2022 OTRI Funding			
	Title	**Researcher**	**$ Amount Funded**
1	Weed Control Evaluations in Processing Tomatoes (Robinson $5,000 - Nurse $3,000)	D Robinson / R. Nurse	$8,000
2	Problem Weed Management in Processing Tomatoes (Robinson $5,000 - Nurse $3,000)	D. Robinson / R. Nurse	$8,000
3	Low and high rates of chlorothalonil for management of late blight in processing tomatoes	C. Trueman	$2,500
4	Fungicide efficacy evaluations for early blight, Septoria leaf spot, anthracnose, and black mold in processing tomatoes	C. Trueman	$4,500
5	Early season insect management in field tomatoes (Part I) – 3-year term	C. Trueman	$4,971/year
6	Early season insect management in field tomatoes (Part II) – 3-year term	C. Trueman	$4,988/year
7	Early season insect management in field tomatoes (Part III) – 3-year term	C. Trueman	$4,994/year
8	Susceptibility of tomato reproductive stages to asymptomatic infection by *Phytophthora capsici*, casual agent of severe buckeye fruit rot	C. Trueman	$4,500
9	Processing tomato cultivar trials, 2022	S. Loewen	$5,000
	Multi-Year Funding Agreed to		
	Processing tomato breeding (2 years remaining) $55,375 (incl. 25% overhead)	S. Loewen	
	Late blight surveillance and management - Part I (one year remaining due to postponement) $9,085	C. Trueman/ Tomecek Agronomy	
	Late blight surveillance and management - Part II (one year remaining) $6,900	C. Trueman/ Tomecek Agronomy	

Project Title: Weed Control and Problem Weed Management in Processing Tomatoes

Research Agency: Ridgetown Campus, University of Guelph

Lead Investigator: Darren Robinson

Executive Summary:

The purpose of this research was to examine i) options for control of certain problem weeds in tomatoes (ie. eastern black nightshade, triazine-resistant lambsquarters and crabgrass), ii) to evaluate postemergence tank mixes for control of annual broadleaf weeds, and iii) to determine the applicability of tank mixing various preemergence (PRE) herbicides.

To meet the first objective of this work, two trials were established to determine tolerance of transplanted tomato to pre-transplant applications of Reflex and pethoxamid. There was very little injury other than some leaf distortion. Tomato showed excellent tolerance to both herbicides in both trials.

Four studies were set up to determine the tolerance of tomatoes to different rate combinations of Sandea (between 14 and 28 g/ac), and either Prism (between 24 and 56 g/ac) or Sencor (120 and 180 ml/ac of Sencor L) applied POST to tomatoes. None of the tank mix combinations caused more than 10% injury, and they did not reduce plant dry weight (at late flower) or yield of tomato.

Two trials, each on a different soil type (ie. sandy clay loam and loamy sand), were conducted to determine differences in weed control and crop tolerance to two-, three-, and four-way tank mixtures of Authority, Sencor, Prowl and Zidua. We also examined Authority Supreme, which is a combination of Authority and Zidua. At both two locations (ie. **on the loamy sand and the loam soil)**, there was significant injury when Zidua or Authority Supreme was included in tank mix with Prowl. The injury in these two treatments lead to a yield reduction, but yields tended to be less than other treatments. In 2021, on the loam soil, none of the treatments lead to significant injury or yield loss in tomato. We had a heavy rainfall event (>2") within 7 days of transplanting that may have been responsible for the increase in injury and yield loss observed in 2022.

Objectives:

1) To determine the best weed control option(s) for control of eastern black nightshade, triazine resistant lambsquarters and crabgrass.

2) To evaluate the effect of tank mixing Sencor, Prism or Pinnacle with Sandea for control of annual broadleaf weeds.

3) To evaluate effect of tank mixing Authority, Sencor, Dual II Magnum and Prowl H2O prior to transplanting for control of eastern blacknightshade.

TRIAL 1: TOLERANCE OF TOMATOES TO PRE-TRANSPLANT HERBICIDES – BROADLEAF HERBICIDES

Materials and Methods

Crop: *Tomato*

Variety: N3306	Planting date: May 25/22
Planting rate: 11803 plants/ac	Depth: 5 cm
Row spacing: 1.5m	Plant spacing: 45 cm

Design: Randomized Complete Block Design

Plot width: 1.5m	Plot length: 10m
Reps: 4	

Field Preparation: Field was worked with an S-tine cultivator and fertilizer was applied at 150 kg N/ha on May 20.

Soil Description:

Sand: 50% and 57%	OM: 4.1% and 2.8%
Silt: 28% and 20%	pH: 6.2 and 7.7
Clay: 22% and 22%	CEC 12.4 and 16.0

Texture: Loamy Sand and Loam
Soil: Both in the Watford/Brady series

Application Information:

	A
APPLICATION DATE	MAY 24/22
TIME OF DAY	6:30AM and 7:00AM
TIMING	PRE-T
AIR TEMP (c)	18 and 21
RH (%)	80 and 75
WIND SPEED (KPH)	3 and 3
SOIL TEMP (c)	15 and 15
CLOUD COVER (%)	25

Spray Equipment:

Application Method: CO2 Backpack	Pressure: 207 KPA (30 PSI)
Nozzle Type: Air Induction	Nozzle Size: ULD120-02
Nozzle Spacing: 50 cm (20")	Boom Width: 1.5 m (60")
Spray Volume: 200 L/ha (20 GAL/AC)	

Results:

Injury ratings were 1% or less, dry weights ranged from 76 to 84 g/plant, and yield ranged from 40 to 43 T/ac (Table 1.1). Plant dry weight and tomato yield were similar to the untreated check in all treatments.

Table 1.1. Effect of herbicide treatment on tomato visual injury 7, 14 and 28 days after planting, plant dry weight 28 days after planting, and yield.

HERBICIDE	RATE	VISUAL INJURY			DRY WT	YIELD
		7D	14D	28D	G	T/AC
1. Check (WEEDFREE)		0B	0	0	78	42
2. REFLEX	400 ML/AC	0B	0	0	76	41
3. REFLEX	800 ML/AC	1A	0	0	84	43
4. pethoxamid	1200 g/AC	0B	0	0	83	43
5. pethoxamid	2400 g/AC	0B	0	0	82	40
LSD (P <0.05)		1	NS	NS	NS	NS

Note: Means followed by the same letter are not significantly different (P=0.05, LSD).

Conclusions:

Two trials were established to determine tolerance of transplanted tomato to pre-transplant applications of Reflex and pethoxamid. There was very little injury other than some leaf distortion. Tomato showed excellent tolerance to both herbicides in both trials.

TRIAL 2: TOLERANCE OF TOMATO TO POST APPLICATIONS OF SANDEA AND PRISM

Materials & Methods:

Crop: *Tomato*

Variety: N3306	Planting date: May 25/22
Planting rate: 11803 plants/ac	Depth: 5 cm
Row spacing: 1.5m	Plant spacing: 45 cm

Design: Randomized Complete Block Design

Plot width: 1.5m	Plot length: 10m
Reps: 4	

Field Preparation: Field was worked with an S-tine cultivator and fertilizer was applied at 150 kg N/ha on May 12.

Soil Description:

Sand: 50% and 57%	OM: 4.1% and 2.8%
Silt: 28% and 20%	pH: 6.2 and 7.7
Clay: 22% and 22%	CEC 12.4 and 16.0

Texture: Loamy Sand and Loam
Soil: Both in the Watford/Brady series

Application Information:

	A
APPLICATION DATE	JUN 15
TIME OF DAY	8:00 AM and 9:00 AM
TIMING	POST (21DAYS AFTER TRANSPLANTING)
AIR TEMP (c)	25 and 27
RH (%)	50 and 45
WIND SPEED (KPH)	4 and 6
SOIL TEMP (c)	26 and 29
CLOUD COVER (%)	0
CROP STAGE	9 LEAF

Spray Equipment:

Application Method: CO2 Backpack	Pressure: 207 KPA (30 PSI)
Nozzle Type: Air Induction	Nozzle Size: ULD120-02
Nozzle Spacing: 50 cm (20")	Boom Width: 1.5 m (60")
Spray Volume: 200 L/ha (20 GAL/AC)	

Results:

Injury ratings were all less than 10%, and tomato yields were all statistically similar to the untreated check (Table 2.1). Injury was 7, 8 and 9% at 7 days after treatments at the high rate of Sandea, where it was applied alone and with 24 or 56 g/ac of Prism. Yields ranged from 39 T/ac (Prism alone at 24 g/ac) to 47 T/ac (Sandea + Prism – 14 g/ac + 24 g/ac).

Table 2.1. Effect of different rates of Sandea plus Prism treatments on percent injury at 7 and 28 days after treatment (DAT) and tomato marketable yield (T/ac).

SANDEA RATE	PRISM RATE	PERCENT INJURY 7 DAT	PERCENT INJURY 28 DAT	Yield (T/ac)
14 G/AC	NA	1A	0A	42A
21 G/AC	NA	2A	2A	44A
28 G/AC	NA	7A	3A	40A
NA	24 G/AC	0A	0A	39A
NA	56 G/AC	3A	2A	43A
14 G/AC	24 G/AC	2A	1A	47A
21 G/AC	24 G/AC	4A	1A	42A
28 G/AC	24 G/AC	8A	1A	41A
14 G/AC	56 G/AC	3A	1A	43A
21 G/AC	56 G/AC	5A	2A	42A
28 G/AC	56 G/AC	9A	5A	44A
LSD (P <0.05)		NS	NS	NS

Note: Means followed by the same letter are not significantly different (P=0.05, LSD).

Conclusions: The purpose of this study was to determine the tolerance of tomatoes to different rate combinations of Sandea (between 14 and 28 g/ac) and Prism (between 24 and 56 g/ac) applied POST to tomatoes. None of the tank mix combinations caused commercially significant injury, nor did they reduce plant dry weight (at late flower) or yield of tomato. Tomato yield was 41 T/ac in the untreated weedfree check, and ranged from 39 to 47 T/ac among all treatments – none of which were significantly different than one another.

TRIAL 3: TOLERANCE OF TOMATO TO POST APPLICATIONS OF SANDEA AND SENCOR

Objective: Determine the effect of different rates of POST applications of Sandea + Sencor on tomato tolerance.

Materials & Methods:

Crop: *Tomato*

Variety: N3306

Planting date: May 25/22

Planting rate: 11803 plants/ac

Depth: 5 cm

Row spacing: 1.5m

Plant spacing: 45 cm

Design: Randomized Complete Block Design

Plot width: 1.5m

Plot length: 10m

Reps: 4

Field Preparation: Field was worked with an S-tine cultivator and fertilizer was applied at 150 kg N/ha on May 20.

Soil Description:

Sand: 50% and 57%

Silt: 28% and 20%

Clay: 22% and 22%

OM: 4.1% and 2.8%

pH: 6.2 and 7.7

CEC 12.4 and 16.0

Texture: Loamy Sand and Loam

Soil: Both in the Watford/Brady series

Application Information:

	A
APPLICATION DATE	JUN 15
TIME OF DAY	8:00 AM and 9:00 AM
TIMING	POST (21DAYS AFTER TRANSPLANTING)
AIR TEMP (c)	26 and 27
RH (%)	50 and 45
WIND SPEED (KPH)	4 and 3
SOIL TEMP (c)	26 and 29
CLOUD COVER (%)	0
CROP STAGE	9 LEAF

Spray Equipment:

Application Method: CO2 Backpack

Nozzle Type: Air Induction

Nozzle Spacing: 50 cm (20")

Spray Volume: 200 L/ha (20 GAL/AC)

Pressure: 207 KPA (30 PSI)

Nozzle Size: ULD120-02

Boom Width: 1.5 m (60")

Results:

Injury ratings were all less than 10%, and tomato yields were all statistically similar to the untreated check (Table 3.1). Injury was 6, 7 and 8% at 7 days after treatments at the high rate of Sandea, where it was applied alone and with 120 or 180 ml/ac of Sencor. Yields ranged from 40 T/ac (Sandea + Sencor at 14 g/ac + 180 ml/ac) to 49 T/ac (Sencor alone – 120 ml/ac).

Table 3.1. Effect of different rates of Sandea plus Sencor treatments on percent injury at 7 and 28 days after treatment (DAT) and tomato marketable yield (T/ac).

SANDEA RATE	SENCOR RATE	PERCENT INJURY 7 DAT	28 DAT	Yield (T/ac)
14 G/AC	NA	1A	0A	48A
21 G/AC	NA	2A	1A	46A
28 G/AC	NA	6A	3A	45A
NA	120 ML/AC	1A	1A	49A
NA	180 ML/AC	1A	0A	47A
14 G/AC	120 ML/AC	0A	0A	43A
21 G/AC	120 ML/AC	1A	0A	44A
28 G/AC	120 ML/AC	7A	4A	42A
14 G/AC	180 ML/AC	2A	0A	40A
21 G/AC	180 ML/AC	2A	2A	45A
28 G/AC	180 ML/AC	8A	5A	42A
LSD (P <0.05)		NS	NS	NS

Note: Means followed by the same letter are not significantly different (P=0.05, LSD).

Conclusions:
The purpose of this study was to determine the tolerance of tomatoes to different rate combinations of Sandea (between 14 and 28 g/ac) and Sencor micro-rates (between 120 and 180 ml/ac) applied POST to tomatoes. None of the tank mix combinations caused commercially significant injury, nor did they reduce plant dry weight (at late flower) or yield of tomato. Tomato yield was 45 T/ac in the untreated weedfree check, and ranged from 40 to 49 T/ac among all treatments – none of which were significantly different than one another.

TRIAL 4: WEED MANAGEMENT WITH AUTHORITY, PROWL AND SENCOR PRE-TRANSPLANT TANK MIXES

Materials & Methods:

Crop: *Tomato*
Variety: N3306
Planting date: May 25/22
Planting rate: 11803 plants/ac
Depth: 5 cm
Row spacing: 1.5m
Plant spacing: 45 cm

Design: Randomized Complete Block Design
Plot width: 1.5m
Plot length: 10m
Reps: 4

Field Preparation: Field was worked with an S-tine cultivator and fertilizer was applied at 150 kg N/ha on May 20.

Soil Description:
Sand: 50% and 57%
OM: 4.1% and 2.8%
Silt: 28% and 20%
pH: 6.2 and 7.7
Clay: 22% and 22%
CEC 12.4 and 16.0

Texture: Loamy Sand and Loam
Soil: Both in the Watford/Brady series

Application Information:

	A
APPLICATION DATE	MAY 24/22
TIME OF DAY	7:30AM and 8:00AM
TIMING	PRE-T
AIR TEMP (c)	22 and 25
RH (%)	70 and 65
WIND SPEED (KPH)	2 and 2
SOIL TEMP (c)	15 and 15
CLOUD COVER (%)	25

Spray Equipment:
Application Method: CO_2 Backpack
Pressure: 207 KPA (30 PSI)
Nozzle Type: Air Induction
Nozzle Size: ULD120-02
Nozzle Spacing: 50 cm (20")
Boom Width: 1.5 m (60")
Spray Volume: 200 L/ha (20 GAL/AC)

Results:
Injury was much greater in the experiment conducted on the loamy sand (Table 4.1) than the experiment on the loam soil (Table 4.2), so data were not combined for the analysis. Visual injury ranged from 1 to 3% among all treatments at 7 DAT, but was 4 to 15% at 28 DAT (Table 4.1). Yield ranged from 47 T/ac in the Dual + Sencor + Prowl treatment to 58 T/ac in the untreated, weed-free check. Tomato yields were equal to the untreated, weed-free check in the Authority, Dual + Sencor, Dual + Sencor + Prowl and Dual + Sencor + Authority + Prowl treatments. The tank mix of Dual + Authority + Prowl and Dual + Authority Supreme + Prowl treatments were 42 and 44 T/ac, respectively – both were less than the untreated, weed-free check.

On the loamy sand trial, visual injury in tomato was less than 3% and yields were similar to the untreated check in all treatments (Table 4.2).

Table 4.1. Effect of Authority, Prowl and Sencor herbicide tank mix treatments on tomato injury at 7 and 28 days after treatment and marketable yield in the treated, weedfree sub-plots – loamy sand soil.

TREATMENT	VISUAL INJURY		YIELD
	7D	28D	(T/AC)
UNTREATED	0A	0C	54A
AUTHORITY	2A	7B	53A
AUTHORITY SUP	4A	15A	47AB
DUAL + SENCOR	2A	2C	53A
DUAL + SENCOR + PROWL	1A	4B	47AB
DUAL + AUTHORITY + PROWL	4A	18A	40B
DUAL + AUTHORITY SUPREME + PROWL	3A	10A	46B
DUAL + SENCOR AUTHORITY + PROWL	4A	8A	48AB
LSD (P <0.05)	NS	5	8

Note 1: Means followed by the same letter are not significantly different (P=0.05, LSD).

Table 4.2. Effect of Authority, Prowl and Sencor herbicide tank mix treatments on tomato injury at 7 and 28 days after treatment and marketable yield in the treated, weedfree sub-plots – loam soil.

TREATMENT	VISUAL INJURY		YIELD
	7D	28D	(T/AC)
UNTREATED	0A	0B	47A
AUTHORITY	2A	0B	46A
AUTHORITY SUP	3A	8A	38B
DUAL + SENCOR	2A	3B	48A
DUAL + SENCOR + PROWL			
DUAL + AUTHORITY + PROWL	3A	1B	45A
DUAL + AUTHORITY SUPREME + PROWL	3A	8A	36B
DUAL + SENCOR AUTHORITY + PROWL	3A	3B	45A
LSD (P <0.05)	NS	4	3

Note 1: Means followed by the same letter are not significantly different (P=0.05, LSD).

