated control.

Interestingly, the growing media Promix Biofungicide, which contains the bacteria *Bacillus subtilis* MBI600 reduced the area of the pepper stem with disease symptoms below that of the nontreated control in both trials where it was tested.

- A. Greenhouse Efficacy Trials, 2010 (p. 3-4)**
- B. Greenhouse Efficacy Trials, 2011 (p. 5-10)**
- C. Greenhouse Efficacy Trials, 2012 (p. 11-13)**

Summary of Field Efficacy Trials

Field trials were established at grower sites in 2010, 2011, and 2012 in Essex County where Phytophthora root rot had previously been reported. However, no or few symptoms develop in the trials and we were not able to make any conclusions on the efficacy of products included in the trials.

- A. Field Efficacy Trial, 2010 (p. 14-17)**
- B. Field Efficacy Trial, 2011 (p. 18-21)**
- C. Field Efficacy Trial, 2012 (p. 22-25)**

TITLE: Screening products and fungicide programs for control of Phytophthora crown and root rot in the greenhouse, 2010

PEST(S): Phytophthora crown and root rot (*Phytophthora capsici*)

MATERIALS: Allegro (fluazinam 40%), Acrobat (dimethomorph 50%), Kocide 2000 (copper hydroxide 53.8%), Revus (mandipropamid 23.3%), Ranman (cyazofamid 34.5%), Zampro (ametoctradin 27% + dimethomorph 20.3%), EXP 1 (unknown)

METHODS: Soil was collected from a commercial pepper field near Harrow, ON, in 2009. Phytophthora crown and root rot has been confirmed at this location and was severe in 2009. Soil was collected from a low spot in the field where all peppers plants had died. Pepper cv. Jalapeno was seeded on Jan 11, 2010 in 200-cell trays and grown using normal practices. Peppers were transplanted into infested soil mixed with sand at a ratio of 5:7 on March 11. A 1 cm layer of potting mix was placed in the bottom of each pot to prevent the soil and sand mixture from washing out the bottom. Treatments, application methods, and application timings are summarized in Table 1. The trial was arranged in a randomized complete block design with 8 replications per treatment. Each replicate consisted of one 8-inch pot. Plants were monitored for disease symptoms throughout the duration of the trial.

RESULTS: No symptoms were observed on any plants in the trial. No phytotoxicity symptoms were observed in any treatments.

CONCLUSIONS: We were not able to make any conclusions on the efficacy of products included in the trial because disease symptoms did not develop. In the future, we plan to try inoculating media with *P. capsici* in order to improve the probability of producing disease symptoms.

Table 1. Treatment list, application type, and application timing for evaluation of different fungicides and fungicide programs for management of Phytophthora crown and root rot in peppers, Ridgeway Campus Greenhouse, Ridgeway, ON, 2010.

Product	Product Rate	Type	Timing
Nontreated control	-	-	-
Allegro	400 mL Ha ⁻¹	Foliar ^a	0, 6, 13, 21 DAT ^b
Acrobat + Kocide 2000	450 g Ha ⁻¹ + 2.5 kg Ha ⁻¹	Foliar	0, 6, 13, 21 DAT
Allegro	400 mL Ha ⁻¹	Foliar	0, 13 DAT
Acrobat + Kocide 2000	450 g Ha ⁻¹ + 2.5 kg Ha ⁻¹	Foliar	6, 21 DAT
Revus	600 mL Ha ⁻¹	Pre-plant drench ^c	0 DAT
Ranman	200 mL Ha ⁻¹	Drench ^d	0, 6, 13, 21 DAT
Ranman alt.	200 mL Ha ⁻¹	Drench	0, 13 DAT
Allegro	400 mL Ha ⁻¹	Foliar	6, 21 DAT
Ranman alt.	200 mL Ha ⁻¹	Drench	0, 13 DAT
Acrobat + Kocide 2000	450 g Ha ⁻¹ + 2.5 kg Ha ⁻¹	Foliar	6, 21 DAT
ZAMPRO	1 L Ha ⁻¹	Drench	0, 6, 13, 21 DAT
ZAMPRO alt.	1 L Ha ⁻¹	Drench	0, 13 DAT
Allegro	400 mL Ha ⁻¹	Foliar	6, 21 DAT
EXP 1	500 ppm	Drench	0, 6, 13, 21 DAT
EXP 1 alt.	500 ppm	Drench	0, 13 DAT
Allegro	400 mL Ha ⁻¹	Foliar	6, 21 DAT
EXP 1 alt.	500 ppm	Drench	0, 13 DAT
Acrobat + Kocide 2000	450 g Ha ⁻¹ + 2.5 kg Ha ⁻¹	Foliar	6, 21 DAT

^a Applied using water volume rate of 400 L Ha⁻¹.

^b DAT = days after transplanting.

^c Plugs were moved from trays and allowed to soak in solution for 15 minutes. Plugs were removed, allowed to drip for 10 seconds, and then planted into pots. 3 mL of solution was absorbed per plant. Pots were watered 4 hours after treatment.

^d 50 mL of solution was applied per pot.

TITLE: Screening products and fungicide programs for control of *Phytophthora* crown and root rot in the greenhouse, 2011

PEST(S): *Phytophthora* crown and root rot (*Phytophthora capsici*)

MATERIALS: Allegro (fluazinam 40%), Acrobat (dimethomorph 50%), Kocide 2000 (copper hydroxide 53.8%), Revus (mandipropamid 23.3%), Ranman (cyazofamid 34.5%), Zampro (ametoctradin 27% + dimethomorph 20.3%), EXP 1 (unknown), Promix Biofungicide (*Bacillus subtilis* MBI600 1×10^7 CFU L⁻¹)

METHODS: Pepper cv. Hot Hungarian was seeded into 128-cell trays on Jan 26. Pro-Mix PGX (Premier Tech Horticulture, Riviere-du-Loup, PQ) was used for all treatments except treatment Pro-Mix Biofungicide, where seeds were sown in Pro-Mix Biofungicide (Premier Tech Horticulture, Riviere-du-Loup, PQ). Trays were placed in a germination room on Jan 26 and removed and placed in the greenhouse 5 days later. Due to a malfunction in the germination room, seeds were exposed to cooler than normal temperatures, and plant emergence was delayed until Feb 7. Peppers were fertilized with 200 ppm N using 20-20-20 on Feb 9, 17, 28, and Mar 7.