Conclusions: Two trials, each on a different soil type (ie. loam and loamy sand), were conducted to determine differences in weed control and crop tolerance to two- and three-way tank mixtures of Authority, Sencor and Prowl. Data were not pooled across soil types. The tank mixes that included Authority or Authority Supreme with Prowl resulted in significant injury (>10%) and yield loss in the trial conducted on both soil types this year. In 2021, we did not observe significant yield loss on the heavier soil (ie. the loam soil). Authority Supreme would be a useful herbicide for growers, as it contains Zidua, which would help with control of eastern black nightshade and Group 2 resistant weeds; however, the increased injury and yield loss in 2022 is a concern.

I recommend that we re-evaluate, but also consider alternate herbicides such as acetochlor – I have done some work with acetoachlor in other crops, and it is being developed for field crops in Canada.

2022 Executive Summary

Dr. Rob Nurse (Robert.Nurse@agr.gc.ca)

The tomato variety H1301 was used in all trials.

Trial 1 – **Tolerance of processing tomato to PRE applications of Authority Supreme.**
Research is required to identify herbicide options for the control of eastern black nightshade and for several herbicide resistant weed species. Authority Supreme is a pre-formulated tank-mix that contains the active ingredients sulfentrazone (group 14) and pyroxasulfone (group 15). This herbicide combination is labeled to control several annual grass and broadleaved weed species including eastern black nightshade, lambsquarters, pigweed, waterhemp and crabgrass. Currently, Authority Supreme is registered for use in field pea, chickpea, and soybean, but may have potential for registration in processing tomato because of known crop safety of the individual active ingredients. This trial specifically evaluated the application of Authority Supreme pre-emergence in processing tomatoes at doses ranging from 1/32 to 16x of the registered soybean dose. A dose response such as this will provide an estimate of the most appropriate dose that will not negatively reduce yield. Tomato injury was evaluated at 7, 14, and 21 days after tomato transplanting. This trial has been conducted for three years. Overall, tolerance of tomatoes was good to Authority Supreme; however there was some injury above 10% noted at the highest (2x to 16x) doses tested, especially at 3 weeks after application. A regression analysis of tomato yield (% of weed-free control) vs herbicide dose was performed and demonstrated that yield was only decreased by more than 10% at the 4x dose and above. Therefore, these data suggest that Authority Supreme would be safe to apply at the currently registered soybean dose.

Trial 2 – **Weed control and tolerance of processing tomatoes to PRE applications of Authority Supreme.**
This trial was conducted for a second year to complement trial 1 by evaluating weed control provided by Authority supreme across a range of doses. This trial specifically evaluated the application of Authority Supreme pre-emergence in processing tomatoes at doses ranging from 1/32 to 16x of the registered soybean dose. A dose response such as this will provide an estimate of the most appropriate dose that will not negatively reduce yield while still providing acceptable weed control. Tomato injury was evaluated at 7, 14, and 21 days after tomato transplanting. Overall, tolerance of tomatoes was good to Authority Supreme; however there was some injury above 10% noted at the highest (2x to 16x) doses tested, especially at 3 weeks after application. The most prominent weeds in the trial were large crabgrass, barnyardgrass, fall panicum, ladysthumb, velvetleaf, common ragweed, and common lambsquarters. Weed control was excellent in the trial unless the dose of the Authority Supreme dropped below a 0.25x dose. A regression analysis of tomato yield (% of weed-free control) vs herbicide dose was performed and demonstrated that yield was only decreased by more than 10% at the 4x dose and above. Therefore, these data suggest that Authority Supreme would provide acceptable weed control, but there is variability in crop safety, especially at higher doses.

Trial 3 – **Weed control and tolerance of processing tomato to several 2 and 3 way herbicide combinations.**

In this trial Treflan or Prowl was applied with Dual II Magnum, Sencor, or Authority either PPI or PRE. There were no injury concerns for any of the treatments tested. The most common weeds in this trial were common lambsquarters, ladysthumb, fall panicum, large/smooth crabgrass and barnyardgrass. Weed control was excellent across all treatments, but were lower when each herbicide was applied alone. Yields were similar among all 2 and 3 way treatments, but were lower when either treflan, authority or sencor were applied alone.

Trial 4. - **Weed control and tolerance of processing tomato to applications of Treflan and/or Prowl with shallow or deep incorporation.**

In this trial depth of incorporation was compared when Prowl H20 or Treflan were applied in processing tomato. For the purposes of this trial incorporation depth was set at either 2.5cm (1") or 10cm (4"). Prowl and Treflan were tankmixed with Dual II Magnum and incorporated and then followed by Authority PRE. None of the 2 or 3 way herbicide combinations or depth of incorporation had an impact on crop safety. The weed spectrum in the field consisted of large crabgrass, barnyardgrass, common lambsquarters, redroot pigweed, eastern black nightshade, common ragweed and velvetleaf. Although the majority of the trial was dominated by redroot pigweed and lambsquarters. Control of all species was excellent for all species across all treatments. Tomato yields did not differ from the Weed-free control for any of the herbicide treatment or by incorporation depth.

2022 Research Report

Low and high rates of chlorothalonil for management of late blight in processing tomatoes

Prepared for the Ontario Tomato Research Committee (OTRI)
September 20, 2022

Research Agency/Location: University of Guelph, Ridgetown Campus

Lead & Key Investigators:

- Cheryl Trueman, Ph.D., Assistant Prof, Dept of Plant Ag, Ridgetown Campus – Univ. of Guelph
- Kevin Dufton, Research Technician

Executive Summary:

- The objective of this research was to determine if current low and high label rates of chlorothalonil differ in efficacy against late blight in susceptible and partially resistant processing tomatoes.
- No late blight developed in the trial, so we were unable to collect data regarding the efficacy of low and high rates of chlorothalonil.

Funding:

- Ontario Tomato Research Institute, Ontario Agri-Food Innovation Alliance.
- We thank Heinz Seed for seed donation and crop protection companies for in-kind product donations.

TITLE: Low and high rates of chlorothalonil for management of late blight in processing tomatoes

OBJECTIVE: Determine if current low and high label rates of chlorothalonil differ in efficacy against late blight in susceptible and partially resistant processing tomatoes.

PEST(S): late blight (*Phytophthora infestans*)

MATERIALS: Bravo ZN (chlorothalonil 500g L^{-1})

METHODS: The trial was completed at Ridgetown Campus, University of Guelph. The trial was a 2 x 3 factorial arranged in a randomized complete block design with four replications. The first factor was host resistance to *P. infestans* ('TSH39', *+Ph-3*; 'TSH34', *-Ph-3*) and the second factor was fungicide treatments (no fungicide, Bravo ZN at 2.4 L/Ha, Bravo ZN at 4.0 L/Ha). Tomatoes were transplanted into twin rows on May 31 using a mechanical transplanter at a rate of 3 plants per metre. Each twin row was spaced 2 m apart. Each treatment plot was 7m long and consisted of one twin row. Applications were made using a hand-held CO_2 sprayer with nozzles ULD 120-03, and a water volume of 300 L Ha^{-1}. Treatments for Bravo Zn at 2.4 L/Ha were applied on an 8 to 10-day interval on Jul 25, Aug 3, 11, 22, 30, and Sep 7 while treatments for Bravo ZN at 4.0 L/Ha were applied on a 14-day interval on Jul 25, Aug 9, 23, and Sep 6. The trial was scouted for symptoms of late blight regularly throughout the season. Yield data was not collected because no late blight developed in the trial.

RESULTS & CONCLUSIONS: The efficacy of low rates of Bravo ZN for late blight management could not be determined, as no late blight was detected in the trial.

2022 Research Report

Low and high rates of chlorothalonil for management of late blight in processing tomatoes

Prepared for the Ontario Tomato Research Committee (OTRI)
September 20, 2022

Research Agency/Location: University of Guelph, Ridgetown Campus

Lead & Key Investigators:

- Cheryl Trueman, Ph.D., Assistant Prof, Dept of Plant Ag, Ridgetown Campus – Univ. of Guelph
- Kevin Dufton, Research Technician

Executive Summary:

- The objective of this research was to determine if current low and high label rates of chlorothalonil differ in efficacy against late blight in susceptible and partially resistant processing tomatoes.
- No late blight developed in the trial, so we were unable to collect data regarding the efficacy of low and high rates of chlorothalonil.

Funding:

- Ontario Tomato Research Institute, Ontario Agri-Food Innovation Alliance.
- We thank Heinz Seed for seed donation and crop protection companies for in-kind product donations.

TITLE: Low and high rates of chlorothalonil for management of late blight in processing tomatoes

OBJECTIVE: Determine if current low and high label rates of chlorothalonil differ in efficacy against late blight in susceptible and partially resistant processing tomatoes.

PEST(S): late blight (*Phytophthora infestans*)

MATERIALS: Bravo ZN (chlorothalonil 500g L^{-1})

METHODS: The trial was completed at Ridgetown Campus, University of Guelph. The trial was a 2 x 3 factorial arranged in a randomized complete block design with four replications. The first factor was host resistance to *P. infestans* ('TSH39', +*Ph-3*; 'TSH34', -*Ph-3*) and the second factor was fungicide treatments (no fungicide, Bravo ZN at 2.4 L/Ha, Bravo ZN at 4.0 L/Ha). Tomatoes were transplanted into twin rows on May 31 using a mechanical transplanter at a rate of 3 plants per metre. Each twin row was spaced 2 m apart. Each treatment plot was 7m long and consisted of one twin row. Applications were made using a hand-held CO_2 sprayer with nozzles ULD 120-03, and a water volume of 300 L Ha^{-1}. Treatments for Bravo Zn at 2.4 L/Ha were applied on an 8 to 10-day interval on Jul 25, Aug 3, 11, 22, 30, and Sep 7 while treatments for Bravo ZN at 4.0 L/Ha were applied on a 14-day interval on Jul 25, Aug 9, 23, and Sep 6. The trial was scouted for symptoms of late blight regularly throughout the season. Yield data was not collected because no late blight developed in the trial.

RESULTS & CONCLUSIONS: The efficacy of low rates of Bravo ZN for late blight management could not be determined, as no late blight was detected in the trial.

2022 Research Report

Fungicides for management of early blight, Septoria leaf spot, anthracnose and black mold in processing tomatoes

Prepared for the Ontario Tomato Research Committee (OTRI)
November 1, 2022

Research Agency/Location: University of Guelph, Ridgetown Campus

Lead & Key Investigators:
- Cheryl Trueman, Ph.D., Assistant Prof, Dept of Plant Ag, Ridgetown Campus – Univ. of Guelph
- Kevin Dufton, Research Technician

Executive Summary:
- The objective of this research was to evaluate the efficacy of new and recently registered fungicides for management of early blight, Septoria leaf spot, anthracnose and black mold.
- Both early blight and Septoria leaf spot were present; disease was slow to start but established well. Total disease over the season (AUDPC) was lower in all fungicide treated plots than the nontreated control. The lowest AUDPC was achieved using Quadris, Miravis Duo, Luna Tranquility, Cevya, Quadris Top, and Aprovia Top, but this was equivalent to both rates of Bravo ZN, Manzate Pro-Stick, Maestro, Luna Privilege, Tanos, and Sercadis, while being significantly lower than Phostrol + Diplomat (both rates).
- Anthracnose incidence was moderate, with all treatments significantly less than the nontreated control except for Phostrol + Diplomat (low rate). Anthracnose severity calculated using the number of lesions on each fruit, was lower in all treatments than the nontreated control.
- Black mold incidence was low and variable so results are not shown.
- There was variability in the yield measurements, resulting in no significant increases in yield in fungicide-treated plots compared to the nontreated control.
- Both the low and the high rate of Bravo ZN limited defoliation to a similar extent. This is an important observation since the high rate represents the middle rate under the previous label for chlorothalonil, while the low rate is the rate approved for seven applications under the new chlorothalonil label in Canada. This is the third year we have observed this effect.
- Results are used to update fungicide efficacy tables which are then posted to ONvegetables.com in late winter each year. We now have three or more years of data under moderate to high disease pressure for early blight and anthracnose on the following fungicides: Bravo (high rate), Quadris, Miravis Duo, Aprovia Top, Luna Privilege, Cevya, Sercadis. Some of these can be removed from future efficacy trials to make space for different products and/or reduce trial size, while some should stay as current or previous standards (ie. Quadris, Bravo (high rate)).

Funding:
- Ontario Tomato Research Institute, Ontario Agri-Food Innovation Alliance. We thank Heinz Seed for seed donation and crop protection companies for in-kind product donations.

TITLE: Fungicides for management of early blight, Septoria leaf spot, anthracnose and black mold in processing tomatoes

OBJECTIVE: Evaluate the efficacy of new and recently registered fungicides for management of early blight, Septoria leaf spot, anthracnose, and black mold.

PEST(S): early blight (*Alternaria solani*), Septoria leaf spot (*Septoria lycopersici*), anthracnose (*Colletotrichum coccodes*), black mold (*Alternaria* spp.)

MATERIALS: Bravo ZN (chlorothalonil 500 g L^{-1}), Manzate Pro-stick (mancozeb 75%), Maestro WSP (captan 80%), Quadris Flowable (azoxystrobin 250 g L^{-1}), Miravis Duo (pydiflumetofen ('Adepidyn') 75 g L^{-1}, difenoconazole 125 g L^{-1}), Luna Privilege (fluopyram 500 g L^{-1}), Luna Tranquility (fluopyram 125 g L^{-1}, pyrimethanil 375 g L^{-1}), Cevya (mefentrifluconazole 400 g L^{-1}), Quadris TOP (azoxystrobin 200 g L^{-1}, difenoconazole 125 g L^{-1}), Aprovia TOP (benzovindiflupyr ('Solatenol') 78 g L^{-1}, difenoconazole 117 g L^{-1}), Tanos (famoxadone 25%, cymoxanil 25%), Sercadis (fluxapyroxad ('Xemium') 300 g L^{-1}), Phostrol (mono- and di-potassium salts of phosphorous acid 53.6%), Diplomat (polyoxin D zinc salt 5%)

METHODS: The trial was completed at Ridgetown Campus, University of Guelph. Tomato transplants cv. H1648 were transplanted into twin rows on June 16 using a mechanical transplanter at a rate of 3 plants per metre. Each twin row was spaced 2 m apart. Each treatment plot was 7m long and consisted of one twin row. The trial was setup as a randomized complete block design, with 4 replications per treatment. Applications were made using a hand-held CO_2 sprayer with nozzles ULD 120-03, and a water volume of 300 L Ha^{-1}.

The trial was inoculated with plants exhibiting symptoms of early blight and Septoria leaf spot after the first fungicide application on July 11. This was done by removing and replacing one healthy seedling at the front and back of each plot with a tomato seedling previously inoculated with *A. solani* or *S. lycopersici*, respectively. The seedlings were inoculated 2-3 weeks before transplanting. Overhead irrigation was applied every night for approximately 15 minutes, on days when no natural precipitation occurred. This continued until August 25, when disease symptoms consistent with early blight and Septoria leaf spot were observed in control plots.

Whole plot defoliation was estimated on August 11, 22, 30, and September 9 using an incremental 5% scale (i.e. 0, 5, 10, etc.). These values were used to calculate the area under the disease progress stairs (AUDPS) using the following equation: AUDPC + $[(Y_1 + Y_n)/2 \times (D/n-1)]$, where Y_1 is the disease level at first assessment, Y_n is the disease level at last assessment, D is the difference in the number of days from the last assessment to the first assessment, n is the number of assessments, and AUDPC = $\sum [((Y_i + Y_{i-1}) (X_i - X_{i-1}))/2]$. For AUDPC, Y_i is number of infected leaves at day X_i and Y_{i-1} is number of infected leaves at day X_{i-1}.

Tomatoes were harvested from a 1 m section of each plot on September 16; red fruit, green fruit, and rots were separated and weighed. Fifty randomly selected red fruit were assessed for anthracnose and black mold after three days in storage by sorting into the following classes: 0 = no lesions, 1 = one lesion, 2 =

two to three lesions, 3 = four or more lesions. A disease severity index (DSI) was calculated using the following equation:

$$DSI = \frac{\sum [(\text{class no.})(\text{no. of fruit in each class})]}{(\text{total no. fruit per sample})(\text{no. classes -1})} \times 100$$

Statistical analysis was conducted using ARM 2022 (Gylling Data Management, Brookings, SD). Data were tested for normality using Levene's test. Analysis of variance was conducted using Tukey's HSD and mean comparisons were performed when $P \leq 0.05$.

RESULTS & CONCLUSIONS: Foliar disease pressure from early blight and Septoria leaf blight was high, with obvious visual differences between plots appearing by the end of August and >80% defoliation of control plots in early September. On the final assessment date of September 9, defoliation was significantly lower in all fungicide treated plots than the nontreated control (Table 1). The lowest levels of defoliation were observed with Brazo ZN (high rate), Quadris, Miravis Duo, Luna Privilege, Luna Tranquility, Cevya, Quadris TOP, Aprovia TOP, and Sercadis; with these treatments having less defoliation than Phostrol + Diplomat (both rates). Total disease over the season (AUDPC) was lower in all fungicide treated plots than the nontreated control. The lowest AUDPC was achieved using Quadris, Miravis Duo, Luna Tranquility, Cevya, Quadris TOP, and Aprovia TOP, but this was equivalent to both rates of Bravo ZN, Manzate Pro-stick, Maestro, Luna Privilege, Tanos, and Sercadis, while being significantly lower than Phostrol + Diplomat (both rates).

Anthracnose incidence in the nontreated control was moderate (15%). All of the fungicide treatments had significantly lower incidence of anthracnose than the nontreated control, except for Phostrol + Diplomat (low rate). Anthracnose disease severity was significantly lower in all fungicide treatments compared to the nontreated control (Table 2).

Black mold incidence was low and variable so the results are not shown.

Tomato yield was high, but variable, and none of the treatments had significantly higher yields than the nontreated control (Table 3).

Table 1. Percent defoliation and area under the disease progress curve (AUDPC) in tomatoes inoculated with *A. solani* (early blight) and *S. lycopersici* (Septoria leaf spot) and treated with different fungicides, Ridgetown, ON, 2022.

Treatment (per Ha) [a]	Defoliation (%) [b]				
	Aug 11	Aug 22	Aug 30	Sept 9	AUDPC
Nontreated control	0 -	9 a	39 a	84 a	852 a
Bravo ZN @ 3.2 L	0 -	0 b	7 bc	16 d	142 bcd
Bravo ZN @ 2.4 L	0 -	2 b	11 bc	24 bcd	237 bcd
Manzate Pro-stick @ 2.5 kg	0 -	2 b	14 bc	25 bcd	264 bcd
Maestro WSP @ 4.25 kg	0 -	2 b	9 bc	19 cd	191 bcd
Quadris @ 400 mL	0 -	1 b	2 c	6 d	54 d
Miravis Duo @ 1 L	0 -	0 b	1 c	6 d	36 d
Luna Privilege @ 225 mL	0 -	0 b	4 bc	15 d	111 cd
Luna Tranquility @ 800 mL	0 -	0 b	3 bc	8 d	65 d
Cevya @ 190 mL	0 -	0 b	4 bc	7 d	66 d
Quadris TOP @ 500 mL	0 -	0 b	3 c	8 d	64 d
Aprovia TOP @ 805 mL	0 -	0 b	1 c	4 d	27 d
Tanos @ 560 g	0 -	1 b	9 bc	19 cd	180 bcd
Sercadis @ 333 mL + NIS @ 0.125% v/v	0 -	1 b	8 bc	11 d	129 bcd
Phostrol @ 5.6 L + Diplomat @ 500 mL	0 -	2 b	15 bc	43 b	362 bc
Phostrol @ 5.6 L + Diplomat @ 250 mL	0 -	2 b	19 b	40 bc	388 b

[a] Treatments were applied on A = Jul 8, B = Jul 18, C = Jul 28, D = Aug 9, E = Aug 19, F = Aug 29, G = Sep 9.

[b] Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Tukey's HSD.

Table 2. Anthracnose incidence and severity on tomatoes inoculated with *A. solani* (early blight) and *S. lycopersici* (Septoria leaf spot) and treated with different fungicides, Ridgetown, ON, 2022.

Treatment (per Ha) [a]	Anthracnose	
	Severity (DSI)	Incidence (%)
Nontreated control	9 a	15 a
Bravo ZN @ 3.2 L	0 b	1 b
Bravo ZN @ 2.4 L	1 b	3 b
Manzate Pro-stick @ 2.5 kg	1 b	2 b
Maestro WSP @ 4.25 kg	0 b	1 b
Quadris @ 400 mL	0 b	1 b
Miravis Duo @ 1 L	2 b	3 b
Luna Privilege @ 225 mL	1 b	3 b
Luna Tranquility @ 800 mL	1 b	3 b
Cevya @ 190 mL	1 b	3 b
Quadris TOP @ 500 mL	1 b	1 b
Aprovia TOP @ 805 mL	0 b	1 b
Tanos @ 560 g	1 b	4 b
Sercadis @ 333 mL + NIS @ 0.125% v/v	2 b	5 b
Phostrol @ 5.6 L + Diplomat @ 500 mL	2 b	4 b
Phostrol @ 5.6 L + Diplomat @ 250 mL	3 b	7 ab

[a] Treatments were applied on A = Jul 8, B = Jul 18, C = Jul 28, D = Aug 9, E = Aug 19, F = Aug 29, G = Sep 9.

[b] Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Tukey's HSD.

Table 3. Yield of tomatoes inoculated with *A. solani* (early blight) and *S. lycopersici* (Septoria leaf spot) and treated with different fungicides, Ridgetown, ON, 2022.

Treatment (per Ha) [a]	Yield (tons/acre) [b]			
	Reds	Greens	Rots	Total
Nontreated control	43.2	1.6 b	0.2	44.9
Bravo ZN @ 3.2 L	48.8	6.7 ab	0.1	55.6
Bravo ZN @ 2.4 L	48.0	7.8 ab	0.1	55.8
Manzate Pro-stick @ 2.5 kg	44.7	5.4 ab	0.0	50.1
Maestro WSP @ 4.25 kg	47.7	7.0 ab	0.1	54.8
Quadris @ 400 mL	43.9	9.0 ab	0.1	52.9
Miravis Duo @ 1 L	41.6	13.3 a	0.1	55.0
Luna Privilege @ 225 mL	47.8	6.9 ab	0.1	54.8
Luna Tranquility @ 800 mL	40.9	12.0 a	0.3	53.2
Cevya @ 190 mL	46.0	11.0 a	0.1	57.1
Quadris TOP @ 500 mL	42.7	9.3 ab	0.2	52.2
Aprovia TOP @ 805 mL	36.9	10.0 ab	0.1	47.1
Tanos @ 560 g	44.7	8.2 ab	0.1	53.0
Sercadis @ 333 mL + NIS @ 0.125% v/v	41.7	13.3 a	0.1	55.2
Phostrol @ 5.6 L + Diplomat @ 500 mL	46.0	5.8 ab	0.1	51.9
Phostrol @ 5.6 L + Diplomat @ 250 mL	45.8	5.4 ab	0.2	51.4

[a] Treatments were applied on A = Jul 8, B = Jul 18, C = Jul 28, D = Aug 9, E = Aug 19, F = Aug 29, G = Sep 9.

[b] Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Tukey's HSD.

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2022 Research Report

Persistent entomopathogenic nematodes (EPNs): persistence and effects on wireworm in tomato / Effects of commercial insecticides and EPNs on wireworm in tomato (Year 1)

Prepared for the Ontario Tomato Research Institute & Fresh Vegetable Growers of Ontario
September 19, 2022

Research Team:

- Cheryl Trueman, Ph.D., Asst Prof, Dept. of Plant Ag, University of Guelph – Ridgetown Campus
- Kevin Dufton, Research Technician
- Jocelyn Smith, Ph.D., Research Scientist
- Amanda Tracey, OMAFRA

Highlights/Summary:

- The objective in Year 1 was to determine the baseline population of wireworms in two research ranges at Ridgetown Campus and increase wireworm populations through the establishment of attractive cover crops, strategic placement of pheromone traps, and introductions from infested commercial fields.
- A rye + clover cover crop was seeded in two ranges at Ridgetown Campus in October 2021 with the purpose of attracting female click beetles to deposit eggs in spring 2022. Wireworm populations were monitored weekly from late April late May in the ranges. Populations were low. Experimental pheromone traps (AAFC) were introduced to further attract adult beetles to the site. Wireworms from local commercial fields were also introduced at each site. Soil temperature was monitored throughout the monitoring period.
- The project was terminated at the end of Year 1 due to the departure of the lead investigator (C. Trueman) from the University of Guelph. Wireworm populations were low; cool and wet soil conditions followed by warmer but very dry soil conditions may have impacted wireworm counts. Future researchers should consider other methods to increase populations and/or consider other sites. However, previous work by the Trueman Lab at an infested commercial field with much higher trap catches yielded little and variable damage to tomato transplants.

Acknowledgements: Funding from the Ontario Tomato Research Institute, Fresh Vegetable Growers of Ontario and the Ontario Agri-Food Innovation Alliance is gratefully acknowledged. We also thank Taylor Davies (summer research assistant) for her contributions to the project.

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TITLE: Persistent entomopathogenic nematodes (EPNs): persistence and effects on wireworm in tomato / Effects of commercial insecticides and EPNs on wireworm in tomato (Year 1)

PEST: Wireworm (*Limonius agonus*)

METHODS:

Cover crop establishment: Winter cereal rye and red clover were seeded in Todd's Garden and Range A1/A2 at Ridgetown Campus on October 20, 2021. Establishment was good. The cover crop was maintained through spring and summer with the intention of herbicide kill down and incorporation in early August in Todd's Garden in preparation for the first EPN application. However, EPNs were not applied due to the departure of the project lead from the University of Guelph.

Wireworm monitoring: flour traps were used to attract wireworms at a rate of approximately 7 traps/acre. Holes were dug approximately 30 cm across and 15 cm deep and one cup of white flour added. The hole was covered with soil and marked with a flag. Traps were checked after 7 to 10 days for the presence of wireworm and new flour added. Traps were established on April 22 in Todd's Garden and Range A1/A2, respectively.

Introduction from commercial fields: three commercial fields in Chatham-Kent were monitored regularly from late April to late May for wireworm using the methods described above for on-campus range monitoring. Wireworms were collected in bait traps and introduced into the ranges at Ridgetown. Wireworms were placed randomly within ranges and the general location of introduction recorded on a range map.

Pheromone lures: experimental pheromone lures for a related wireworm species were placed in both ranges on April 22 (Figure 1). There were 10 lures in Todd's Garden and 24 lures in Range A1/2.

RESULTS & CONCLUSIONS:

The study was not completed due to the departure of the lead investigator. Low numbers of wireworms were observed in both ranges (Table 1). This may be due to inherent low populations or a combination of moderate population and dry soil conditions, which encourage wireworm migration away from the soil surface. The efficacy of the pheromone traps could not be assessed as effects would not be apparent until spring 2023 when the larvae resulting egg-laying are present.

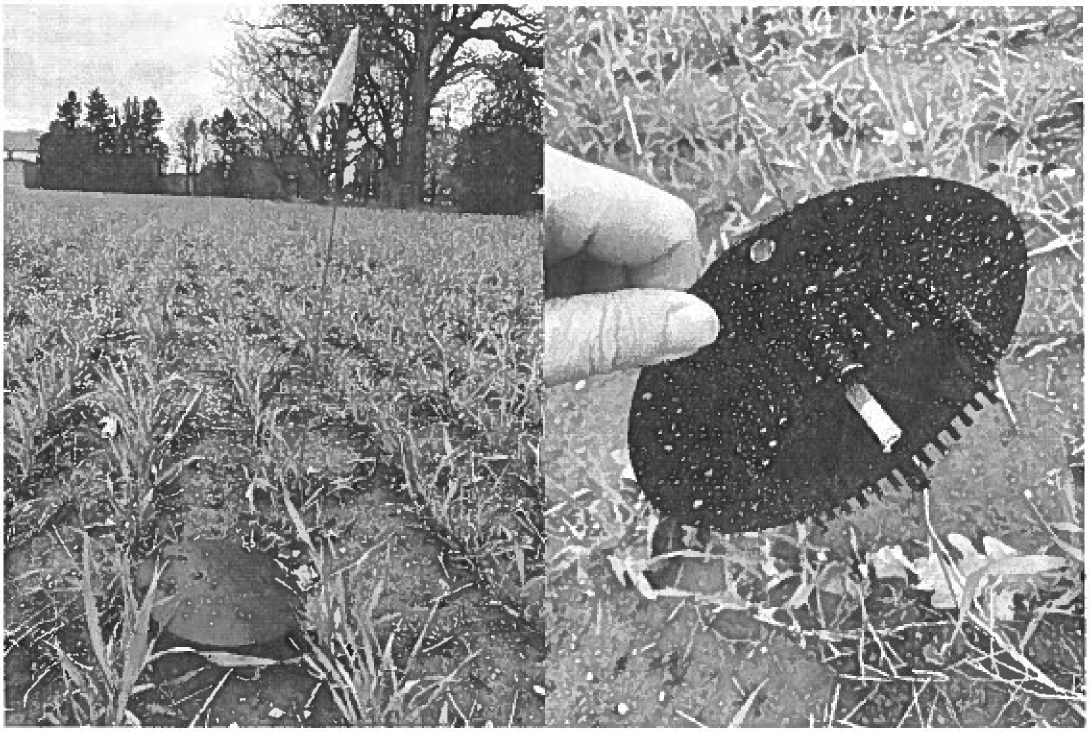

Figure 1. Pheromone traps (without a catch) to attract egg-laying click beetles to research ranges at the University of Guelph, Ridgetown Campus, 2022.

Table 1. Wireworms trapped in two research ranges at the Ridgetown Campus, University of Guelph, April 22 to May 19, 2022.

	Todd's Garden		Range A1/A2	
	# wireworms/trap	Soil T (°C)	# wireworms/trap	Soil T (°C)
April 29	0	8	0	11
May 6	0	12	0	13
May 13	0	17	0	26
May 20	0	16	0	19
May 25	0	19	0	19

Six traps were established in Todd's Garden and 10 traps in Range A1/A2.
Soil temperature at the time traps were monitored.

2022 Research Report

Early season insect management in field tomatoes (Part II): Wireworm
- ***Random plant stand loss, cultivar, and planting density on tomato yield***

Prepared for the Ontario Tomato Research Committee (OTRI)
November 1, 2022

Research Agency/Location: University of Guelph, Ridgetown Campus

Lead & Key Investigators:
- Cheryl Trueman, Ph.D., Assistant Prof, Dept of Plant Ag, Ridgetown Campus – Univ. of Guelph
- Kevin Dufton, Research Technician

Executive Summary:
- The objective of this research was to evaluate the potential for tomato planting density to be used as a cultural control for mitigating yield loss due to wireworm damage. This work will also serve to determine the level of uneven plant stand loss required to incur yield losses in processing tomatoes.
- Preliminary analysis was performed on the three factors considered including cultivar maturity (Factor A), initial planting density (Factor B) and degree of uneven stand loss (Factor C).
- For the cultivar maturity (Factor A), there were no significant differences in red or total fruit yield for the cultivars tested (H5108 with early-season maturity vs CC337 with mid-season maturity).
- The assessment of initial planting densities (Factor B) indicated significantly higher yields for the red, breaker / turning and green fruit categories of the highest density (16,000 plants / acre) compared to the lowest density (11,500 plants / acre).
- The degrees of uneven stand loss (Factor C) showed significant differences in red fruit from 0% to 20% to 40% uneven stand loss. However, in terms of total fruit, only 40% stand loss was significantly lower than 0% while 10% and 20% were not. This preliminary review of the data suggests that processing tomatoes have some ability to sustain 10-20% stand loss without having a significant reduction in total fruit yield (averaged across cultivars and initial planting densities).
- A comparison of all factorial combinations together (cultivar x initial planting density x degree of uneven stand loss) revealed minimal significant differences.
- Further regression analysis will be performed to assess for more trends and interactions within the dataset. An updated report will be provided by December 31, 2022.

Funding:
- Ontario Tomato Research Institute, Ontario Agri-Food Innovation Alliance. We thank Heinz Seed and ConAgra Foods Canada for seed donation.

TITLE: Early season insect management in field tomatoes (Part II): Wireworm

- ***Random plant stand loss, cultivar, and planting density on tomato yield***

OBJECTIVE: Evaluate the potential for processing tomato planting density as a cultural control tool to mitigate yield loss. This work will also serve to determine the level of uneven plant stand loss required to incur yield losses in processing tomatoes.

PEST(S): uneven stand loss, to simulate damage by Wireworm species

MATERIALS: tomato seed (H5108, CC337)

METHODS: The trial was completed at Ridgetown Campus, University of Guelph during the 2022 growing season. The trial was set up as a 2 x 3 x 4 factorial arranged in a randomized complete block design, with 4 replications per treatment. The factors were cultivar (A), initial planting density (B) and degree of uneven stand loss (C) as follows:

Factor A: cultivar

Treatment	Maturity
H5108	Early-season
CC337	Mid-season

Factor B: initial planting density

Treatment	Density (plants/acre)
Low	11,500
Medium	13,000
High	16,000

Factor C: degree of uneven stand loss

Treatment	Stand loss (%)
None	0
Low	10
Medium	20
High	40

Tomato transplants were transplanted into twin rows on June 21 using a mechanical transplanter with the respective cultivars (Factor A) and initial planting densities (Factor B) according to the trial randomization. Each twin row was spaced 1.5 m apart. Each treatment plot was 7m long and consisted of one twin row. Each 7 m plot was then divided with stakes into 3 x 2 m "harvest" sub-plots with 0.5 m guard plants at each end, on July 4. The degree of uneven stand loss (Factor C) was applied on July 8 by first randomly selecting one of the 2 m sub-plots as the section to be harvested. Then the necessary number of plants were randomly removed to achieve the expected final stand count based on the initial planting density (Factor B) and degree of uneven stand loss (Factor C) for each respective plot.

The trial was maintained using standard commercial practices.

Tomatoes were harvested from the 2 m sub-section in each plot that had been selected for the yield assessment. Fruit was sorted into 4 categories (red, breaker / turning, green and rots) and weighed. The plots with cultivar H5108 were earlier maturing and harvested on September 22, while the plots with cultivar CC337 were later maturing and harvested on October 4.

Statistical analysis was conducted using ARM 2022 (Gylling Data Management, Brookings, SD). Data were tested for normality using Levene's test. Analysis of variance was conducted using Tukey's HSD and mean comparisons were performed when $P \leq 0.05$.