Peppers were transplanted into 4-inch pots filled with Pro-Mix PGX on March 8. After transplanting, plants were thoroughly watered before the first treatment application. The trial was arranged as a randomized complete block with eight replications per treatment and one plant per pot. Peppers were fertilized with 200 ppm N using 20-20-20 on Mar 10.

Inoculum was prepared by growing a *Phytophthora capsici* obtained from C. Saude at the University of Guelph Simcoe Research Station, on sterilized millet seed in sealed, glass jars under fluorescent light. Inoculum was thoroughly mixed, weighed, and added to enough soilless mix (Pro-Mix PGX) for one 4-inch pot. The inoculated soilless mix was then transferred to pots. All pots in replications 1 thru 6 were inoculated with 2.5 g of inoculum one day before transplanting, while replications 7 and 8 were inoculated with 10 g of inoculum per pot on the same day as transplanting. The inoculum from the two jars with the most mycelial growth was used for replication 1 thru 6, while a less dense inoculum was used for replications 7 and 8.

Treatments, application methods, and application timings are summarized in Table 1. The intention was to repeat the 2010 trials with the same treatments, and the addition of Pro-Mix Biofungicide treatment, however there were deviations from the original protocol. Specifically, Ranman was applied as a drench treatment alone and with Revus, and the first applications of EXP 1 (0 DAT) were applied as foliar treatments at a lower rate. In the case of EXP 1, drench applications were made 3 DAT because the first application did not use the correct application method or rate.

Peppers were monitored regularly for the development of disease symptoms. The percentage of the stem with crown rot symptoms was estimated on March 14. On March 16, 21, and 24 each replicate was rated for the extent of wilt, where 0 = no wilt and 5 = completely dead.

Because of the deviations from the treatment protocol in Trial 1, a second trial (Trial 2) was initiated on March 9, using the remaining pepper transplants grown for Trial 1. Peppers were transplanted into 4-inch pots filled with Fafard germination mix (Conrad Fafard Inc., Agawam, MA). Each replicate consisted of one 4-inch pot with one pepper plant. There were eight replications pre treatment, and the trial was arranged as a randomized complete block.

Peppers were inoculated on March 24 using *P. capsici* infested millet seeds. The millet seeds were soaked in distilled water, autoclaved, and inoculated with the same *P. capsici* culture used in Trial 1, one week prior to inoculating the trial. Inoculation was completed by removing the top 1cm of media from each pot, sprinkling 0.6 g of inoculum in the pot, and replacing the media.

Treatments, application methods, and application timings are summarized in Table 2. The severity of wilting was assessed on March 29, 31, April 3, 5, 11, 15, and 19.

Statistical analysis was conducted using ARM 7 (Gylling Data Management, Brookings, SD). Data were tested for normality using Bartlett's homogeneity of variance test. Data which were not normal ($P \leq 0.05$) were transformed using an arsine, log, or square root transformation, as indicated in the results tables. Analysis of variance was conducted using Duncan's new multiple range test and means comparisons were performed when $P \leq 0.05$.

RESULTS: Refer to Table 3 and Table 4.

CONCLUSIONS: In Trial 1, treatment programs that included EXP 1 were most effective at delaying symptom development. Treatment programs that included Revus or Ranman also delayed the development of stem canker, but were not as effective as EXP 1. In Trial 2, Ranman alone was not effective at delaying disease development. Treatments that included EXP 1 were most effective at delaying the development of disease symptoms, but Revus drenched pre-plant also delayed symptom development.

Table 1. Treatment list, application type, and application timing for evaluation of different fungicides and fungicide programs for management of Phytophthora crown and root rot in peppers, Ridgetown Campus Greenhouse, Ridgetown, ON, Trial 1, 2011.

Product	Product Rate	Type ^a	Timing (DAT) ^b
Nontreated control	-	-	-
Allegro	400 mL Ha ⁻¹	Foliar	0, 7
Acrobat + Kocide 2000	450 g Ha ⁻¹ + 2.5 kg Ha ⁻¹	Foliar	0, 7
Allegro	400 mL Ha ⁻¹	Foliar	0
Acrobat + Kocide 2000	450 g Ha ⁻¹ + 2.5 kg Ha ⁻¹	Foliar	7
Revus + Ranman	600 mL Ha ⁻¹ + 200 mL Ha ⁻¹	Pre-plant drench ^c	0
Revus	600 mL Ha ⁻¹	Drench ^d	7
Revus	600 mL Ha ⁻¹	Pre-plant drench ^c	0
Ranman alt.	200 mL Ha ⁻¹	Drench	0
Allegro	400 mL Ha ⁻¹	Foliar	
Ranman alt.	200 mL Ha ⁻¹	Drench	0
Acrobat + Kocide 2000	450 g Ha ⁻¹ + 2.5 kg Ha ⁻¹	Foliar	7
ZAMPRO	1 L Ha ⁻¹	Drench	0, 7
ZAMPRO alt.	1 L Ha ⁻¹	Drench	0
Allegro	400 mL Ha ⁻¹	Foliar	7
EXP 1	500 ppm	Foliar	0
EXP 1		Drench	3, 7
EXP 1	500 ppm	Foliar	0
EXP 1	400 mL Ha ⁻¹	Drench	3
Allegro		Foliar	7
EXP 1	500 ppm	Foliar	0
EXP 1	450 g Ha ⁻¹ + 2.5 kg Ha ⁻¹	Drench	3
Acrobat + Kocide 2000		Foliar	7
Promix Biofungicide (soilless mix)	Growing media for transplants	-	At seeding

^a Foliar treatments were applied using water volume rate of 1000 L Ha⁻¹; for drench treatments, 5 mL pot⁻¹ of solution was applied to the soil using a syringe.

^b DAT = days after transplanting into inoculated soilless mix.