RESULTS & CONCLUSIONS: As a preliminary analysis, the effect of each factor was considered individually. The overall yield of cultivars differing in maturity (Factor A) showed no significant difference between H5108 (early-season maturity) and CC337 (mid-season maturity) for red fruit yield or total fruit yield (Table 1). When comparing initial planting densities (Factor B), significantly higher yields were measured for the red, breaker / turning and green fruit grade categories of the highest density (16,000 plants / acre) compared to the lowest density (11,500 plants / acre), (Table 2). The degrees of uneven stand loss (Factor C) showed significant differences in red fruit yield from 0% to 20% to 40% uneven stand loss (Table 3). However, in terms of total fruit yield, only 40% stand loss was significantly lower than 0% while 10% and 20% were not. This preliminary review of the data suggests that processing tomatoes have some ability to sustain 10-20% stand loss without having a significant reduction in total fruit yield (averaged across cultivars and initial planting densities).

A comparison of all factorial combinations (cultivar x initial planting density x degree of uneven stand loss) revealed minimal significant differences but a couple observations were made. First, the yield of CC337 at 0% stand loss (16,000 plants / acre) was significantly higher than H5108 at 40% stand loss (11,500 or 13,000 plants / acre). Secondly, the yield of H5108 at 0% stand loss (13,000 or 16,000 plants / acre) was significantly higher than CC337 at 40% stand loss (11,500 plants / acre). This is expected that a high planting density with no stand loss would be significantly higher yielding than a low planting density with high stand loss. Further regression analysis will be performed to assess for more trends and interactions within the dataset. An updated report will be provided by December 31, 2022.

Table 1. Yield of tomatoes averaged across cultivars (Factor A), Ridgetown, ON, 2022.

Cultivar	Yield (tons/acre) [a]				
	Reds	Breaker / Turning	Greens	Rots	Total
H5108 (early-season maturity)	43.9	4.1 a	4.8	0.3	53.1
CC337 (mid-season maturity)	43.7	2.4 b	4.7	0.4	51.2

[a] Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Tukey's HSD.

Table 2. Yield of tomatoes averaged across initial planting densities (Factor B), Ridgetown, ON, 2022.

Initial planting density (plants / acre)	Yield (tons/acre) [a]				
	Reds	Breaker / Turning	Greens	Rots	Total
11,500	40.3 b	3.7 a	5.6 a	0.3	49.9
13,000	44.5 a	3.2 ab	4.5 ab	0.4	52.5
16,000	46.7 a	2.8 b	4.2 b	0.4	54.1

[a] Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Tukey's HSD.

Table 3. Yield of tomatoes averaged across degrees of uneven stand loss (Factor C), Ridgetown, ON, 2022.

Degree of uneven stand loss	Yield (tons/acre) [a]				
	Reds	Breaker / Turning	Greens	Rots	Total
0%	47.8 a	3.0	4.5	0.4	55.8 a
10%	46.0 ab	3.1	4.1	0.4	53.7 a
20%	43.1 b	3.6	5.2	0.3	52.2 a
40%	38.3 c	3.3	5.2	0.3	47.0 b

[a] Numbers in a column followed by the same letter are not significantly different at $P \leq 0.05$, Tukey's HSD.

2022 Research Report

Susceptibility of tomato reproductive stages to asymptomatic infection by *Phytophthora capsici*, causal agent of severe buckeye rot

Prepared for the Ontario Tomato Research Committee (OTRI)
September 19, 2022

Lead and Key Investigators

- Lead: Cheryl Trueman, Ph.D., Asst. Professor, Dept of Plant Ag, UofG Ridgetown
- Amanda Tracey, Vegetable Crop Specialist, OMAFRA

Highlights/Summary:

- The objective of this research was to determine which reproductive stages of tomato are susceptible to asymptomatic infection by *P. capsici* in order to support more evidence-based recommendations on fungicide spray timing targeting this pathogen.
- *Phytopthora capsici* DNA was detected in 20% of asymptomatic samples, including those collected at the flower bud (50%), anthesis (25%) and fruit development ('walnut size') (17%) stages. In addition, 95% of asymptomatic samples tested positive for *Fusarium* spp. while only one (5%) of asymptomatic samples tested positive for *Pythium* spp. All tomatoes with visual symptoms of buckeye rot tested positive for *P. capsici* and *Fusarium* spp.
- Previous strip trials completed at commercial farms in Essex Co. in 2018 and 2019 showed that fungicide programs targeting buckeye rot beginning at fruit set (three or five applications) reduced rots, suggesting early management of buckeye rot (before symptoms appear) is beneficial. The results of the current study support the conclusion that *P. capsici* infects early reproductive growth stages in tomato and the use of preventative fungicide applications in locations where the presence of *P. capsici* is known. The role of *Fusarium* spp. in tomato fruit rot should be investigated further.

Funding:

- Ontario Tomato Research Institute, Ontario Agrifood Innovation Alliance

TITLE: Susceptibility of tomato reproductive stages to asymptomatic infection by *Phytophthora capsici*, causal agent of severe buckeye rot

PEST(S): *Phytophthora capsici*

METHODS: Sampling was completed on August 25 at two processing tomato fields (site 1, site 2) located in Essex County, Ontario. Low areas of each field were scouted for symptoms of buckeye rot, and all asymptomatic samples were collected from an area within 1 to 5 m^2 of symptomatic fruit. A total of five areas were samples (two at site 1, three at site 2). There were limited flower bud and anthesis stages at the time of sampling, thus at site 2, only fruit set (pea size) and fruit development (walnut size) stages were sampled, and the sampling area was expanded beyond the 1 m^2 area near symptomatic fruit that was initially planned. Symptomatic green or red fruit were collected from each sampling area to confirm the presence of *P. capsici*. Samples were photographed, wrapped in paper towel, placed in a Ziplock bag and then a cooler until shipping, which occurred on the same day as sampling. Samples were shipped overnight to the University of Guelph diagnostic clinic for the DNA multiscan, which includes a test for *P. capsici*.

RESULTS & CONCLUSIONS:
Phytopthora capsici DNA was detected in 20% of asymptomatic samples, including those collected at the flower bud (50%), anthesis (25%) and fruit development ('walnut size') (17%) stages (Table 1). All tomatoes with visual symptoms of buckeye rot tested positive for *P. capsici* and *Fusarium* spp. (Table 1 & Table 2). In addition, 95% of asymptomatic samples tested positive for *Fusarium* spp. while only one (5%) of asymptomatic samples tested positive for *Pythium* spp. (Table 2).

The results of the current study support the conclusion that *P. capsici* infects early reproductive growth stages in tomato. The role of *Fusarium* spp. in tomato fruit rot should be investigated further.

Table 1. Summary statistics for *P. capsici* detected on asymptomatic flower buds, anthesis, fruit set (pea size) and fruit development (walnut size) tomato growth stages in two Essex County processing tomatoes fields collected within the vicinity of red or green fruit with buckeye rot (within 1 to 5 m^2) in 2022.

Growth Stage [a]	Samples Positive for *P. capsici* (%)
All asymptomatic samples (n = 20)	20
Flower bud (n = 4)	50
Anthesis (n = 4)	25
Fruit set (n = 6)	0
Fruit development (n = 6)	17
Symptomatic red or green fruit (n = 5)	100

[a] Flower bud, anthesis, and fruit set samples consisted of 5 to 10 flower buds, flowers, or pea size fruit. Fruit development samples consisted of a minimum of 3 walnut sized fruit. Symptomatic fruit samples consisted of 2 to 3 mature green or red fruit.

Table 2. Summary statistics for *Fusarium* spp., *Fusarium oxysporum* complex, *Fusarium solani* complex, and *Pythium* spp. detected on asymptomatic flower buds, anthesis, fruit set (pea size) and fruit development (walnut size) tomato growth stages in two Essex County processing tomatoes fields collected within the vicinity of red or green fruit with buckeye rot (within 1 to 5 m^2) in 2022.

Growth Stage [a]	Samples with Positive Detection (%)			
	Fusarium spp.	*F. oxysporum* complex	*F. solani* complex	*Pythium* spp.
All asymptomatic samples (n = 20)	95	20	35	5
Flower bud (n = 4)	100	0	0	0
Anthesis (n = 4)	75	0	50	0
Fruit set (n = 6)	100	17	33	0
Fruit development (n = 6)	100	50	50	17
Symptomatic red or green fruit (n = 5)	100	80	20	0

[a] Flower bud, anthesis, and fruit set samples consisted of 5 to 10 flower buds, flowers, or pea size fruit. Fruit development samples consisted of a minimum of 3 walnut sized fruit. Symptomatic fruit samples consisted of 2 to 3 mature green or red fruit.

Project Title

Processing tomato cultivar trials, 2022

Research Agency/location

University of Guelph Ridgetown Campus

Lead and Key Investigators

Steve Loewen

Satinder Chopra

Executive summary

Processing tomato cultivar trials were conducted at two locations. At the "Ridgetown" site the trial evaluating cultivar performance was combined with a Pinnacle tolerance screening trial in a split-plot design. Cultivar performance was evaluated at a second site in Chatham Township. Cultivars recommended by processing company representatives were evaluated for field yield performance, fruit size and handling measurements, processing measurements and fruit quality measurements. In 2022 it was possible to detect differences in yield, fruit size, handling and peeling measurements, and in fruit quality measurements for the cultivars evaluated. The results of the Pinnacle tolerance screening will be summarized in a separate report to follow.

Objectives

1. To measure the field, handling, peeling and fruit quality performance of new hybrids recently listed in seed company catalogues.
2. To evaluate the trial entries for tolerance to Pinnacle herbicide.

Materials and Methodology

Cultivars

Ontario processing tomato company representatives were surveyed for the names of the hybrids of interest for the trial. There were 20 entries plus 2 check cultivars H3406 and H5108 in the cultivar trial.

Transplants were grown in 200 cell plug trays in the greenhouses at Ridgetown Campus.

Trial sites

Ridgetown site

One site was established in the same field as the processing tomato breeding plots near Selton Line and Kenesserie Road. This trial was set in the field on May 27, 2022. The cultivar trial was set up as an RCBD experimental design with 4 replications. Cultivars were randomized in all 4 replications.

The Pinnacle tolerance screening trial was superimposed on 3 replications of the RCBD cultivar trial, as a split-plot design. Main plot treatment was cultivar and sub-plot treatment was unsprayed or sprayed 2x rate of Pinnacle.

Row spacing was 5 feet apart. Main plots were 36 feet long and planted in twin rows 22 inches apart and plants 18 inches apart within a row, to achieve a plant population of 11,616 plants per acre. Weeds were controlled by ppi Dual Magnum 2.2 L/ha followed by directed sprays of Sencor 67 g/acre, cultivation and hoeing. Foliar and fruit diseases were controlled with sprays of Echo 720 (1 L/acre) and Bravo (1.5 L/acre or 0.6 L/acre). This site received 8.7 inches of rainfall from June 07 to September 25.

Chatham Township site

A second trial site was established on a farm of Rob McKerrall on Eberts Line in Chatham Township. The trial at this site was established on May 24, 2022, in an RCBD experimental design with 3 replications. There were no sub-plot treatments at this site. The trial was planted with the same transplanter at the same row, twin-row and plant spacings as the Ridgetown site. PPI weed control was managed by the grower as was spraying for diseases.

Yield measurements

The plots at both sites were not sprayed with Ethrel in order to observe the natural sequence in maturity. At the Ridgetown site unsprayed sub-plots, and at the Chatham township site the plots, were harvested on 2 days each week, on the date closest to the time when 80% of the fruit were red ripe. Five plants, with no adjacent plants missing, were cut at soil level and the fruit were shaken by hand into a wheelbarrow. Fruit were sorted into red ripe, breakers, processing green, grass green and limited use/rots grade categories and the weight of fruit in each grade category was measured. An 11-quart basket of red ripe fruit was retained as a sample for fruit handling, peeling and quality evaluations.

Fruit handling measurements

From the 11-quart basket sample of red ripe fruit, a 3 kg sub-sample of fruit was weighed out for further evaluations. The number of fruit in this sub-sample was counted to measure average fruit size in grams. The fruit were dropped onto a concrete floor from a height of 4 feet. Only the fruit with cracks extending into the flesh were weighed and the results are reported as % cracking. The fruit with stems attached were counted and reported as percent of the total fruit number to estimate persistence of stem attachment. The uniformity of fruit size (i.e., diameter) was estimated on a weight basis by grading the fruit into 4 size categories using spaced steel bars. Size 1 was 1" or less, size 2 was greater than 1" and less than or equal to 1 1/2", size 3 was greater than 1 1/2"and less than or equal to 1 3/4" and size 4 was fruit diameter greater than 1 3/4".

Peeling and peeled colour measurements

After going through the handling evaluations described above, the 3 kg fruit samples were peeled. The tomatoes were submerged in caustic potash (30% solution by weight) with Turgitol surfactant (0.3% by volume), at 102 +/- 1°C for 40 seconds. The sample was rinsed twice in water. The peels were removed mechanically. The peeled tomatoes were rinsed in water and drained and weighed. This weight was expressed as percent of the initial sample weight and is reported as percent peeling recovery. After peeling, the tomatoes were sorted for colour, peels still attached, and blemishes. The percent of fruit that had no significant colour defects, and that peeled relatively easily were reported as percent cannable.

Fruit quality measurements

The remaining red ripe fruit from the 11-quart basket field sample were made into thin pulp and used for fruit quality measurements. Fruit were washed and dried and blended in a Waring Commercial blender, (with customized tomato blades) on medium speed, for 40 seconds, under vacuum. The juice sample was collected with a ladle through the sieve. Colour (Hunter a and Hunter b) was measured with a Konica-Minolta CR-410T chroma meter. The Hunter a/b ratio and Hunter Hue Angle were calculated. The pH of the juice was measured using a benchtop digital pH meter and natural tomato soluble solids (NTSS) was measured in degrees Brix using a Palette PR-101 digital refractometer.

Pinnacle tolerance screening

At the Ridgetown site (described above) one sub-plot within each cultivar main plot was sprayed with a 2x rate of Pinncle (thifensulfuron-methyl 50%) 4 weeks after transplanting (June 24).

Visual ratings of Pinnacle injury

Three days later (June 27) a first rater assessed the plants for symptoms of Pinnacle injury. On this same date a second rater also assessed the plants for symptoms of Pinnacle injury. The second rater rated the plants again 11 days after Pinnacle application to assess plant recovery.

Yield measurements and maturity

Plants in both unsprayed and sprayed sub-plots were harvested as described above for Yield Measurements. Yields from the Pinnacle-sprayed subplots were not included in the cultivar trial data, but were used only for the Pinnacle screening trial. Samples of red ripe fruit were not retained for any further measurements for the Pinnacle-sprayed sub-plots.

Results/Conclusions

General comments about the yield results

In 2022 many real differences were detected from variation among tomato cultivars (as opposed to numerical differences resulting only from random variation). To address the challenges from 2021, the number of replications for the yield trial was increased to 4 at the Ridgetown site in 2022.

Ridgetown site yields (Table 1)

Table 1 shows the maturity and yield results from the Ridgetown site alone. The trial entries are arranged by maturity since comparisons of cultivar performance are most meaningful within similar maturity categories. In addition to the red ripe yield, and the yields of individual fruit grade categories, cumulative yields were created by summing different grade categories (as may be done in some contracts).

Ridgetown site fruit size and handling (Table 2)

Table 2 shows the results of fruit size measurements, stem retention, cracking or firmness and a distribution of different fruit size categories for the Ridgetown site alone. These four size categories help to show how uniform fruit size is since the average fruit size does not show this. Fruit size uniformity is important for whole peeled tomatoes.

At the beginning of the harvest season fruit samples from the Ridgetown site were peeled for peeling and fruit recovery measurements. Due to the very poor peeled colour among all entries evaluated, possibly due to the low soil pH at this site in 2022, this work was discontinued for the Ridgetown site only and no results reported.

Ridgetown site fruit quality measurements (Table 3)

Table 3 shows the results of fruit quality measurements from the Ridgetown site alone. As above, the cultivars are sequenced by maturity date. The natural tomato soluble solids in 2022 were better than 2021. This is likely due to the lower rainfall measured at the Ridgetown site in 2022. Again in 2022 the fruit pH tended to be high. A target pH is 4.3 for food safety and the values were well above that for some entries.

Chatham Township site yield data (Table 4)

The entries are arranged in sequence of maturity first by number of days from transplant to harvest and secondly, alphabetically within equivalent numbers of days. The maturity sequence is slightly different from the Ridgetown site.

For red ripe yield there was more random variation at the Chatham Township site than at the Ridgetown site since we were not able to declare the red ripe yields different despite the large numerical differences. If a slightly less stringent approach was taken than the customary 0.05 level of significant, differences would be declared if an F-test p-value of 0.09 was accepted. From a practical standpoint this means that if we could accept being wrong almost 1 year in every 10 years then we would have declared a difference in these yields. The customary p-value of 0.05 implies much more certainty in the differences; that we can tolerate being wrong 1 year in every 20 years.

Chatham Township fruit size, handling and peeling measurements (Table 5)

Fruit samples from the Chatham Township site were peeled in 2022. The weight of the fruit after peeling was divided by the weight of the fruit put into the peeling process and expressed as a percent (peeled wt, percent). This represents how much weight remained after peel removal. This measurement provides another way to estimate fruit firmness.

The fruit were sorted after peeling based on colour and attached peel tags assuming they would be used for wholepack end use. The fruit with good enough quality to can were weighed and this was divided by the weight of the fruit that came out of the peeling process and expressed as a percent (cannable, percent). This represents how much sorting might be necessary after peeling.

Finally, the weight of fruit good enough to can was divided by the weight of fruit put into the peeling process and expressed as a percent (recovery, percent). This represents the percent of fruit, by weight, coming into the factory that would end up in a can if they were packed for wholepack end use.

Chatham Township fruit quality measurements (Table 6)

The NTSS measured at the Chatham Township site was higher, on average, than solids at the Ridgetown site. Overall the fruit pH was lower than what was measured at the Ridgetown site and this is similar to the trend observed in 2021.

Pinnacle tolerance screening

The results for the Pinnacle tolerance screening (Objective 2) will be summarized and interpreted in a second part to this report.

Acknowledgements

The support of the Ontario Tomato Research Institute, the seed companies, the processor representatives and Rob McKerrall are gratefully acknowledged.

Table 1. Processing tomato cultivar trial yield measurements, Ridgetown site, 2022.

Name	days	Red ripe	Breakers	Proc Grn	Grass Grn	Lim Use	Red + Breakers	Red + Breakers + Proc Grn	Red + Breakers + Proc Grn + Grass Grn	Potential Yld
		tons/acre	tons/acre	tons/acre	tons/acre	tons/acre	tons/acre	tons/acre	tons/acre	tons/acre
N3306	99 g	16.3 d	3.7	0.5	0.9	1.4	19.9 e	20.4 e	21.4 d	22.8 d
TSH43	102 fg	29.7 abcd	1.9	0.1	0.2	0.7	31.6 bcde	31.8 bcde	32.0 bcd	32.7 bcd
TSH44	102 fg	28.9 bcd	3.7	0.6	0.9	0.6	32.6 abcde	33.2 bcde	34.2 bcd	34.8 bcd
H1014	105 efg	33.9 abc	1.8	0.9	1.9	0.7	35.7 abcde	36.6 abcd	38.5 abc	39.2 abc
CC337	108 def	32.5 abcd	2.2	1	2.3	0.3	34.6 abcde	35.7 abcde	38.0 abc	38.3 abcd
H5108_check	108 def	29.0 bcd	2.9	0.6	0.9	2.1	31.9 bcde	32.5 bcde	33.3 bcd	35.5 bcd
APRIX	109 cdef	22.5 cd	2.8	0.9	1.7	2	25.2 de	26.2 de	27.9 cd	29.9 cd
H1881	110 cdef	31.4 abcd	2.1	0.6	0.7	1	33.5 abcde	34.1 abcde	34.8 abcd	35.8 abcd
H2021	110 cdef	38.4 abc	4.5	1.5	1	0.4	42.8 ab	44.3 ab	45.3 ab	45.8 ab
H1648	112 bcde	27.1 bcd	1.8	1.6	1.4	1.7	28.9 bcde	30.5 bcde	31.9 bcd	33.6 bcd
AND 4123	113 bcde	30.0 abcd	2.6	0.8	0.7	1.3	32.6 abcde	33.4 bcde	34.2 bcd	35.5 bcd
H1178	114 abcde	34.9 abc	1.4	0.5	1.9	1.1	36.4 abcd	36.9 abcd	38.8 abc	39.9 abc
H1902	114 abcde	29.6 abcd	3.3	1.5	1.4	1.1	32.9 abcde	34.5 abcde	35.9 abcd	37.0 abcd
Pumatis	114 abcde	30.2 abcd	1.9	0.6	0.9	0.8	32.1 bcde	32.7 bcde	33.6 bcd	34.4 bcd
H1301	116 abcd	31.5 abcd	1.6	0.7	1.4	2	33.2 abcde	33.9 abcde	35.3 abcd	37.3 abcd
H1776	116 abcd	24.6 bcd	1.5	0.9	0.9	2.1	26.1 cde	27.0 cde	27.9 cd	30.0 cd
H1651	117 abcd	28.3 bcd	4.3	1.4	1.2	1.8	32.6 abcde	34.0 abcde	35.2 abcd	37.0 abcd
H9706	117 abcd	45.4 a	2.7	1.3	1.2	0.7	48.1 a	49.4 a	50.6 a	51.2 a
H3406_check	118 abc	38.8 ab	2.4	1.2	2.4	0.4	41.2 abcd	42.4 abc	44.8 ab	45.2 abc
H2009	120 ab	35.0 abc	3.2	1.8	1.2	1.7	38.2 abcd	40.0 abcd	41.2 abc	42.9 abc
H1418	121 ab	39.0 ab	2.3	1.5	1.7	1.8	41.3 abc	42.8 ab	44.6 ab	46.4 ab
HM 5369	122 a	34.4 abc	2.3	1.1	1.9	0.9	36.7 abcd	37.9 abcd	39.8 abc	40.7 abc
p value	***	***	0.167	0.02064	0.039511	0.0279	***	***	***	***
Mean	111.2	31.4	2.6	0.99	1.3	1.2	34.01	3.5	36.3	37.5
CV	3.1	19.6	57.4	63.1	63.2	71.7	17.8	16.9	16.5	15.6

Means are based on fruit samples from 5 plants harvested in each of 4 replications. Entries are arranged by days from transplant to harvest and then alphabetically. Means within columns followed by the same letter are not different (Tukey's HSD, $\alpha = 0.05$).

Table 2. Processing tomato cultivar trial, fruit size and handling measurements, Ridgetown site, 2022.

Name	Days	Avg fr sz	Stems	Cracking	Size 1	Size 2	Size 3	Size 4
		grams	percent	percent	percent	percent	percent	percent
N3306	99 g	66.5 cdefg	3.2	12.6 bcd	0	41.4 cd	31.6 ab	25.7 efghi
TSH43	102 fg	83.5 ab	0.7	29.2 ab	0	2 g	24.4 abc	73.3 ab
TSH44	102 fg	71.2 bcde	0	31 ab	0	21.8 defg	37 ab	40.8 cdefg
H1014	105 efg	61.6 defg	2.6	27.1 ab	0	38.5 cde	51.2 a	11.9 ghi
CC337	108 def	59 efg	1.6	13.2 bcd	0	71.5 b	24.3 abc	0.7 i
H5108_check	108 def	66.1 cdefg	0.6	23.4 abcd	0	15.8 efg	33.3 ab	47.3 bcde
APRIX	109 cdef	77.7 abc	1.4	18.2 abcd	0	8.8 fg	30.1 abc	58.2 abcd
H1881	110 cdef	85.1 a	0	19.9 abcd	0	5.5 g	18.4 bc	74 ab
H2021	110 cdef	54.3 g	0	4.7 cd	0.4	97.7 a	1.8 c	0 i
H1648	112 bcde	82.1 ab	0.8	23.5 abc	0	9.2 fg	33.1 ab	54.7 abcde
AND 4123	113 bcde	73 abcd	1.3	14.6 abcd	0	6 g	24.9 abc	67.5 abc
H1178	114 abcde	73 abcd	0.6	23.3 abcd	0	15.3 efg	40.1 ab	44.4 bcdef
H1902	114 abcde	70.9 bcde	2.9	25.5 ab	0	13.7 fg	53.8 a	32.3 defgh
Pumatis	114 abcde	68.7 cdef	1.1	22.1 abcd	0	13.3 fg	41.3 ab	43.7 bcdef
H1301	116 abcd	56 fg	0	33.2 a	0	53.8 bc	39 ab	7.2 hi
H1776	116 abcd	67.9 cdef	1.3	3.6 d	0	14.9 efg	36.8 ab	48.4 bcde
H1651	117 abcd	82.9 ab	1.4	17.9 abcd	0	3 g	16.1 bc	80.6 a
H9706	117 abcd	74.1 abcd	0.6	21.4 abcd	0	10.5 fg	34 ab	55.1 abcde
H3406_check	118 abc	67 cdefg	0.6	29.1 ab	0	13.5 fg	44 ab	41.5 cdefg
H2009	120 ab	65.5 cdefg	1.6	18.3 abcd	0	43 cd	42.2 ab	14.2 fghi
H1418	121 ab	70.8 bcde	1.9	16.4 abcd	0	31 cdef	43.4 ab	25.2 efghi
HM 5369	122 a	83.1 ab	0	16.5 abcd	0	20.5 defg	44.3 ab	34.6 defgh
p value	***	***	0.549	***	0.000935	***	***	***
Mean	111.2	70.9	1.1	20.2	0.019	25	33.9	40.1
CV	3.1	6.8	176.4	36.9	562.8	36.8	33	29.4

Means are based on fruit samples from 5 plants harvested in each of 4 replications. Entries are arranged by days from transplant to harvest and then alphabetically. Means within columns followed by the same letter are not different (Tukey's HSD, $\alpha = 0.05$).

Table 3. Processing tomato cultivar trial, fruit quality measurements, Ridgetown site, 2022.

Name	Days	Hunter a/b	Hue Angle	NTSS	pH	tomato sauce score
				°Brix		
N3306	99 g	1.8 abcd	21.9 bcdefg	4.8 abc	4.8 a	23.5 abcde
TSH43	102 fg	1.7 cd	21.2 defg	4.3 abcde	4.8 a	25.5 abcd
TSH44	102 fg	1.8 bcd	22.2 abcdef	4.0 cde	4.6 ab	21.6 def
Pumatis	105 efg	1.8 abcd	21.4 defg	4.2 abcde	4.4 ab	23.7 abcde
APRIX	108 def	1.8 abcd	21.4 defg	4.3 abcde	4.8 ab	23.7 abcde
H5108	108 def	1.7 d	23.4 abc	3.9 de	4.4 ab	18.6 f
H1014	109 cdef	1.9 abc	21.0 efg	4.4 abcde	4.7 ab	26.0 abc
CC337	110 cdef	2.0 ab	20.8 fg	4.6 abcd	4.7 ab	25.9 abc
H1648	110 cdef	1.8 abcd	21.9 cdefg	4.1 bcde	4.7 ab	24.6 abcde
AND 4123	112 bcde	2.0 a	20.2 g	4.8 abc	4.5 ab	27.7 a
H1881	113 bcde	1.9 abcd	21.5 defg	4.1 cde	4.6 ab	24.3 abcde
H1902	114 abcde	1.9 abc	20.9 efg	4.6 abcd	4.3 ab	25.8 abcd
H1651	114 abcde	1.8 bcd	22.0 bcdefg	4.4 abcde	4.5 ab	22.1 bcdef
H9706	114 abcde	1.8 abcd	21.5 defg	4.5 abcde	4.5 ab	23.8 abcde
H1178	116 abcd	1.7 d	23.8 ab	4.4 abcde	4.6 ab	18.3 f
H1776	116 abcd	1.8 bcd	22.1 bcdefg	4.9 ab	4.2 b	21.2 ef
H2021	117 abcd	1.9 abc	20.5 fg	5.0 a	4.2 ab	26.2 ab
H2009	117 abcd	1.6 d	24.0 a	3.7 e	4.5 ab	18.0 f
H1301	118 abc	1.7 bcd	22.9 abcd	4.2 abcde	4.4 ab	21.8 cdef
HM 5369	120 ab	1.8 abcd	22.0 bcdefg	4.3 abcde	4.5 ab	23.7 abcde
H1418	121 ab	1.8 abcd	21.9 cdefg	4.5 abcd	4.4 ab	24 abcde
H3406	122 a	1.8 bcd	22.7 abcde	4.4 abcde	4.6 ab	23.4 bcde
p value	***	***	***	***	0.00978	***
Mean	114.9	1.8	21.9	4.3	4.5	23.3
CV	3.1	4.8	3.2	7	5.2	6.8

Means are based on fruit samples from 5 plants harvested in each of 4 replications. Entries are arranged by days from transplant to harvest and then alphabetically. Means within columns followed by the same letter are not different (Tukey's HSD, $\alpha = 0.05$).

Table 4. Processing tomato cultivar trial yield measurements, Chatham Township site, 2022.

Name	days	Red ripe	Breakers	Proc Grn	Grass Grn	Lim Use	Red + Breakers	Red + Breakers + Proc Grn	Red + Breakers + Proc Grn + Grass Grn	Potential Yld
		tons/acre	tons/acre	tons/acre	tons/acre	tons/acre	tons/acre	tons/acre	tons/acre	tons/acre
N3306	98 h	36.4	1.1	0.2	1.2	0	37.4	37.7 b	38.9 b	38.9 b
TSH43	105 gh	47.8	0.9	0.3	3.7	0.6	48.7	49.0 ab	52.8 ab	53.4 ab
TSH44	105 gh	46.3	1.4	0.5	1.9	0.2	47.7	48.2 ab	50.1 ab	50.3 ab
Pumatis	107 fgh	53.0	2.4	0.9	1.6	1	55.4	56.2 ab	57.9 ab	58.8 ab
APRIX	107 fgh	45.5	2.9	1.3	2.4	0.4	48.4	49.8 ab	52.2 ab	52.6 ab
H5108 check	109 efgh	56.2	1.5	1.5	2.5	0.6	57.7	59.2 ab	61.7 ab	62.3 ab
H1014	111 defg	50.7	0.9	1.1	7.1	0.6	51.6	52.8 ab	59.9 ab	60.5 ab
CC337	113 cdefg	43.8	2.5	1.4	9.3	0.7	46.3	47.7 ab	57.0 ab	57.7 ab
H1648	113 cdefg	48.2	0.7	0.7	3.7	0.6	48.9	49.6 ab	53.4 ab	54.0 ab
AND 4123	115 bcdefg	56.7	0.8	1	1.8	1.4	57.5	58.5 ab	60.3 ab	61.6 ab
H1881	116 bcdefg	52.2	2.6	1.2	4	1.2	54.8	56.0 ab	60.0 ab	61.2 ab
H1902	116 bcdefg	50.8	1.7	0.7	3.4	1.7	52.4	53.1 ab	56.6 ab	58.3 ab
H1651	117 abcdef	40.2	3.2	3.2	3.2	1.1	43.4	46.6 ab	49.8 ab	50.9 ab
H9706	117 abcdef	55.2	3.4	2.2	5.7	0.5	58.6	60.8 ab	66.5 a	67.0 a
H1178	119 abcde	56.0	1.6	1.5	4.9	1	57.7	59.1 ab	64.1 ab	65.0 ab
H1776	121 abcd	52.4	3.1	2.1	3.6	2.7	55.5	57.6 ab	61.2 ab	63.9 ab
H2021	121 abcd	58.3	1.9	1.7	3.8	1.7	60.2	61.9 ab	65.6 a	67.4 a
H2009	121 abcd	48.4	3	2.9	3.6	0.6	51.5	54.4 ab	58.0 ab	58.5 ab
H1301	123 abc	44.7	0.8	1	6.3	1.3	45.5	46.5 ab	52.8 ab	54.1 ab
HM 5369	124 abc	47.8	1.4	1.2	3.8	1.3	49.2	50.4 ab	54.2 ab	55.5 ab
H1418	125 ab	54.6	2.1	2.5	4.7	1	56.7	59.2 ab	63.9 ab	65.0 ab
H3406 check	128 a	59.4	3.5	2.9	6.5	1.6	62.9	65.8 a	72.3 a	73.9 a
p value	***	0.0883	0.0683	0.00703	***	0.0213	0.0827	0.0524	0.0171	0.0138
Mean	114.9	30.8	1.9	1.5	4	0.99	53.6	34.3	57.7	58.7
CV	3.1	20	63.3	63.9	41.9	74.9	15.7	17.5	14.6	14.7

Means are based on fruit samples from 5 plants harvested in each of 3 replications. Entries are arranged by days from transplant to harvest and then alphabetically. Means within columns followed by the same letter are not different (Tukey's HSD, $\alpha = 0.05$).

Table 5. Processing tomato cultivar trial, fruit size, handling and peeling measurements, Chatham Township site, 2022.

Name	Days	Avg fr sz	Stems	Cracking	Size 1	Size 2	Size 3	Size 4	peeledwt	cannable	recovery
		grams	percent	percent	percent	percent	percent	percent	percent	percent	percent
N3306	98 h	61.1 defghi	2.6 bc	13.7 b	0.1	47.5 cdef	41.5 abcd	10.6 cde	74.3 ab	95.6	70.8
TSH43	105 gh	86.5 a	2.5 bc	35.6 ab	0	10.2 h	21.3 bcde	68.1 a	76.9 ab	91.5	70.3
TSH44	105 gh	64.5 bcdefghi	7.5 abc	26.7 ab	0	23.7 efgh	44.9 abc	31.3 bcde	76.2 ab	94.8	72.2
Pumatis	107 fgh	70.0 abcdefg	1.7 c	30.1 ab	0	17.8 fgh	38.8 abcd	42.3 abc	74.8 ab	94.9	70.9
APRIX	107 fgh	78.0 abcde	8.6 abc	18.9 ab	0	10.7 h	36.4 abcd	52.5 ab	76.1 ab	88.6	67.3
H5108	109 efgh	63.9 bcdefghi	3.9 abc	30.4 ab	0	25.5 defgh	49.8 abc	24.4 bcde	78.2 ab	97.2	76
H1014	111 defg	55.4 fghi	4.5 abc	37.4 ab	0	53.9 bcd	41.3 abcd	4.5 de	81.7 ab	90.4	73.7
CC337	113 cdefg	49.4 hi	11.5 a	20.4 ab	0.6	86.0 a	11.8 de	1.4 de	75.6 ab	93.9	71
H1648	113 cdefg	74.7 abcdef	0 c	31.3 ab	0	13.6 gh	44.2 abc	42.2 abc	80.3 ab	85.3	67.9
AND 4123	115 bcdefg	68.6 abcdefgh	2.5 bc	19.9 ab	0	14.8 gh	35.4 abcd	50.8 ab	78.2 ab	91.6	71.4
H1881	116 bcdefg	83.7 ab	2.8 abc	21.1 ab	0	10.1 h	43.6 abc	46.1 ab	75.6 ab	95.7	72.4
H1902	116 bcdefg	61.3 cdefghi	6 abc	25.0 ab	0.2	34.7 defgh	53.2 a	11.7 cde	78.1 ab	90.4	70.6
H1651	117 abcdef	79.9 abcd	6 abc	25.3 ab	0	5.1 h	23.0 abcde	71.7 a	80.3 ab	88.9	71.5
H9706	117 abcdef	66.5 abcdefgh	10.6 ab	16.3 b	0	23.4 fgh	42.5 abcd	33.7 bcd	78.1 ab	93.8	73
H1178	119 abcde	66.9 abcdefgh	3 abc	37.9 ab	0	31.9 defgh	44.0 abc	23.7 bcde	73.2 b	95.2	69.6
H1776	121 abcd	75.0 abcdef	4.1 abc	12.5 b	0	6.3 h	41.2 abcd	52.7 ab	78.3 ab	92.4	72.4
H2021	121 abcd	44.1 i	0 c	13.3 b	7.3	92.5 a	0 e	0 e	76.0 ab	94.1	71.6
H2009	121 abcd	65.8 bcdefgh	7.3 abc	21.0 ab	0.2	77.0 abc	20.4 cde	2.2 de	75.4 ab	92.5	69.7
H1301	123 abc	53.2 ghi	3.9 abc	45.4 a	0.1	78.1 ab	21.3 bcde	0 e	78.1 ab	92.2	71.9
HM 5369	124 abc	81.7 abc	0 c	17.5 b	0	23.0 fgh	43.7 abc	32.8 bcde	85.3 a	80.2	68.4
H1418	125 ab	58.6 efghi	2.3 bc	36.4 ab	0	53.7 bcde	35.9 abcd	10.5 cde	81.7 ab	88	72
H3406	128 a	56.7 fghi	1 c	35.1 ab	0	41.4 defg	51.4 ab	7.3 de	81.3 ab	93.7	76.2
p value	***	***	***	0.0005	***	***	***	***	0.0518	0.389	0.846
Mean	114.9	66.6	4.2	25.9	0.39	35.5	35.7	28.2	77.9	91.9	71.4
CV	3.1	9.8	67.5	34.3	293.1	27.1	27.7	37.4	4.9	7	6.6

Means are based on fruit samples from 5 plants harvested in each of 3 replications. Entries are arranged by days from transplant to harvest and then alphabetically. Means within columns followed by the same letter are not different (Tukey's HSD, $\alpha = 0.05$).