Table 2. Treatment list, application type, and application timing for evaluation of different fungicides and fungicide programs for management of Phytophthora crown and root rot in peppers, Ridgetown Campus Greenhouse, Ridgetown, ON, Trial 2, 2011.

Product	Product Rate	Type ^a	Timing (DPI) ^b
Nontreated control	-	-	-
Ranman	200 mL Ha ⁻¹	Foliar	0, 6, 12
EXP 1	500 ppm	Drench	-1, 6, 12
EXP 1 alt.	500 ppm	Drench	-1, 12
Allegro	400 mL Ha ⁻¹	Foliar	6
EXP 1 alt.	500 ppm	Drench	-1, 12
Acrobat + Kocide 2000	450 g Ha ⁻¹ + 2.5 kg Ha ⁻¹	Foliar	6
Revus	600 mL Ha ⁻¹	Drench	-1

^a Foliar treatments were applied using water volume rate of 1000 L Ha⁻¹; for drench treatments, 5 mL pot⁻¹ of solution was applied to the soil using a syringe.

^b DPI = days post-inoculation.

Table 3. Severity of canker and wilt symptoms in pepper cv. Hot Hungarian inoculated with *Phytophthora capsici* at the time of transplanting, Ridgetown Campus Greenhouse, Trial 1.

Treatment (method) (timing DAT) ^a	Stem Canker	Wilt Rating		
	(% area) 6 DAT ^b	8 DAT	13 DAT ^b	16 DAT ^b
Nontreated control	49.1 a ^c	4.8 a	5.0 a	5.0 a
Allegro @ 400 mL Ha ⁻¹ (F) (0, 7)	10.8 abc	4.0 a	4.9 a	5.0 a
Acrobat @ 450 g Ha ⁻¹ + Kocide 2000 @ 2.5 kg Ha ⁻¹ (F) (0, 7)	30.7 ab	4.4 a	4.9 a	5.0 a
Allegro @ 400 mL Ha ⁻¹ (F) (0); Acrobat @ 450 g Ha ⁻¹ + Kocide 2000 @ 2.5 kg Ha ⁻¹ (F) (7)	6.8 b-e	3.9 a	4.9 a	5.0 a
Revus @ 600 mL Ha ⁻¹ + Ranman @ 200 mL Ha ⁻¹ (PPD) (0); Revus @ 600 mL Ha ⁻¹ (D) (7)	1.4 d-g	2.0 b	4.4 a	5.0 a
Revus @ 600 mL Ha ⁻¹ (PPD) (0)	1.4 d-g	1.9 b	4.4 a	5.0 a
Ranman @ 200 mL Ha ⁻¹ (PPD) (0); Allegro @ 400 mL Ha ⁻¹ (F) (7)	0.0 g	1.0 bc	3.3 b	4.8 a
Ranman @ 200 mL Ha ⁻¹ (PPD) (0); Acrobat @ 450 g Ha ⁻¹ + Kocide 2000 @ 2.5 kg Ha ⁻¹ (F) (7)	0.8 efg	1.8 b	4.0 ab	4.8 a
ZAMPRO @ 1000 mL Ha ⁻¹ (F) (0); ZAMPRO @ 1000 mL Ha ⁻¹ (D) (7)	14.2 abc	3.6 a	5.0 a	5.0 a
ZAMPRO @ 1000 mL Ha ⁻¹ (D) (0); Allegro @ 400 mL Ha ⁻¹ (F) (7)	4.8 c-f	3.5 a	4.8 a	5.0 a
EXP 1 @ 500 ppm (F) (0); EXP 1 @ 500 ppm (D) (3, 7)	0.0 g	0.0 c	0.3 d	2.4 d
EXP 1 @ 500 ppm (F) (0); EXP 1 @ 500 ppm (D) (3); Allegro @ 400 mL Ha ⁻¹ (F) (7)	0.0 g	0.0 c	1.0 cd	4.0 b
EXP 1 @ 500 ppm (F) (0); EXP 1 @ 500 ppm (D) (3); Acrobat @ 450 g Ha ⁻¹ + Kocide 2000 @ 2.5 kg Ha ⁻¹ (F) (7)	0.3 fg	0.0 c	1.3 c	3.3 c
Promix Biofungicide (at seeding)	9.5 bcd	4.1 a	4.8 a	5.0 a

^a DAT = days after transplanting into inoculated soilless mix; for application method, F = foliar, PPD = pre-plant drench, D = drench.

^b Data was transformed using a log transformation; back-transformed means are shown here.

^c Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Duncan's new multiple range test. ns = not significant.

Table 4. Severity of wilt symptoms in pepper cv. Hot Hungarian inoculated with *Phytophthora capsici* 15 days after transplanting, Ridgetown Campus Greenhouse, Trial 2.

Treatment (method) (timing DPI) ^a	Wilt Rating							
	5 DPI	7 DPI	10 DPI	12 DPI	14 DPI	18 DPI	22 DPI	26 DPI
Nontreated control	0.6 b ^b	2.5 a	4.8 a	5.0 a	5.0 a	5.0 a	5.0 a	5.0 a
Ranman @ 200 mL Ha ⁻¹ (F) (0, 6, 12)	1.0 a	2.5 a	4.3 a	4.8 a	5.0 a	5.0 a	5.0 a	5.0 a
EXP 1 @ 500 ppm (D) (-1, 6, 12)	0.0 c	0.0 c	0.0 c	0.0 c	0.9 b	2.6 b	4.1 ab	3.8 ab
EXP 1 @ 500 ppm (D) (-1, 12); Allegro @ 400 mL Ha ⁻¹ (F) (6)	0.0 c	0.0 c	0.0 c	0.0 c	0.6 b	2.0 b	3.6 b	3.3 b
EXP 1 @ 500 ppm (D) (-1, 12); Acrobat @ 450 g Ha ⁻¹ + Kocide 2000 @ 2.5 kg Ha ⁻¹ (F) (6)	0.0 c	0.0 c	0.0 c	0.0 c	0.9 b	2.4 b	4.0 ab	3.6 b
Revus @ 600 mL Ha ⁻¹ (D) (-1)	0.4 bc	1.0 b	3.5 b	4.3 b	4.6 a	5.0 a	5.0 a	5.0 a

^a DPI = days post inoculation; for application method, F = foliar, D = drench.

^b Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Duncan's new multiple range test. ns = not significant.

TITLE: Screening products and fungicide programs for control of Phytophthora crown and root rot in the greenhouse, 2012

PEST(S): Phytophthora crown and root rot (*Phytophthora capsici*)

MATERIALS: Allegro (fluazinam 40%), Acrobat (dimethomorph 50%), Kocide 2000 (copper hydroxide 53.8%), Revus (mandipropamid 23.3%), Ranman (cyazofamid 34.5%), Zampro (ametoctradin 27% + dimethomorph 20.3%), EXP 1 (unknown), V10208 (unknown), Reason (fenamidone 500 g L⁻¹), Presidio (fluopicolide 39.5%), Promix Biofungicide (*Bacillus subtilis* MBI600 1 x 10⁷ CFU L⁻¹)

METHODS: Pepper cv. 'Hot Hungarian' was seeded into 128-cell trays on Jan 27. Pro-Mix PGX (Premier Tech Horticulture, Riviere-du-Loup, PQ) was used for all treatments except treatment Pro-Mix Biofungicide, where seeds were sown in Pro-Mix Biofungicide (Premier Tech Horticulture, Riviere-du-Loup, PQ). Peppers were fertilized with 200 ppm N using 20-20-20 on Feb 9, 17, 24, and Mar 2.

Peppers were transplanted into 4-inch pots filled with Pro-Mix PGX on March 12. After transplanting, plants were thoroughly watered before the first treatment application. The trial was arranged as a randomized complete block with eight replications per treatment and one plant per pot. Peppers were fertilized with 200 ppm N using 20-20-20 on Mar 10.

Inoculum was prepared by growing *Phytophthora capsici* obtained from C. Saude at the University of Guelph Simcoe Research Station on sterilized millet seed in sealed glass jars under fluorescent light. Inoculum was thoroughly mixed, weighed, and added to enough soilless mix (Fafard Growing Mix) for one 4-inch pot. The inoculated soilless mix was then transferred to pots one day prior to transplanting.

Treatments, application methods, and application timings are summarized in Table 1.

Peppers were monitored regularly for the development of disease symptoms. The percentage of the stem with crown rot symptoms and the severity of wilt, where 0 = no wilt and 5 = completely dead, were assessed on March 19, 23, and 26.

Statistical analysis was conducted using ARM 7 (Gylling Data Management, Brookings, SD). Analysis of variance was conducted using Duncan's new multiple range test and means comparisons were performed when $P \leq 0.05$.

RESULTS: Refer to Table 2.

CONCLUSIONS: Drench applications of EXP 1, Presidio, V10208, and Reason were most effective at delaying the onset of Phytophthora crown and root rot. Foliar applications of these products also reduced disease severity as compared to the nontreated control, but were not as effective as drench applications. Interestingly, seedlings grown in Promix Biofungicide has less stem area affected by canker than the nontreated control at 7 and 11 days post inoculation.

Table 1. Treatment list, application type, and application timing for evaluation of different fungicides and fungicide programs for management of Phytophthora crown and root rot in peppers, Ridgeway Campus Greenhouse, Ridgeway, ON, 2012.

Product	Product Rate	Type ^a	Timing (DAT) ^b
Nontreated control	-	-	-
Revus	584 mL Ha ⁻¹	Pre-plant drench	0
Allegro	400 mL Ha ⁻¹	Foliar	0, 7
Acrobat + Kocide 2000	450 g Ha ⁻¹ + 2.5 kg Ha ⁻¹	Foliar	0, 7
Ranman	200 mL Ha ⁻¹	Foliar	0, 7
Zampro	1 L Ha ⁻¹	Foliar	0, 7
Zampro	1 L Ha ⁻¹	Drench	0, 7
EXP 1	500 ppm	Foliar	0, 7
EXP 1	500 ppm	Drench	0, 7
Presidio	292 mL Ha ⁻¹	Foliar	0, 7
Presidio	292 mL Ha ⁻¹	Drench	0, 7
V10208	1120 mL Ha ⁻¹	Foliar	0, 7
V10208	1120 mL Ha ⁻¹	Drench	0, 7
Reason	600 mL Ha ⁻¹	Foliar	0, 7
Reason	600 mL Ha ⁻¹	Drench	0, 7
Promix Biofungicide (soilless mix)	Growing media for transplants	-	At seeding
Revus	600 mL Ha ⁻¹	Foliar	0, 7

^a Foliar treatments were applied using water volume rate of 1000 L Ha⁻¹; for drench treatments, 5 mL pot⁻¹ of solution was applied to the soil using a syringe.

^b DAT = days after transplanting into inoculated soilless mix.

Table 2. Severity of canker and wilt symptoms in pepper cv. 'Hot Hungarian' inoculated with *Phytophthora capsici* at the time of transplanting, Ridgetown Campus Greenhouse, 2012