Table 6. Processing tomato cultivar trial, fruit quality measurements, Chatham Township site, 2022.

Name	Days	Hunter a/b	Hue Angle	NTSS	pH	tomato sauce score
				°Brix		
N3306	98 h	3.1 a	17.9 e	5.6 abc	4.6 a	32.5 a
TSH43	105 gh	3.0 ab	18.4 de	5.0 abcd	4.4 abcd	31.3 ab
TSH44	105 gh	2.9 abcdefg	19.0 bcde	5.0 abcd	4.4 abcde	29.8 abcd
Pumatis	107 fgh	2.7 defg	20.6 abc	4.9 bcd	4.5 ab	26.6 bcdef
APRIX	107 fgh	2.9 abcde	19.0 bcde	5.2 abcd	4.4 abcd	30.1 abcd
H5108	109 efgh	2.7 cdefg	20.3 abcd	4.5 d	4.3 bcde	26.9 bcdef
H1014	111 defg	2.8 bcdefg	19.7 abcde	5.0 abcd	4.3 bcde	27.9 abcde
CC337	113 cdefg	2.8 abcdefg	19.6 abcde	5.0 abcd	4.3 bcde	28.4 abcde
H1648	113 cdefg	3.0 abc	18.6 cde	6.0 a	4.3 bcde	31.0 abc
AND 4123	115 bcdefg	2.7 cdefg	20.4 abc	4.8 cd	4.3 bcde	26.8 bcdef
H1881	116 bcdefg	3.0 abcd	18.7 cde	5.5 abcd	4.2 cde	30.7 abcd
H1902	116 bcdefg	2.7 cdefg	20.3 abcd	5.4 abcd	4.3 bcde	25.7 cdef
H1651	117 abcdef	2.9 abcdef	19.0 bcde	5.7 abc	4.2 de	29.8 abcd
H9706	117 abcdef	2.6 g	21.1 a	4.6 cd	4.3 bcde	23.6 ef
H1178	119 abcde	2.8 bcdefg	19.8 abcde	5.3 abcd	4.3 bcde	27.0 abcde
H1776	121 abcd	2.8 bcdefg	20.0 abcd	5.6 abc	4.1 e	25.3 def
H2021	121 abcd	2.8 bcdefg	19.9 abcd	5.0 abcd	4.4 bcde	27.4 abcde
H2009	121 abcd	2.8 abcdefg	19.4 abcde	5.4 abcd	4.2 cde	28.5 abcde
H1301	123 abc	2.6 efg	20.9 ab	5.2 abcd	4.4 abc	24.0 ef
HM 5369	124 abc	2.6 efg	20.7 ab	5.4 abcd	4.4 abcde	26.0 bcdef
H1418	125 ab	2.8 abcdefg	19.4 abcde	5.9 ab	4.3 bcde	28.1 abcde
H3406	128 a	2.6 fg	21.0 a	5.1 abcd	4.4 abcde	21.5 f
p value	***	***	***	***	***	***
Mean	114.9	2.8	19.7	5.2	4.3	27.7
CV	3.1	3.4	3.2	6.5	1.8	6.3

Means are based on fruit samples from 5 plants harvested in each of 3 replications. Entries are arranged by days from transplant to harvest and then alphabetically. Means within columns followed by the same letter are not different (Tukey's HSD, $\alpha = 0.05$).

Project Title

Processing tomato cultivar trials Part 2: screening for Pinnacle tolerance, 2022

Research Agency/location

University of Guelph Ridgetown Campus

Lead and Key Investigators

Steve Loewen

Satinder Chopra

Executive summary

A split plot RCBD experimental design, with unsprayed and sprayed with a 2x rate of Pinnacle was used to investigate differences in processing tomato cultivar tolerance to Pinnacle herbicide. Based on several different methods the following conclusions were drawn: Susceptible: AND 4123, H1014, H1418, H1651, H1776, H1881, H5108, N1069 (susceptible check); possibly susceptible: APRIX, H2009, Pumatis; unclear or possibly resistant: H1178, H2021, H9706; resistant: CC337, H1301, H1648, H1902, H3406, HM 5369, N1480e (resistant check), N3306, TSH34, TSH44. Across all years of conducting Pinnacle tolerance trials by this research program, the 2022 season gave the clearest results.

Objective

The first objective of this project was to measure the field, handling, peeling and fruit quality performance of new hybrids recently listed in seed company catalogues. The results of that work are presented in a separate report.

The second objective was to evaluate the trial entries for tolerance to Pinnacle herbicide. These results are reported here.

Materials and Methodology

Cultivars

The cultivars used were the same as for the cultivar trial with minor differences. N1069 and N1480e were added for the Pinnacle tolerance trial as check cultivars based on their known reaction to Pinnacle exposure. Previous work by Darren Robinson and others identified N1069 as showing significant visual injury from Pinnacle exposure and N1480e as being resistant to all rates of Pinnacle tested.

Transplants were grown in 200 cell plug trays in the greenhouses at Ridgetown Campus.

Trial site

The trial site and experimental setup is reproduced here from the first report for convenience. A single trial site was established in the same field as the processing tomato breeding plots near Selton Line and Kenesserie Road. This trial was set in the field on May 27, 2022. The trial was set up as an RCBD experimental design. The Pinnacle tolerance screening trial was superimposed on 3 replications of the

RCBD cultivar trial, as a split-plot design. Main plot treatment was cultivar and sub-plot treatment was unsprayed or sprayed 2x rate of Pinnacle.

Row spacing was 5 feet apart. Main plots were 36 feet long and planted in twin rows 22 inches apart and plants 18 inches apart within a row, to achieve a plant population of 11,616 plants per acre. Weeds were controlled by ppi Dual Magnum 2.2 L/ha followed by directed sprays of Sencor 67 g/acre, cultivation and hoeing. Foliar and fruit diseases were controlled with sprays of Echo 720 (1 L/acre) and Bravo (1.5 L/acre or 0.6 L/acre). This site received 8.7 inches of rainfall from June 07 to September 25.

Pinnacle application

One randomly chosen sub-plot within each cultivar main plot was sprayed with a 2x rate of Pinnacle (thifensulfuron-methyl 50%) 4 weeks after transplanting (June 24). In 2021 sub-plots were sprayed 3 weeks after transplanting.

Visual ratings of Pinnacle injury

Three days later (June 27) a first rater assessed the plants for symptoms of Pinnacle injury. On this same date a second rater also assessed the plants for symptoms of Pinnacle injury. The second rater rated the plants again 11 days after Pinnacle application to assess plant recovery.

Yield measurements and maturity

Plants in both unsprayed and sprayed sub-plots were harvested Yield Measurements. The plots were not sprayed with Ethrel in order to observe the natural sequence in maturity. Sub-plots were harvested on 2 days each week, on the date closest to the time when 80% of the fruit were red ripe. Five plants, with no adjacent plants missing, were cut at soil level and the fruit were shaken by hand into a wheelbarrow. Fruit were sorted into red ripe, breakers, processing green, grass green and limited use/rots grade categories and the weight of fruit in each grade category was measured.

Results/Conclusions

Yield results (Table 1)

In this experiment where the goal is to determine if a tomato cultivar is tolerant to Pinnacle or not, the most interesting response to observe is the interaction between cultivar (= entry in Table 1) and Pinnacle treatment (unsprayed or sprayed). If the interaction is determined to be truly different and not merely numerically different (which is usually an artifact of random variation in experimental conditions), then we would conclude that a cultivar behaves differently if it is exposed to Pinnacle than if it is not exposed.

In 2022 the interactions were significant between cultivar and all measurement except yield of breaker fruit. For comparison, the 2021 results showed that none of the interactions between cultivar and Pinnacle treatment were significant for the yield grade categories measured and this was similar to 2019 as well. Some years the differences are clear, while other years the differences are masked by various factors.

For 2022, spraying with a 2X rate of Pinnacle resulted in a real delay in maturity for: AND4123, H1014, H1651, H1776, H1881, H5108, N1069 (susceptible control).

In spite of the wide range of yields, only H1418 was found to have a real reduction in yield (not attributable to random variation). This tends to support findings from previous years, that it is difficult to detect differences in yield between sprayed and unsprayed plots for any particular cultivar by the time harvest arrives.

Incidence of visual injury ratings for all symptoms (Table 2)

Four days after spraying subplots with a 2x rate of Pinnacle, the plants in each sprayed subplot were rated for visual symptoms of Pinnacle injury on a scale of 0 to 5, where 0 = completely resistant, no evidence of any symptoms; 1 = probably resistant, uncertain or very slight amount of yellowing of meristems; 2 = possibly resistant, very slight cupping of leaflets, very slight yellowing of meristems; 3 = intermediate, slight yellowing, slight cupping of leaflets; 4 = probably susceptible, clear yellowing of leaflets, cupping of leaflets; 5 = clearly susceptible, epinasty of leaves, usually yellowing of meristems and leaflets, often necrosis on recently emerged leaflets.

Since these were category ratings rather than evenly spaced, continuous quantities, for each cultivar, the number of each rating category was counted (Table 2). Since there were 3 replications in the trial, and there were 2 individuals rating separately, the maximum number of ratings for each cultivar is 6. This is different from 2021 where only 1 rater did this evaluation.

The results of this assessment for 2022 showed that AND4123, APRIX, H1014, H1178, H1418, H1651, H1776, H1881, H2009, H2021, Pumatis, H5108 and N1069 (susceptible check) were susceptible to severe visual foliar injury 4 days after spraying.

These entries showed good evidence of resistance to severe visual foliage injury: CC337, H1648, H1902, H3406, N1480e (resistant check), N3306, TSH43 and TSH44.

There were three entries, H1301, H9706, HM 5369 that were probably resistant although the evidence was less clear.

Incidence of visual ratings for chlorosis (Table 3)

The visual ratings for chlorosis or yellowing, usually of the growing point and most recently emerged leaves, are summarized in Table 3. These ratings were completed by one rater 10 days after spraying with a goal of determining which cultivars would grow out of the initial symptoms most quickly.

In 2022 the results showed: AND 4123, APRIX, H1014, H1418, H1651, H1776, H1881, H2009, H5108, N1069 (susceptible check) and Pumatis were showing moderate to severe chlorosis of foliage 10 days after spraying.

While CC337, H1178, H1301, H1648, H1902, H2021, H3406, HM 5369, N1480e (resistant check), N3306, TSH43 and TSH44 showed evidence of greater recovery from Pinnacle injury 10 days after spraying and are probably resistant.

H9706 seemed less clear although there was a tendency for foliage to show recovery from injury at 10 days after spraying.

Summary (Table 4)

A range of rating methods and maturity and yield measurements results in the following conclusions on cultivar response to being sprayed with a 2X rate of pinnacle 4 weeks after transplanting in 2022:

Susceptible: AND 4123, H1014, H1418, H1651, H1776, H1881, H5108, N1069 (susceptible check).

Possibly susceptible: APRIX, H2009, Pumatis

Unclear or possibly resistant: H1178, H2021, H9706

Resistant: CC337, H1301, H1648, H1902, H3406, HM 5369, N1480e (resistant check), N3306, TSH34, TSH44.

Acknowledgements

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Table 1. Days from transplant to harvest and yields for unsprayed and Pinnacle-sprayed plots for each cultivar, 2022.								
Entry	Pinnacle trt	days	Red ripe	Breakers	Proc Grn	Grass Grn	Limited Use / rots	Potential yield
			tons/acre	t/a	t/a	t/a	t/a	tons/acre
AND 4123	21_unsprayed	111 efghijkl	29 abcdefghij	3.1	1	0.7	1.1	34.9 bcdefg
AND 4123	21_Pinnacle	129 a	18.9 fghijk	3.7	1.8	1.1	1.1	26.6 efg
APRIX	22_unsprayed	109 ghijklm	22.9 defghijk	2.5	1	2	2.2	30.5 cdefg
APRIX	22_Pinnacle	119.7 abcdefgh	22.1 defghijk	5.5	2.4	1.8	0.7	32.5 cdefg
CC337	1_unsprayed	108 hijklm	35.7 abcdefg	1.7	0.8	2.3	0.2	40.7 abcdef
CC337	1_Pinnacle	115.7 bcdefghij	30.9 abcdefghij	1.8	1.2	1.9	0.2	36.1 bcdefg
H1014	2_unsprayed	106 ijklm	34.1 abcdefgh	2.1	0.8	1.9	0.8	39.8 abcdef
H1014	2_Pinnacle	122 abcdef	27.5 bcdefghijk	4.6	1.7	1.8	0.7	36.3 bcdefg
H1178	3_unsprayed	113.3 cdefghijk	35 abcdefg	1.7	0.5	2.5	0.7	40.3 abcdef
H1178	3_Pinnacle	115.7 bcdefghij	34.6 abcdefg	2.1	1.4	1	0.5	39.5 abcdefg
H1301	4_unsprayed	115.7 bcdefghij	30.7 abcdefghij	1.7	0.9	1.6	1.6	36.5 bcdefg
H1301	4_Pinnacle	119.7 abcdefgh	35.6 abcdefg	3.2	0.8	0.8	0.3	40.8 abcdef
H1418	5_unsprayed	122 abcdef	41.4 abc	1.9	1.7	2	1.9	48.9 abc
H1418	5_Pinnacle	129 a	20.5 efghijk	9	5.5	5.2	0.5	40.8 abcdef
H1648	6_unsprayed	110.3 fghijkl	26.4 bcdefghijk	2.1	2.1	1.8	1.4	33.9 cdefg
H1648	6_Pinnacle	108 hijklm	25.8 cdefghijk	5	2.2	1.2	0.8	35.1 bcdefg
H1651	7_unsprayed	115.7 bcdefghij	31.2 abcdefghij	4.1	1.5	1.4	0.8	39 abcdefg
H1651	7_Pinnacle	129 a	14.9 jk	5.5	5.9	1.8	1.8	29.9 defg
H1776	8_unsprayed	115.7 bcdefghij	23.5 defghijk	1.6	1.2	1	1.8	29.1 defg
H1776	8_Pinnacle	129 a	11.1 k	2.9	3	2.7	1.3	21 g
H1881	9_unsprayed	108 hijklm	33 abcdefghi	2.4	0.7	0.8	0.6	37.6 bcdefg
H1881	9_Pinnacle	126.7 ab	15.7 ijk	5.5	5.4	6.6	0.9	34.1 cdefg
H1902	16_unsprayed	113.3 cdefghijk	29.2 abcdefghij	3.8	1.9	1.8	0.9	37.6 bcdefg
H1902	16_Pinnacle	117.3 abcdefghi	31.9 abcdefghij	3.9	1.4	0.9	0.6	38.7 abcdefg
H2009	18_unsprayed	119.7 abcdefgh	36.8 abcde	2.9	1.8	1.4	1.1	44.1 abcde
H2009	18_Pinnacle	129 a	25.1 cdefghijk	7.4	4	2.6	0.9	40.1 abcdef
H2021	17_unsprayed	108 hijklm	36.2 abcdefg	5.4	1.8	1.2	0.3	44.8 abcde
H2021	17_Pinnacle	119.7 abcdefgh	37.6 abcde	3.6	0.9	0.9	0.6	43.7 abcde
H3406	10_unsprayed	118 abcdefgh	39.4 abcd	2	1.4	2.6	0.2	45.7 abcd
H3406	10_Pinnacle	122 abcdef	36.8 abcde	1.9	1.2	1.8	0.4	42.1 abcde
H5108	11_unsprayed	108 hijklm	31.2 abcdefghij	2.6	0.5	1	2	37.2 bcdefg
H5108	11_Pinnacle	124.3 abcd	27.8 bcdefghijk	7.6	2.1	1.7	0.5	39.7 abcdef
H9706	12_unsprayed	115.7 bcdefghij	46 a	3.4	1.6	1.3	0.6	52.9 ab
H9706	12_Pinnacle	122.7 abcde	43.5 ab	7.3	3.3	1.8	0.9	56.8 a
HM 5369	20_unsprayed	122 abcdef	36.3 abcdef	2.7	1	2.2	0.6	42.9 abcde
HM 5369	20_Pinnacle	125 abc	31 abcdefghij	4.1	1.4	2.6	0.9	40 abcdef
N1069 (susc check)	23_unsprayed	97.3 m	18.6 ghijk	2.7	0.7	0.5	0.6	23.3 fg
N1069 (susc check)	23_Pinnacle	112.7 defghijk	16.9 hijk	2	1.4	0.9	0.9	22.1 fg
N1480e (res check)	24_unsprayed	102 cde	25.5 abcdef	2.4	0.5	1.3	0.7	30.4 cdefg
N1480e (res check)	24_Pinnacle	106 abcde	28.0 abcdef	3.1	1.3	1.1	0.4	33.9 cdefg
N3306	13_unsprayed	99.7 lm	16.2 ijk	3.4	0.6	0.9	1.9	23 fg
N3306	13_Pinnacle	104 jklm	25.2 cdefghijk	2.3	0.6	0.8	0.6	29.5 defg
Pumatis	19_unsprayed	115.7 bcdefghij	29.5 abcdefghij	1.8	0.6	1.1	1.1	34 cdefg
Pumatis	19_Pinnacle	120.3 abcdefg	16.5 ijk	3	1.4	1.1	0.7	22.7 fg
TSH43	14_unsprayed	102 klm	27.1 bcdefghijk	2.4	0.2	0.2	0.7	30.5 cdefg
TSH43	14_Pinnacle	106 ijklm	30.6 abcdefghij	4.8	1.2	1	0.6	38.1 bcdefg
TSH44	15_unsprayed	102 klm	30.5 abcdefghij	4.1	0.7	1.1	0.8	37.1 bcdefg
TSH44	15_Pinnacle	108 hijklm	21.6 efghijk	5.2	0.8	0.7	0.6	28.8 defg
unsprayed		111 b	31.1 a	2.7 a	1.1 a	1.5 a	1.0 a	37.3 a
Pinnacle		119 a	26.3 b	4.4 a	2.2 a	1.8 a	0.7 a	35.4 a
CV		0.3	17.7	64.6	419.8	81.5	66.6	18.7
Mean		115	28.7	3.5	1.62	1.64	0.87	36.32
interaction (entry x pinnacle trt)		p 0.001	p 0.001	ns	p 0.05	p 0.05	p 0.05	p < 0.05
subplot (unsprayed or sprayed)		p 0.001	p 0.001	p 0.001	p 0.001	ns	p 0.01	p 0.05
main plot (entry)		p 0.001	p 0.001	ns	p 0.001	ns	ns	p 0.001
Means are based on 3 reps. Entries arranged alphabetically. Means within cols followed by same letter are not different Tukey's HST, (α=0.05).								

Table 2. Incidence of visual ratings for Pinnacle-sprayed subplots, 4 days after spraying, pooled over 3 replications and 2 raters, 2022.						
	Categories of visual injury in response to 2x rate of Pinnacle					
Entry	0 completely resistant	1 probably resistant	2 possibly resistant	3 intermediate	4 probably susceptible	5 clearly susceptible
AND 4123				1	3	2
APRIX				1	2	2
CC337		2	2	2		
H1014					3	3
H1178			1	2	2	1
H1301			1	2	3	
H1418					2	4
H1648	1	2	1	1	1	
H1651					3	3
H1776					3	3
H1881				1	1	4
H1902	1	3		1	1	
H2009					3	3
H2021			1	1	4	
H3406	1	2	1	1	1	
H5108					3	3
H9706			2	2	1	1
HM 5369		2	1	1	1	1
N1069 (susc)				1	1	4
N1480e (res)	1	4	1			
N3306	1	5				
Pumatis					4	2
TSH43	1	5				
TSH44	1	3	1		1	

Visual injury rating scale: 0 = completely resistant, no evidence of any symptoms; 1 = probably resistant, uncertain or very slight amount of yellowing of meristems; 2 = possibly resistant, very slight cupping of leaflets, very slight yellowing of meristems; 3 = intermediate, slight yellowing, slight cupping of leaflets; 4 = probably susceptible, clear yellowing of leaflets, cupping of leaflets; 5 = clearly susceptible, epinasty of leaves, usually yellowing of meristems and leaflets, often necrosis on recently emerged leaflets.

Table 3. Incidence of visual ratings of foliar yellowing for Pinnacle-sprayed subplots, 10 days after spraying, pooled over 3 replications, 2022.										
	Ratings of severity of leaflet chlorosis in response to 2x rate of Pinnacle									
Entry	0 normal green	1	2	3	4	5	6	7	8	9 severe chlorosis
AND 4123					2	1				
APRIX						3				
CC337	2				1					
H1014						1			2	
H1178		2			1					
H1301	1	2								
H1418					1	2				
H1648	2	1								
H1651					1	1			1	
H1776						1			2	
H1881						2			1	
H1902	1	1	1							
H2009					1	1			1	
H2021	1	1	1							
H3406	3									
H5108						1			2	
H9706	1	1							1	
HM 5369	2	1								
N1069 (susc)					1				2	
N1480e (res)	3									
N3306	1	1	1							
Pumatis					2	1				
TSH43	3									
TSH44	2		1							
Results from 1 rater.										

Table 4. Summary of results of different evaluations assessing tolerance of processing tomato cultivars to a 2X rate of Pinnacle, 2022.

	Conclusions from different assessments					
Entry	Delay in maturity, 2022	Yield reduction, 2022	Injury 4 days after spraying, 2022	Foliar chlorosis 10 days after spraying, 2022	Conclusion from 2021 season	Final conclusion, 2022
AND 4123	susc		Susc	Susc	Susc	Susceptible
APRIX			Susc	Susc		Susceptible?
CC337			Res	Res		Resistant
H1014	Susc		Susc	Susc	Susc	Susceptible
H1178			Susc	Res		Unclear
H1301			Res?	Res	Unclear	Resistant
H1418		Susc	Susc	Susc	Susc	Susceptible
H1648			Res	Res		Resistant
H1651	Susc		Susc	Susc		Susceptible
H1776	Susc		Susc	Susc		Susceptible
H1881	Susc		Susc	Susc		Susceptible
H1902			Res	Res		Resistant
H2009			Susc	Susc		Susceptible?
H2021			Susc	Res		Unclear
H3406			Res	Res		Resistant
H5108	Susc		Susc	Susc	Susc?	Susceptible
H9706			Res?	unclear		Unclear
HM 5369			Res?	Res		Resistant
N1069 (susc)	Susc		Susc	Susc	Susc	Susceptible
N1480e (res)			Res	Res		Resistant
N3306			Res	Res		Resistant
Pumatis			Susc	Susc		Susceptible?
TSH43			Res	Res		Resistant
TSH44			Res	Res		Resistant

Not all entries evaluated in 2022 were evaluated in 2021. "Susceptible?" is interpreted as possibly susceptible and "Unclear" is interpreted as unclear or possibly resistant.

Project title:

Processing tomato breeding, 2021 to 2023: Report to OTRI for year 2 of 3.

Research Agency/location:

University of Guelph Ridgetown Campus

Lead and Key Investigators:

Steve Loewen, Satinder Chopra, 2022-11-01

Description of the project

A central objective of the processing tomato breeding program at Ridgetown has been to serve as a source of breeding lines with increased genetic diversity, but that are still well-adapted for our Ontario processing tomato production and processing system. Breeding and selection for early maturity and field-holding ability assist in lengthening our harvest season. Traits like yield, fruit colour, fruit size, fruit firmness and other characteristics are important both for field performance, and for performance in the factory. Selection to combine multiple genes for disease resistance, and work with a recently discovered trait on early fruit colouring will be pursued. The goal is to develop and release 15 advanced breeding lines annually, for further development by private-sector seed companies, into commercial cultivars.

Project term:

Start date: 2021-04-01; End date: 2024-03-31

Project activities for Year 2 (up to November 2022)

Tomato breeding field plots

Eight acres of field breeding plots were established on rented land near Selton Line and Kenesserie Road in Chatham-Kent. Field transplanting began on May 30 and ended on June 11. There were 765 breeding lines from F6 to F2 generations grown out in 2022. Field selection started on August 29 and was completed on September 6. There were 745 selections made in Fall 2022.

Similar to previous years selection decisions considered a wide range of traits: yield, concentration of maturity, good fruit size, uniform fruit size, uniform fruit shape, good external fruit colour, uniform external fruit colour, fruit firmness, good shoulder colour (including absence of colour defects), small core, deep red internal colour, plant vigour, plant habit, disease resistance, general foliage health, early maturity.

In contrast to what was experienced in the commercial crop in 2022, colour defects were pervasive in the breeding plots this past season. This was attributed largely to low soil pH. Many breeding lines exhibited poor shoulder colour. Some lines produced fruit with very good should colour under these conditions and so this was used as an opportunity to select for good fruit colour under less-than-ideal soil conditions.

Selection for extending the harvest season

For each field selection, the date on which it reached 80% red ripe was recorded in order to use the days from transplanting to harvest as a way to select for early maturity. The number of weeks that each selection held fruit quality in the field, once it had reached 80% red ripe was also recorded. This allowed for identification and retention of the lines with long field holding ability.

In Fall 2022 there were 11 selections that held fruit quality for 5 weeks and 102 selections that held fruit quality for 4 weeks. While it would never be recommended to hold fruit this long prior to harvest, these numbers serve as an index of the resistance to cracking and disease, and other traits that combine to prevent fruit breakdown in the field. Lines with extended field holding ability may contribute to maintaining quality at the end of the season.

In efforts to get an earlier start at the harvest season, in 2022 we identified 8 breeding lines that matured in 84 days from transplanting to harvest. Since 2012 we have been attempting to increase the number of lines in the breeding program that reach 80% red ripe maturity earlier than 95 days following transplanting.

Release of breeding lines

There were 15 breeding lines released in March 2022, in time for spring planting. These included one with evidence of Fusarium race 3 resistance and multiple lines with different accessions of Solanum habrochaites in the recent pedigrees.

Stacking multiple disease resistances

We continued to place a priority on making selections within, and crosses between, breeding lines where molecular markers showed evidence of multiple disease resistances. We have been working with markers for resistance to Fusarium 2, Fusarium 3, nematodes, Verticillium 1, TSWV, and late blight (Ph-2 and Ph-3). We continued the work with 31 parent lines identified as having various combinations of at least 3 or 4 stacked resistances.

Early fruit colouring trait

A new trait called early fruit colouring was discovered at Ridgetown in 2005. The fruit begin to show some external colouring in response to exposure to sunlight while they are still immature, as evidenced by the fact that the gel has not yet formed around the seeds. It may be possible to blend some of these "less-green" fruit with ripe fruit to elevate the viscosity in the manufacture of tomato paste. The idea is that while a small percentage of normal green fruit is already blended with red tomatoes in making paste, this early fruit colouring might permit a higher percentage of these immature, presumably high-pectin fruit to be blended in, thus possibly resulting in paste the same finished colour level but with even higher viscosity than is currently achieved.

A population of recombinant inbred lines (RILs) was developed previously for genetic study of this trait. In 2022, a sub-set of 7 of these RILs was grown out for evaluation as being suitable parents for incorporating this trait into commercially useful breeding lines.

Collaborative project screening for tomato brown rugose fruit virus (ToBRFV) resistance

The collaborative project with J. Griffiths (AAFC-Vineland) is ongoing. Work in other labs has identified resistance in *Solanum pimpinellifolium, S. habrochaites* and *S. chilense*. A screening trial completed as part of this AAFC collaborative project in summer 2022 identified some Ridgetown breeding lines with evidence of resistance to ToBRFV. This trial will be repeated to verify results. If the project is able to proceed further, the goals are to identify the resistance sequences and develop molecular markers for breeders to use so that they are not required to work with the actual virus to screen for resistance.

Natural tomato soluble solids (NTSS)

Measurements of NTSS (°Brix) were completed on 104 F6 generation field selections in Fall 2022. There were 27 of these selections that had °Brix equal to or greater than 5.0. One selection had NTSS of 6.3 and another had NTSS of 7.6 but these results still need to be cross-referenced with yield and fruit size data since these other important traits are inversely related to NTSS. This information is used to guide decisions on breeding lines to release and also to identify potential parent lines with high NTSS to use in the development of new breeding lines. Generally, it is expected that any gains in NTSS levels through breeding will be modest since soluble solids levels are influenced by so many genetic and environmental factors. Despite this, NTSS levels are so important to the Ontario industry we continue to make them a factor in breeding decisions.

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2022 Research Report

Title: Enhancing Late Blight Surveillance and Management in Tomatoes – Annual Report YEAR 3

Prepared for the Ontario Tomato Research Committee (OTRI)
September 26, 2022

Research Agency/Location: University of Guelph, Ridgetown Campus

Lead and Key Investigators:

- Cheryl Trueman, Ph.D., Assistant Professor, Dept of Plant Ag, U of G – Ridgetown (lead)
- Joe Tomecek, Tomecek Agronomic Services
- Genevieve Marchand, Ph.D., Research Scientist, Agriculture and Agri-Food Canada, Harrow
- Yaima Arocha-Rosete, Ph.D., Kristine White, Sporometrics
- Herve Van der Heyden, Phytodata
- Amanda Tracey, OMAFRA
- Kevin Dufton, Research Technician

Executive Summary:

- The objectives of this research are: a) compare the efficacy of the Spornado passive spore trap and the Rotorod active spore trap for early capture of *P. infestans* sporangia from the air, causal agent of late blight, in one of the Ontario processing tomato production regions, and b) conduct a field trial to validate the use of spore trapping versus current methods used to identify high-risk late blight periods and modify fungicide programs. The spore traps tested were established in eight locations in Kent County. This is the third and final year of research in a three-year project. Research was delayed in 2020 due to the COVID-19 pandemic and resumed in 2021. This report focusses on results from the 2022 season.
- Late blight symptoms were first detected in Ottawa county (eastern Ontario) on July 26. Despite the positive detection in the Great Lakes region, no symptoms were reported within the study region of Chatham-Kent.
- The Spornado had zero detections of of *P. infestans* this year at the 3m height. Using the Spornado would have reduced fungicide use and saved producers the cost of applying the more specific late blight fungicides compared to the current method of symptom detection in the Great Lakes Region threshold. This differed from 2021 and 2019, when a detection in the Spornado triggered high-risk sprays earlier in the season, prior to the standard practice of waiting for symptoms to develop in the region.
- The Rotorod first detected *P. infestans* on August 25. Thus, using the Rotorod would also have reduced fungicide use and saved producers the cost of applying the more specific late blight fungicides earlier in the season compared to BliteCast and symptom detection in the Great Lakes Region. This year, as in 2019 and 2021, we used a threshold of 10 sporangia m^3 to initiate fungicide applications using the Rotorod traps. Sporangia counts did not exceed the threshold at any point this season, nor during the 2019 and 2021 season. Using this approach, fungicide use was reduced further than any other high-risk threshold, including the current method of waiting

until late blight symptoms are reported in the Great Lakes Region. Positive detections from the Rotorod traps occurred at two sampling intervals with only no instances of multiple traps at different locations detecting *P. infestans* sporangia.

- Field trials were conducted again at Ridgetown and Cedar Springs. The trials were assessed for defoliation weekly beginning July 28, with the final assessment occurring on September 15. No late blight symptoms were observed, which was similar to 2021 and 2019.
- Regular updates regarding spore trap detections were posted on ONvegetables.com as requested by OTRI. It should be noted that although we reported positive detections, as observed in 2019 and 2021, positive detections alone do not always mean that late blight will develop.

Funding:

- Ontario Tomato Research Institute
- Ontario Agri-Food Innovation Alliance
- Fresh Vegetable Growers of Ontario
- In kind support from: Sporometrics, Weather Innovations Inc

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TITLE: Comparison of spore trap technology for *Phytophthora infestans* surveillance, 2022

PEST(S): late blight (*Phytophthora infestans*)

MATERIALS: Sporometrics passive spore traps 'Spornado', Rotorod

OBJECTIVE: Compare the efficacy of the Spornado passive spore trap and the Rotorod active spore trap for early capture of *P. infestans* sporangia from the air, causal agent of late blight, in one Ontario processing tomato production region.

METHODS: Spornado passive spore traps (Figure 1) and Rotorod active spore traps (Figure 2) were situated at the edge of eight commercial processing tomato fields near Ridgetown (PI-01), Cedar Springs (PI-02), Chatham (PI-03), Erieau (PI-04), Dover (PI-05), Wallaceburg (PI-06), Dresden (PI-07), and Eberts (PI-08), Ontario. Traps were setup along field edges as close as possible to the tomato crop without interfering with spray applications and other field work. Traps were installed on a metal pole 2.9 m high at all sites. At four sites, and additional set of traps was setup at a height of 1.0 m. Data collection from the 3m and 1m Spornado and Rotorod traps began June 6. Spornado traps function when air moves passively through a removable cassette with a fine mesh filter. Conversely, Rotorod traps have a consistent volume of air passing through or over the area collecting spores. Rotorod traps were set to operate from 6:00 to 15:00, alternating between 10 minutes on and 10 minutes off. The cassettes and glass rods for the Spornado and Rotorod traps, respectively, were changed twice a week, placed individually in a plastic bag to avoid cross-contamination, and shipped by overnight courier for same-day detection of *P. infestans* DNA using quantitative PCR. Spornado cassettes were shipped to Sporometrics while Rotorod rods were sent to Phytodata. The final cassettes or rods for each spore trap were collected on Aug 29. Based on the DNA copy number qPCR limit of detection (LOD) for Spornado traps, results for *P. infestans* identification were expressed as positive (*P. infestans* DNA detected, ≥LOD) /negative (*P. infestans* DNA not detected, >LOD). Identification from Rotorod traps was provided as sporangia per m^3. Sentinel tomato plots, consisting of late blight susceptible cultivars, were also established at the Ridgetown, Cedar Springs, and Dresden locations to visually determine the presence of *P. infestans* and were a minimum of 100 m^2 in size.