Treatment	Stem Canker (% area)			Wilt Rating		
	7 DPI	11 DPI	14 DPI	7 DPI	11 DPI	14 DPI
Nontreated control	59 ab	97.1 a	95.7 a	4.4 a	4.9 a	5.0 a
Revus (pre-plant drench)	36 abc	82.9 ab	85.7 ab	2.6 bcd	4.1 ab	4.3 a
Allegro (foliar)	40 abc	97.1 a	100.0 a	4.3 4.3	5.0 a	5.0 a
Acrobat + Kocide 2000 (foliar)	64 a	100.0 a	100.0 a	4.0 abc	5.0 a	5.0 a
Ranman (foliar)	46 abc	98.6 a	100.0 a	3.9 a-d	4.9 a	5.0 a
Zampro (foliar)	44 abc	98.6 a	100.0 a	4.4 a	5.0 a	5.0 a
Zampro (drench)	44 abc	78.6 ab	98.6 a	2.7 a-d	4.6 a	5.0 a
EXP 1 (foliar)	27 cd	92.9 ab	100.0 a	2.1 d	5.0 a	5.0 a
EXP 1 (drench)	0 d	7.1 d	57.1 c	0.0 e	0.1 d	3.1 b
Presidio (foliar)	33 bc	77.1 ab	100.0 a	3.0 a-d	4.7 a	5.0 a
Presidio (drench)	0 d	14.3 d	71.4 bc	0.0 e	1.6 c	4.1 a
V10208 (foliar)	16 cd	85.7 ab	100.0 a	2.3 cd	5.0 a	5.0 a
V10208 (drench)	0 d	0.0 d	25.7 d	0.0 e	0.3 d	2.1 c
Reason (foliar)	23 cd	95.7 ab	100.0 a	3.6 a-d	5.0 a	5.0 a
Reason (drench)	0 d	48.6 c	95.7 a	0.1 e	3.7 b	4.9 a
Promix Biofungicide (at seeding)	21 cd	71.4 b	98.6 a	3.3 a-d	4.4 ab	5.0 a
Revus (foliar)	41 abc	98.6 a	100.0 a	4.3 ab	5.0 a	5.0 a

^a DPI = days post inoculation

^b Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Duncan's new multiple range test. ns = not significant.

TITLE: Screening products and fungicide programs for control of Phytophthora crown and root rot in the field, 2010

PEST(S): Phytophthora crown and root rot (*Phytophthora capsici*)

MATERIALS: Allegro (fluazinam 40%), Acrobat (dimethomorph 50%), Ranman (cyazofamid 34.5%), ZAMPRO (unknown), EXP 1 (unknown)

METHODS: A field trial was established near Amherstburg, Ontario in a grower field previously reported by collaborate Dave Pelletier (Settington's) to have pepper plants with symptoms of Phytophthora crown and root rot. Pepper cv. Super Sheperd (Italian sweet peppers) were transplanted on June 4 using a mechanical transplanter. Rows were spaced 1 m apart. Each replicate consisted of one 7 m row, and there were four replications per treatment.

Drip irrigation lines were installed 4 days after planting. The emitters were 12" apart. The drip lines were placed along the pepper rows as close to the plants as possible. A feeder line was placed in the walkway between replication 1 and 2, and between replication 3 and 4. An individual line was placed in each plot. A shut-off valve was used to connect individual lines of drip tape to the feeder line. Water was supplied by a water tank in the back of a pickup truck. The tank was connected to a transfer pump. A MixRite injector was used to introduce the treatments into the irrigation line. A pressure regulator (20 psi max) was placed in line between the transfer pump and the MixRite injector. The Injector was set to apply the treatment at 1:100 dilution rate. The valves on the lines for an individual treatment were opened and water was run through the lines to check for leaks. The treatment was placed in a beaker under the MixRite injector. The MixRite's feeder tube was placed in the beaker. When all of the treatment had entered the system, water was placed in the beaker. This allowed the MixRite to clean itself out and to protect the seals in the MixRite. Each treatment was irrigated for 1 hour to allow enough time for the treatment to move through the feeder lines and into the drip tape. After treatment, there was a band of wet ground approximately 10 cm in width along the row of the peppers. Sometimes, if the ground was very dry, individual circles of wet ground could be seen. Treatments and application timings are summarized in Table 1.

Disease incidence was monitored throughout the season and plants were monitored for symptoms of phytotoxicity. All peppers were harvested on Sept 2. All fruit were harvested and separated into immatures (too small to be marketed), mature green (full size, still green), breakers (full size with red and green colour), reds (full size and completely red), rots, and mummies (fruit dry with papery shell). The weight of fruit in each category was recorded.

Statistical analysis was conducted using ARM 7 (Gylling Data Management, Brookings, SD). Data were tested for normality using Bartlett's homogeneity of variance test. Data which were not normal ($P \leq 0.05$) were transformed using an arcsine, log, or square root transformation. Analysis of variance was

conducted using Duncan's new multiple range test and means comparisons were performed when $P \leq 0.05$.

RESULTS: The number and weight of breaker fruit was higher in treatment EXP 1 than the nontreated control, Acrobat, Ranman alt. Acrobat, Allegro, and EXP 1 alt. Acrobat (Table 2, Table 3). Treatment Ranman and ZAMPRO also had a higher number and weight of breaker fruit than Acrobat and EXP 1 alt. Acrobat. The number of red fruit was also higher for treatment EXP 1 than the nontreated control and Acrobat. Fruit weight for red fruit was higher in treatment Ranman than the nontreated control, Acrobat, Allegro, and EXP 1 alt. Acrobat. Treatments ZAMPRO and EXP 1 also had higher red fruit weight than the nontreated control, Acrobat, and Allegro. Marketable fruit number was higher in treatment EXP 1 than the nontreated control, Acrobat, Allegro, and EXP 1 alt. Acrobat. Ranman and ZAMPRO also produce more fruit than the nontreated control and Acrobat alone. Similarly, marketable fruit weight was higher in treatment EXP 1 than the nontreated control, Acrobat, and Allegro (Table 4).

No disease symptoms were observed on any plants in the trial. No phytotoxicity symptoms were observed in any treatments.

CONCLUSIONS: Applications of EXP 1 increased marketable fruit weight above levels in the nontreated control, indicating a yield benefit in the absence of severe symptoms of Phytophthora root rot. This effect was also noted for marketable fruit number in treatments EXP 1, Ranman, and ZAMPRO. One possible explanation is that these fungicides helped reduced the severity of other soilborne pathogens that are commonly present in Ontario soils (ie. *Pythium* spp.) however this was not evaluated in the current study. We are able to make any conclusions on the efficacy of products included in the trial because disease symptoms did not develop.

Table 1. Treatment list, application type, and application timing for evaluation of different fungicides and fungicide programs for management of Phytophthora crown and root rot in peppers, Essex County, ON, 2010.

Product	Product Rate	Type	Timing
Nontreated control	-	-	-
Acrobat	450 g Ha ⁻¹	Foliar	4, 9, 17, 23, 36, 43, 57, 72 DAT ^a
Ranman	200 mL Ha ⁻¹	Chemigation	4, 9, 17, 23, 35, 43, 57, 72 DAT
ZAMPRO	1 L Ha ⁻¹	Chemigation	4, 9, 17, 23, 35, 43, 57, 72 DAT
EXP 1	500 ppm	Chemigation	4, 9, 17, 23, 35, 43, 57, 72 DAT
Ranman alt.	200 mL Ha ⁻¹	Chemigation	4, 17, 35, 57 DAT
Acrobat	450 g Ha ⁻¹	Foliar	9, 23, 43, 72 DAT
Allegro	400 mL Ha ⁻¹	Foliar	4, 9, 17, 23, 36, 43, 57, 72 DAT
EXP 1 alt.	500 ppm	Chemigation	4, 17, 35, 57 DAT
Acrobat	450 g Ha ⁻¹	Foliar	9, 23, 43, 72 DAT

^a DAT = days after transplanting.

Table 2. Number of harvested fruit in peppers treated with different fungicides for management of Phytophthora crown and root rot, Essex County, ON, 2010.

Treatment	No. of Fruit					
	Immature	Greens	Breakers	Reds	Rots	Mummies
Nontreated control	41.0 ns ^a	16.3 ns	9.8 bc	32.3 b	1.5 a	0.8 ab
Acrobat	39.5	21.8	7.0 c	31.3 b	1.8 a	0.5 ab
Ranman	43.8	17.8	14.5 ab	45.8 a	3.8 ab	0.0 b
ZAMPRO	39.8	23.3	15.3 ab	42.8 ab	5.5 b	0.8 ab
EXP 1	41.3	22.3	20.3 a	45.5 a	3.0 ab	0.0 b
Ranman alt. Acrobat	37.3	22.5	10.5 bc	39.3 ab	2.5 ab	2.5 a
Allegro	53.0	19.8	10.5 bc	33.8 ab	0.8 a	0.8 ab
EXP 1 alt. Acrobat	49.3	19.5	5.8 c	39.5 ab	3.0 ab	0.0 b

^a Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Duncan's new multiple range test. ns = not significant.

Table 3. Weight of harvested fruit in peppers treated with different fungicides for management of *Phytophthora* crown and root rot, Essex County, ON, 2010.

Treatment	Weight (kg) ^a				
	Immature	Greens ^b	Breakers	Reds	Rots
Nontreated control	0.95 ns ^c	1.43 ns	1.05 bc	3.25 c	0.02 ns
Acrobat	0.84	1.93	0.79 c	3.08 c	0.12
Ranman	1.21	1.51	1.71 ab	4.97 a	0.20
ZAMPRO	0.94	1.56	1.82 ab	4.63 ab	0.21
EXP 1	0.81	1.82	2.27 a	4.86 ab	0.11
Ranman alt. Acrobat	0.88	1.90	1.17 bc	4.00 abc	0.09
Allegro	1.27	1.50	1.04 bc	3.20 c	0.03
EXP 1 alt. Acrobat	0.96	5.06	0.54 c	3.65 bc	0.14

^a Mummies are not included because weight could not be recorded to 0.01 kg.

^b Data is not normal and could not be normalized using square root or log transformations.

^c Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Duncan's new multiple range test. ns = not significant.

Table 4. Total number and weight of marketable (greens, breakers, red) and nonmarketable fruit (immatures, rots, mummies) in peppers treated with different fungicides for management of *Phytophthora* crown and root rot, Essex County, ON, 2010.

Treatment	Fruit (#)			Weight (kg)		
	M ^a	NM	Total	M ^b	NM	Total ^b
Nontreated control	58.3 d ^c	2.3 b	101.5 ns	6.52 b	0.02 ns	7.43 b
Acrobat	60.0 d	2.3 b	101.8	6.60 b	0.12	7.57 b
Ranman	78.0 abc	3.8 ab	125.5	9.03 ab	0.20	10.40 ab
ZAMPRO	81.3 ab	6.3 a	127.3	9.19 ab	0.21	10.44 ab
EXP 1	88.0 a	3.0 ab	132.3	9.83 a	0.11	10.72 a
Ranman alt. Acrobat	72.3 a-d	5.0 ab	114.5	7.92 ab	0.09	8.82 ab
Allegro	64.0 cd	1.5 b	118.5	6.67 b	0.03	7.93 ab
EXP 1 alt. Acrobat	64.8 bcd	3.0 ab	117.0	8.60 ab	0.14	9.78 ab

^a M = marketable, NM = nonmarketable.

^b Data was transformed using a log transformation; back-transformed means are shown here.

^c Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Duncan's new multiple range test. ns = not significant.

TITLE: Screening products and fungicide programs for control of Phytophthora crown and root rot in the field, 2011

PEST(S): Phytophthora crown and root rot (*Phytophthora capsici*)

MATERIALS: Allegro (fluazinam 40%), Ranman (cyazofamid 34.5%), Zampro (ametoctradin 27% + dimethomorph 20.3%), EXP 1 (unknown), Revus (mandipropamid 23.3%)

METHODS: A field trial was established near Amherstburg, Ontario in a grower field previously reported by collaborator Dave Pelletier (Settington's) to have pepper plants with symptoms of Phytophthora crown and root rot. Pepper cv. Super Sheperd (Italian sweet peppers) was transplanted on June 4 using a mechanical transplanter. Rows were spaced 1 m apart and spacing within rows was 57 cm. Each replicate consisted of one 7 m row, and there were four replications per treatment.

Drip irrigation lines were installed after planting. The emitters were 4" apart. The drip lines were placed along the pepper rows as close to the plants as possible. A shut-off valve was used to connect individual lines of drip tape to the feeder line. Water was supplied by a water tank in the back of a pickup truck. The tank was connected to a transfer pump. A MixRite injector was used to introduce the treatments into the irrigation line. A pressure regulator (20 psi max) was placed in line between the transfer pump and the MixRite injector. The injector was set to apply the treatment at 1:100 dilution rate. The valves on the lines for an individual treatment were opened and water was run through the lines to check for leaks. The treatment was placed in a beaker under the MixRite injector. The MixRite's feeder tube was placed in the beaker. When all of the treatment had entered the system, water was placed in the beaker. This allowed the MixRite to clean itself out and to protect the seals in the MixRite. Once the spray solution was injected, the water was run for 30 to 45 minutes to clear the oval hose of spray material. Foliar treatments were applied using a 1 m handheld boom (35 psi, water volume 200 L Ha⁻¹). The drench treatment was applied by soaking the transplant tray in the product solution. Treatments and application timings are summarized in Table 1.