RESULTS: Unfortunately, there were a few issues with the Rotorod spore traps this summer. On several occasions, motors responsible for rotating the rods malfunctioned. In each instance it is unclear how long the Rotorod traps functioned properly during the sampling interval. The malfunction was not noticed until the beginning of the next sampling interval, as the traps would be observed functioning after fresh rods were installed.

For traps placed at 3 m above ground, no positive detections of *P. infestans* in the Spornado occurred (Table 1). The first documented *P. infestans* detection from a Rotorod trap occurred on August 25 (sampling period August 22-25) at 1 of 8 sites. During the entire sampling period there were no instances when both traps detected *P. infestans* sporangia during the same sampling interval. Sporangia counts from positive Rotorod detections were 1/m^3 on August 25 at PI-05 (Dover) and 1/m^3 on August 29 at PI-02 (Cedar Springs).

For Rotorod traps placed at 1 m above ground there were no *P. infestans* detections. Data for the Spornados is not yet available, as these samples were held until the end of the season to reduce testing costs.

Despite identifying the presence of *P. infestans* on August 25 with the Rotorod traps, no late blight symptoms were observed on any of the sentinel tomato plants, nor was late blight reported in the Chatham-Kent growing region during the sampling period. Late blight was identified in field tomatoes in Ottawa County on July 26. The lack of late blight symptoms on tomatoes was not surprising as the environmental conditions were not conducive for infection by *P. infestans* throughout much of the summer. For example, disease severity values (DSV) accumulation from the BliteCast model was significantly lower in 2022 than 2021 at both trial locations. Specifically, the duration relative humidity greater than 90% and precipitation amounts were lower. DSV accumulation was 63 and 172 at Ridgetown and Cedar Springs respectively in 2022, compered to 127 and 243 at Ridgetown and Cedar Springs respectively in 2021.

CONCLUSIONS: Only the Rotorod traps detected the presence of *P. infestans* this season. Detection of *P. infestans* sporangia occurred approximately four to ten weeks later than when BliteCast would have recommended the first late blight fungicide treatment, which was on June 13 at Cedar Springs and August 4 at Ridgetown (DSV of 18 reached, see field trial report 'Validation of fungicide programs for late blight based on pathogen surveillance' for further information). Unlike previous years, the first positive detection occurred after symptoms were observed within the Great Lakes Region. The first confirmed case was in the Ottawa county, in the eastern part of Ontario. It is suspected that the initial inoculum was from a local source that overwintered nearby. Typically, the first reports of symptoms are in the southern US with symptoms moving north as the season progresses. Using the first positive detection from the Rotorod delayed late blight fungicide sprays by 4 weeks compared to the standard practice of waiting for symptoms to develop in the region. While sporangia were detected by the Rotorod, counts were not sufficient to trigger the application of high-risk late blight fungicides in the 10 sporangia/m^3 treatment. Use of either spore trap would have delayed the application of high-risk late blight fungicides, resulting in savings of input costs for growers and reducing pesticide use compared to BliteCast and symptom detection in the Great Lakes Region, but not compared to the quantitative Rotorod threshold or Spornado detection. Additional research is required to validate spore traps as a decision support tool compared to other methods to determine high risk periods for late blight, particularly because late blight symptoms did not develop during the sampling period this year.

Figure 1. Spornado passive spore trap (right) Rotorod active spore trap (left) placed at 3 m and 1 m above the soil line at the Dover (PI-05) sampling location, 2021.

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Table 1. Results for the presence of P. infestans sporangia in Spornado and Rotorod spore traps located near Ridgetown (PI-01), Cedar Springs (PI-02), Chatham (PI-03), Erieau (PI-04), Dover (PI-05), Wallaceburg (PI-06), Dresden (PI-07) and Eberts (PI-08), Ontario, 2021.

		Detection of P. infestans in Spornado and Rotorod																							
		June[c]							July[c]								August[c]								
ID[a]	Trap[b]	9	13	16	20	23	27	30	4	7	11	14	18	21	25	28	1	4	8	11	15	18	22	25	29
PI-01	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S1																								
	R	-	-	-	-	-	-	-	-	-	-	- •	- •	- •	- •	- •	-	- •	-	-	-	-	-	-	-
	R1	-	-	-	-	-	-	-	-	-	-	-	- •	- •	- •	- •	-	- •	-						
PI-02	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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	R	-	-	- •	-	-	-	-	-	-	-	-	- •	-	-	-	-	-	-	-	-	-	-	-	+ (1)
	R1	-	-	-	-	-	-	-	- •	-	-	-	- •	-	-	-	-	-	-						
PI-03	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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PI-04	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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PI-05	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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PI-06	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PI-07	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S1																								
	R	-	-	-	- •	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	R1	-	-	-	- •	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
PI-08	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	R	-	-	- •	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

[a] Trap locations were Ridgetown (PI-01), Cedar Springs (PI-02), South Chatham (PI-03), Erieau (PI-04), Dover (PI-05), Wallaceburg (PI-06), Dresden (PI-07), and Egberts (PI-08). [b] Cassettes or rods were collected two times a week. S = 3 m Spornado, S1 = 1m Spornado, R = 3 m Rotorod, R1 = 1m Rotorod. [c] Empty cells represent missing data. Number in parentheses represent sporangia m3. A '+' indicates detection of P. infestans and '-' indicates no detection of P. infestans • Instances where duration of proper Rotorod function is unknown because unit was not functioning when rods where changed.

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TITLE: Validation of fungicide programs for late blight based on pathogen surveillance, 2022

PEST(S): late blight (*Phytophthora infestans*)

MATERIALS: Bravo ZN (chlorothalonil 500g L^{-1}), Quadris Flowable (azoxystrobin 250 g L^{-1}), Aprovia Top (benzovindiflupyr ('Solatenol') 100 g L^{-1}, difenoconazole 117 g L^{-1}), Orondis Ultra (oxathiapiprolin 30 g L^{-1}, mandipropamid 250 g L^{-1}), Torrent (cyazofamid 400 g L^{-1}), Tanos (famoxadone 25%, cymoxanil 25%), Revus (mandipropamid 250 g L^{-1})

OBJECTIVES: Evaluate the use of disease forecasting and spore trapping to identify high-risk late blight periods and modify fungicide programs compared to current methods.

EQUIPMENT/FORECASTING SYSTEMS: Spornado passive spore trap (Sporometrics), Rotorod (Phytodata), BliteCast (as per Krause, 1975)

METHODS: The trial was completed at Ridgetown Campus, University of Guelph. Two cultivars, 'TSH39' (*+Ph-3*) and 'TSH34' (*–Ph-2*) with similar maturity dates were used were transplanted into twin rows on May 31 at Ridgetown and June 2 at Cedar Springs using a mechanical transplanter at a rate of 3 plants per metre. Each twin row was spaced 2 m apart. Each treatment plot was 7 m long and consisted of one twin row. Transplanted between each plot twin row was a guard row, cultivar TSH39, to ensure treatment separation. The trial was designed as a split-plot randomized complete block, 2 x 10 factorial with four replications. Factor A was the trigger initiating the application of high-risk fungicides for late blight management and factor B was the host resistance to *P. infestans*. The triggers tested were: late blight symptoms reported on tomato or potato in Ontario, Michigan, or Ohio, a Spornado positive finding for *P. infestans* at any trap location, a Rotorod positive finding for *P. infestans* at any trap location, a Rotorod sporangia count of 10 per m^3 or greater at any trap location, the accumulation of a DSV value of 18 from BliteCast, BliteCast DSV value of 18 and a positive Spornado result, BliteCast DSV value of 18 and a Rotorod sporangia count of 10 per m^3 or greater and BliteCast DSV value of 18 and a positive Rotorod result. In addition to the triggers there was also a non-treated control and a control that was only sprayed with fungicides applied during low *P. infestans* periods. Trap locations were those outlined in the previous study 'Comparison of spore trap technology for *Phytophthora infestans* surveillance'; Ridgetown, Cedar Springs, Eberts, Chatham, Erieau, Dover, Wallaceburg, and Dresden, Ontario. BliteCast was calculated by Weather Innovations Inc. using weather data collected at Ridgetown Campus according to the parameters of Krause (1975). A threshold of 18 DSV used to initiate a change in fungicide program. Except for the non-treated control, each treatment was sprayed with a standard, low-risk fungicide *P. infestans* management program throughout the season (Table 1). Once the respective high-risk trigger was initiated treatments were sprayed with the required 'high-risk' fungicides in addition to the low-risk program (Table 2). Fungicide treatments, application date, and their 'risk' level are listed in Table 1.

Applications were made using a hand-held CO_2 sprayer with nozzles ULD 120-03, and a water volume of 300 L Ha^{-1}.

A change in experimental design was required at the Cedar Springs trial due to severe plant mortality in replications 1 and 2 and in several plots in replications 3 and 4 caused by herbicide carry-over in the soil. A completely randomized design (CRD) with 4 replications was selected to best utilize the remaining plots. Plots were reduced from 7m to 2m and guard rows were used to increase the number of useable plots. Even with these changes, some treatments for 'TSH34' had to be eliminated. The triggers tested were: late blight symptoms reported on tomato or potato in Ontario, Michigan, or Ohio (TSH39 and TSH34), a Spornado positive finding for *P. infestans* at any trap location (TSH39 and TSH34), a Rotorod positive finding for *P. infestans* at any trap location (TSH39 and TSH34), a Rotorod sporangia count of 10 per m^3 or greater at any trap location (TSH39 and TSH34), the accumulation of a DSV value of 18 from BliteCast (TSH39), BliteCast DSV value of 18 and a positive Spornado result (TSH39), BliteCast DSV value of 18 and a Rotorod sporangia count of 10 per m^3 or greater (TSH39) and BliteCast DSV value of 18 and a positive Rotorod result (TSH39). In addition to the triggers there was also a non-treated control and a control that was only sprayed with fungicides applied during low *P. infestans* periods (TSH39 and TSH34).

Despite the absence of late blight symptoms, trials were still assessed for defoliation by estimating the percent of leaf canopy missing. Defoliation ratings were taken approximately every seven days starting on July 28 and continuing until September 15. These values were used to calculate the area under the disease progress stairs (AUDPC) using the following equation: $AUDPC = [(Y_1 + Y_n)/2 \times (D/n-1)]$, where Y_1 is the disease level at first assessment, Y_n is the disease level at last assessment, D is the difference in the number of days from the last assessment to the first assessment, n is the number of assessments.

Since there was no late blight in the trials, yield was not measured.

RESULTS: No late blight symptoms were observed in the trial. BliteCast DSV accumulation of 18 reached by June 13 at Cedar Springs and August 4 at Ridgetown (Appendix A) and the first positive Rotorod result being recorded on August 25 (see previous report 'Comparison of spore trap technology for *Phytophthora infestans* surveillance'. The accumulated DSV value and positive Rotorod result triggered the initiation of the high-risk sprays beginning on September 2 for treatment 5 and 9 (Table 3), respectively. The detection of late blight symptoms on July 26 in Ontario triggered the initiation of the high-risk sprays in treatment 3. While *P. infestans* sporangia were also detected by the Rotorod trap, no sample sporangia count reached the required threshold, 10 per m^3, to trigger the application of high-risk fungicides.

Defoliation rating values were primarily a result of bacterial disease and lower canopy leaf yellowing, likely due to a lack of water, not late blight, and so are not presented here.

Damage to a portion of the trial at Cedar Springs due to herbicide carryover in the soil, resulted in a change to experimental design and treatments. Moreover, the damage occurred after the Blitecast threshold had been exceeded on June 13 resulting in those treatments having to restart July 7. On July 4, herbicide drift damage was observed at the Ridgetown trial. Replication 4 had the most damage with moderate amounts of injury in replications 2 and 3. Replication 1 had the least amount of injury and was mostly unscathed. Assessments continued as planned but only replication 1 was used to determine trial maturity for a potential harvest.

CONCLUSIONS: Late blight did not occur during the experiment, so we were unable to identify if any of the high-risk spray triggers decreased late blight damage. However, for the third consecutive season, treatment initiation triggers of a Rotorod sporangia count of 10 per m^3 most closely aligned with the lack of late blight observed in the trial. This was similar to 2021 and 2019, when treatment initiation triggers of a Rotorod sporangia count of 10 per m^3 and in 2019 the identification of late blight symptoms in potato or tomato elsewhere in ON, MI, or OH most closely aligned with lack of late blight in the trial. The BliteCast disease severity values threshold to determine initiation of higher-risk, late blight fungicides was reached on June 13 and August 4 in Cedar Springs and Ridgetown, respectively, while only the Rotorod traps tested positive and initiated high-risk fungicide use on September 2, using the positive/negative thresholds. As several of the high-risk *P. infestans* fungicides are more costly than the low-risk options, producers would have begun a more costly management program earlier than required this year using Blitecast, positive detections in the Rotorod and reports of symptoms in the Great Lakes Region systems compared to the Rotorod with a 10 sporangia m^3 threshold or Spornado detection

Table 1. Low-Risk Fungicide Application Schedule. This program was applied to all treatments except the no fungicide control.

Ridgetown			Cedar Springs		
Product	**Rate / Ha**	**Date**	**Product**	**Rate / Ha**	**Date**
Bravo ZN	2.4 L	Jul 9	Bravo ZN	2.4 L	Jul 15
Quadris	400 mL	Jul 20	Quadris	400 mL	Jul 27
Bravo Zn	2.4 L	Jul 30	Bravo Zn	2.4 L	Aug 6
Aprovia Top	805 mL	Aug 10	Aprovia Top	805 mL	Aug 20
Bravo Zn	2.4 L	Aug 20	Bravo Zn	2.4 L	Sep 1
Bravo Zn	2.4 L	Sep 1			

Table 2. High-Risk Fungicide Application Schedule.

Application Order	Product	Rate / Ha
1st	Orondis Ultra	600 mL
2nd	Torrent + Sylgard 309	150 mL + 4:3 ratio
3rd	Tanos	560 g
4th	Revus + Sylgard 309	500 mL + 0.25%
5th	Torrent + Sylgard 309	150 mL + 4:3 ratio
6th	Tanos	560 g
7th	Orondis Ultra	600 mL
8th	Torrent + Sylgard 309	150 mL + 4:3 ratio
9th	Tanos	560 g

Table 3. Fungicides applied to processing tomato to validate fungicide programs based on *P. infestans* surveillance methods, 2022

Trt[a]	Trigger	High-Risk Fungicide Application[b]					
		Ridgetown			Cedar Springs		
		Product[c]	Date	# Applications	Product[c]	Date	# Applications
1	Non-treated Control	-	-	0	-	-	0
2	Control	-	-	0	-	-	0
3	Symptoms on potato or tomato in ON, MI, OH	Orondis Ultra Torrent + Sylgard 309 Tanos Revus + Sylgard 309 Torrent + Sylgard 309	Jul 28 Aug 9 Aug 17 Aug 25 Sep 2	5	Orondis Ultra Torrent + Sylgard 309 Tanos Revus + Sylgard 309 Torrent + Sylgard 309	Jul 28 Aug 9 Aug 18 Aug 26 Sep 2	5
4	Spornado Detection			0			0
5	Rotorod Detection	Orondis Ultra Torrent + Sylgard 309	Sep 2 Sep 12	2	Orondis Ultra Torrent + Sylgard 309	Sep 2 Sep 12	2
6	Rotorod Detection (≥10 sporangia/m³)	-	-	0	-	-	0
7	BliteCast (18 DSV)	Orondis Ultra Torrent + Sylgard 309 Tanos Revus + Sylgard 309 Torrent + Sylgard 309	Aug 5 Aug 15 Aug 23 Aug 31 Sep 9	5	Orondis Ultra Torrent + Sylgard 309 Tanos Revus + Sylgard 309 Torrent + Sylgard 309 Tanos Orondis Ultra Torrent + Sylgard 309	Jul 7 Jul 18 Jul 26 Aug 3 Aug 11 Aug 18 Aug 26 Sep 7	8
8	BliteCast (18 DSV) + Spornado Detection			0			0
9	BliteCast (18 DSV) + Rotorod Detection	Orondis Ultra Torrent + Sylgard 309	Sep 2 Sep 12	2	Orondis Ultra Torrent + Sylgard 309	Sep 2 Sep 12	2
10	BliteCast (18 DSV) + Rotorod Detection (≥10 sporangia/m³)	-	-	0	-	-	0

[a] The trigger, initiating the start of high risk fungicide applications, for treatments 6 and 10 was not reached during trial evaluation dates. [b] All treatments except the nontreated control received the low-risk fungicide spray program (see Table 1). [c] See Table 2 for product rates.

APPENDIX A: BliteCast DSV accumulation at Ridgetown Campus and Cedar Spring Research Farm in 2022. A threshold of DSV 18 was used to initiate a high-risk program for late blight (indicated by arrow).