Disease incidence was monitored throughout the season and plants were monitored for symptoms of phytotoxicity. Red peppers from the whole plot were harvested on Aug 22. All peppers were harvested on Sept 29 from a 4 m section in each plot. Peppers on Sept 29 were separated into mature green (full size, still green), breakers (full size with red and green colour), reds (full size and completely red), and rots. The weight of fruit in each category was recorded.

Statistical analysis was conducted using ARM 7 (Gylling Data Management, Brookings, SD). Data were tested for normality using Bartlett's homogeneity of variance test. Data which were not normal ($P \leq 0.05$) were transformed using an arcsine, log, or square root transformation. Analysis of variance was conducted using Duncan's new multiple range test and means comparisons were performed when $P \leq 0.05$.

RESULTS: Fewer fruit were harvested in treatment Revus than all other treatments on Aug 22. There were no differences in the number of fruit harvested on Sept 29. Total fruit weight was also lower in treatment Revus than in all other treatments.

CONCLUSIONS: No disease symptoms develop in the trial so we were unable to evaluate the efficacy of the products and application programs on reducing the incidence of Phytophthora crown and root rot. Applications of Revus appeared to negatively impact pepper yield in this trial.

Table 1. Treatment list, application type, and application timing for evaluation of different fungicides and fungicide programs for management of Phytophthora crown and root rot in peppers, Essex County, ON, 2011.

Product	Product Rate	Type	Timing
Nontreated control	-	-	-
Allegro	400 mL Ha ⁻¹	Foliar	3, 11, 19, 36, 47 DAT
Ranman	200 mL Ha ⁻¹	Chemigation	3, 11, 19, 36, 47 DAT
Revus	600 mL Ha ⁻¹	Transplant Drench	0 DAT
Ranman alt.	200 mL Ha ⁻¹	Chemigation	3, 19, 47 DAT
Allegro	400 mL Ha ⁻¹	Foliar	11, 36 DAT
Zampro	1.0 L Ha ⁻¹	Chemigation	3, 11, 19, 36, 47 DAT
Zampro alt.	200 mL Ha ⁻¹	Chemigation	3, 19, 47 DAT
Allegro	400 mL Ha ⁻¹	Foliar	11, 36 DAT
EXP 1	2.8 L Ha ⁻¹	Chemigation	3, 11, 19, 36, 47 DAT
EXP 1 alt.	2.8 L Ha ⁻¹	Chemigation	3, 19, 47 DAT
Allegro	400 mL Ha ⁻¹	Foliar	11, 36 DAT

^a DAT = days after transplanting.

Table 2. Number of harvested fruit in peppers treated with different fungicides for management of Phytophthora crown and root rot, Essex County, ON, 2011.

Treatment	No. of Fruit					Season Total
	Aug 22	Sept 29				
	Red	Greens	Breakers	Reds	Total	
Nontreated control	12.0 a ^a	51.5 ns	7.5 ns	17.0 ns	76.0 ns	88.0 ab
Allegro	9.0 a	53.0	7.3	30.0	90.3	99.3 a
Ranman	12.3 a	62.3	8.0	30.5	100.8	113.0 a
Revus	1.3 b	29.8	6.3	28.8	64.8	66.0 b
Ranman alt. Allegro	12.5 a	60.0	7.8	25.5	93.3	105.8 a
Zampro	11.0 a	52.5	12.0	30.0	94.5	105.5 a
Zampro alt. Allegro	9.5 a	50.0	5.5	25.5	81.0	90.5 ab
EXP 1	12.5 a	51.3	5.0	23.3	79.5	92.0 ab
EXP 1 alt. Allegro	12.8 a	43.3	10.3	26.3	79.8	92.5 ab

^a Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Duncan's new multiple range test. ns = not significant.

Table 3. Weight of harvested fruit in peppers treated with different fungicides for management of *Phytophthora* crown and root rot, Essex County, ON, 2011.

Treatment	Weight (kg)					Season Total
	Aug 22	Sept 29				
	Red	Greens	Breakers	Reds	Total	
Nontreated control	1.22 ns ^a	3.24 ns	0.89 ns	2.37 ns	6.50 ns	7.72 ab
Allegro	0.95	3.67	0.79	3.58	8.03	8.97 a
Ranman	1.29	4.09	0.76	4.07	8.90	10.19 a
Revus	0.08	2.74	0.71	2.52	5.96	6.04 b
Ranman alt. Allegro	1.30	4.08	0.79	3.31	8.18	9.48 a
Zampro	1.19	3.32	1.21	4.06	8.59	9.78 a
Zampro alt. Allegro	1.02	3.12	0.62	3.21	6.94	7.95 ab
EXP 1	1.05	3.32	0.53	2.81	6.65	7.70 ab
EXP 1 alt. Allegro	1.15	3.00	0.90	3.24	7.14	8.29 ab

^a Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Duncan's new multiple range test. ns = not significant.

TITLE: Screening products and fungicide programs for control of Phytophthora crown and root rot in the field, 2012

PEST(S): Phytophthora crown and root rot (*Phytophthora capsici*)

MATERIALS: Revus (mandipropamid 23.3%), EXP 1 (unknown), V10208 (unknown), Presidio (fluopicolide 39.5%)

METHODS: A field trial was established near Leamington, Ontario in a grower field previously reported to have tomato plants with symptoms of Phytophthora crown and root rot. Pepper cv. Red Knight was transplanted on June 5 using a mechanical transplanter. Rows were spaced 1.5 m apart and plant spacing within rows was 33 cm. Each replicate consisted of one 7 m row, and there were four replications per treatment.

Drip irrigation lines were installed after planting. The emitters were 4" apart. The drip lines were placed along the pepper rows as close to the plants as possible. A shut-off valve was used to connect individual lines of drip tape to the feeder line. Water was supplied by a water tank in the back of a pickup truck. The tank was connected to a transfer pump. A MixRite injector was used to introduce the treatments into the irrigation line. A pressure regulator (20 psi max) was placed in line between the transfer pump and the MixRite injector. The injector was set to apply the treatment at 1:100 dilution rate. The valves on the lines for an individual treatment were opened and water was run through the lines to check for leaks. The treatment was placed in a beaker under the MixRite injector. The MixRite's feeder tube was placed in the beaker. When all of the treatment had entered the system, water was placed in the beaker. This allowed the MixRite to clean itself out and to protect the seals in the MixRite. Once the spray solution was injected, the water was run for 45 minutes to clear the oval hose of spray material. Foliar treatments were applied using a 1 m handheld boom (35 psi, water volume 200 L Ha⁻¹). The drench treatment was applied by soaking the transplant tray in the product solution. Treatments and application timings are summarized in Table 1.

Disease incidence was monitored throughout the season and plants were monitored for symptoms of phytotoxicity. Peppers from the whole plot were harvested on Aug 1 and Aug 17. The number and weight of fruit in each category was recorded. The final harvest data is not included in this report because it was due prior to the final harvest being completed.

Statistical analysis was conducted using ARM 7 (Gylling Data Management, Brookings, SD). Data were tested for normality using Bartlett's homogeneity of variance test. Data which were not normal ($P \leq 0.05$) were transformed using an arcsine, log, or square root transformation. Analysis of variance was conducted using Duncan's new multiple range test and means comparisons were performed when $P \leq 0.05$.

RESULTS: There were no differences among treatments for the number of wilted plants, number of peppers harvested, or harvest weight (Table 2 and Table 3).

CONCLUSIONS: Disease incidence was very low, and we were unable to determine if any of the spray programs provided better disease management than the nontreated control. None of the treatments appeared to negatively impact yield.

Table 1. Treatment list, application type, and application timing for evaluation of different fungicides and fungicide programs for management of Phytophthora crown and root rot in peppers, Essex County, ON, 2012.

Product	Product Rate	Type	Timing
Nontreated control	-	-	-
Revus	140 mL/Ha ^b	Prior to transplanting	0 DAP
EXP1	1400 mL/Ha	Drip	1, 8, 15, 22, 31, 38 DAP
EXP1	1400 mL/Ha	Foliar	1, 8, 15, 22, 31, 38 DAP
V-10208	1120 mL/Ha	Drip	1, 8, 15, 22, 31, 38 DAP
V-10208	1120 mL/Ha	Foliar	1, 8, 15, 22, 31, 38 DAP
Presidio	292 L/Ha	Drip	1, 8, 15, 22, 31, 38 DAP
Presidio	292 L/Ha	Foliar	1, 8, 15, 22, 31, 38 DAP
Revus	584 mL/Ha	Prior to transplanting	0 DAP
EXP1	500 ppm	Foliar	1, 22 DAP
V-10208	1120 mL/Ha	Foliar	8, 31 DAP
Presidio	292 mL/Ha	Foliar	15, 38 DAP
Revus	584 mL/Ha	Prior to transplanting	0 DAP
EXP1	500 ppm	Drip	1, 22 DAP
V-10208	1120 mL/Ha	Drip	8, 31 DAP
Presidio	292 mL/Ha	Drip	15, 38 DAP

^a DAT = days after transplanting.

^b Trays were soaked in solution just prior to transplanting. The target product rate was 584 mL / Ha, but the plugs were completely saturated and only the equivalent of 140 mL / Ha was absorbed.

Table 2. Number of wilted plants in peppers treated with different fungicides for management of Phytophthora crown and root rot, Essex County, ON, 2012.

Treatment (P = preplant; F = foliar; D = drip)	No. of Wilted Plants ^a		
	Jul 25	Aug 1	Aug 17
Nontreated control	0.3 ns ^b	0.0 ns	0.0 ns
Revus (P)	0.3	0.0	0.0
EXP1 (D)	0.0	0.0	0.0
EXP1 (F)	0.3	0.0	0.0
V-10208 (D)	0.0	0.0	0.0
V-10208 (F)	0.3	0.3	0.3
Presidio (D)	0.0	0.0	0.0
Presidio (F)	0.0	0.0	0.0
Revus (P) followed by EXP1 (F) alt. V-10208 (F) alt. Presidio (F)	0.3	0.3	0.3
Revus (P) followed by EXP1 (D) alt. V-10208 (D) alt. Presidio (D)	0.0	0.0	0.0

^a Fruit yield and weight adjusted to represent 21 plants per plot.

^b Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Duncan's new multiple range test. ns = not significant.

Table 3. Number and weight of harvested fruit in peppers treated with different fungicides for management of Phytophthora crown and root rot, Essex County, ON, 2012.

Treatment (P = preplant; F = foliar; D = drip)	No. of Fruit Per Plot ^a		Weight (kg) per Plot ^a	
	Aug 1	Aug 17	Aug 1	Aug 17
Nontreated control	72.3 ns ^b	62.3 ns	9.06 ns	10.73 ns
Revus (P)	77.3	54.5	9.45	9.16
EXP1 (D)	82.3	44.4	11.56	7.23
EXP1 (F)	76.4	53.1	9.99	7.97
V-10208 (D)	72.4	57.7	10.15	9.88
V-10208 (F)	64.6	58.9	8.79	9.62
Presidio (D)	79.2	46.7	11.19	7.12
Presidio (F)	70.5	54.1	9.19	8.81
Revus (P) followed by EXP1 (F) alt. V-10208 (F) alt. Presidio (F)	67.9	47.5	8.76	7.58
Revus (P) followed by EXP1 (D) alt. V-10208 (D) alt. Presidio (D)	63.5	57.5	10.54	9.03

^a Fruit yield and weight adjusted to represent 21 plants per plot.

^b Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Duncan's new multiple range test. ns = not significant.