2013 OTRI RESEARCH REPORT

	Project Title	Researcher	Funding
1	Tomato Cultivar Tolerance to Pinnacle	Darren Robinson	$1,000
	Weed Control and Crop Tolerance Evaluations in Processing Tomatoes	Darren Robinson Rob Nurse	$5,000 $3,000
	Herbicide-Fungicide and Herbicide-Insecticide Tank Mix Interaction in Tomatoes	Darren Robinson Rob Nurse	$5,000 $3,000
2	Re-Evaluation of Planting Densities in Processing Tomatoes	John Zandstra	$5,000
3	The development of pest management strategies for bacterial disease on processing tomato using copper and other tools - 2013	Cheryl Trueman	$4,900
	The development of pest management strategies for bacterial disease on processing tomato using alternative methods, 2013	Cheryl Trueman	$4,900
	The development of pest management strategies for foliar disease and fruit rots in processing tomatoes, 2013	Cheryl Trueman	$4,900
4	Impact of Soil Amendments on Processing Tomato Yield and Quality	Laura Van Eerd	$4,000
5	Impact of Transplant Treatments on Crop Productivity	Laura Van Eerd	$4,000
6	Assessing Vine Decline Disease Complex in the Rhizosphere	Laura Van Eerd	$4,000
7	Processing Tomato Breeding Program	Steve Loewen	
		Total	**$42,700**

EXECUTIVE SUMMARY – WEED CONTROL IN TOMATOES (2013)

BY: DARREN ROBINSON, RIDGETOWN CAMPUS, UNIVERSITY OF GUELPH

Herbicide-Fungicide Tank-Mix Interactions in Tomato

Objective: Determine whether Kocide 2000, Cabrio or Quadris increase injury to tomato or reduce weed control of Excel Super, Venture L, or Poast Ultra.

Conclusions: Kocide 2000 and Quadris reduced control of crabgrass by Excel Super and Poast Ultra. The reduction in grass control did correspond to a yield reduction compared to yield in those treatments where herbicides were applied alone. Quadris reduced crabgrass control by Excel and yield. Tank mixes of Kocide, Cabrio and Quadris with Excel Super and Poast Ultra can result in reduced weed control. It is recommended that these fungicides not be tank mixed with Poast Ultra or Excel Super, as reduced weed control may result in yield loss.

Herbicide-Insecticide Tank-Mix Interactions in Tomato

Objective: Determine whether Admire or Matador increase injury to tomato or reduce weed control of Excel Super, Venture L, or Poast Ultra.

Conclusions: The addition of Matador to Poast Ultra reduced crabgrass control, and resulted in a reduction in yield. The addition of either insecticide to Excel Super also reduced crabgrass control; despite this reduction in grass control, crop yield was not less in the Excel tank mix treatments than in those treatments where Excel Super was applied alone.

Tolerance of Tomato to Preemergence Herbicides

Objective: This trial was established to determine tolerance of transplanted tomato to pre-transplant applications of Reflex, Prowl, Valtera and tank mixes with Dual II Magnum and Sencor.

Conclusions: Valtera caused significant injury, but did not cause yield loss, as has been seen in previous years. Tomato showed excellent tolerance to Reflex and Prowl H2O. **Data were submitted to support minor use submissions for Reflex.**

Tolerance of Processing Tomato Varieties to Pinnacle

Objective: This trial was established to determine the tolerance of six processing tomato varieties to Pinnacle (thifensulfuron-methyl) applied 28 days after transplanting (DAT) at a rate of 6.4 g/ac.

Conclusions: H2401, H1308, H1289, H1315 AND H4007, and H3406 were injured by Pinnacle applied at 6.4 g/ac, and had delayed flowering and reduced yield. H1301, H1311, and H1178 were tolerant to Pinnacle.

Do Copper Formulation and Addition of Dithane Affect Weed Control or Tomato Tolerance to Prism?

Objective: This trial was established to determine the effect of tank mixing a) Kocide or Parasol with Prism, or b) Dithane, with either Kocide or Parasol, and Prism on weed control and tolerance of transplanted tomato.

Conclusions: None of the tank mixes caused more than 2% visual injury to tomato. Kocide or Parasol alone or tank-mixed with Dithane did not reduce efficacy of Prism. The addition of either copper formulation or Dithane to Prism did not reduce weed control.

2013 Processing Tomato Weed Management Report

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The tomato variety H9553 was used in all trials.

Trial 1 – **Evaluation of new herbicides for use in processing tomatoes.**

The herbicides tested were Reflex (0.4 and 0.8 L/ac), Prowl H2O (0.9 and 1.8 L/ac), Valtera (56 and 112 g/ac) all PPI. Tank-mixes of each were also tested with Dual + Sencor (0.59 + 0.53 L/ac) PPI.

The trial was kept weed-free so that crop tolerance could be accurately assessed. Visual injury symptoms from all treatments were minor except for the treatments containing Valtera. Injury from Valtera ranged from 19 to 38% in comparison to the untreated control. Yield in the Valtera treatments were about 6 Ton/ac lower than the control plots. Yield in the untreated control averaged 32 Ton/ac and did not differ from yields in any of the non-Valtera herbicide treatments.

Trial 2 – **Tolerance of processing tomato to Refine SG POST.**

Refine SG is a pre-mix of Pinnacle and another ALS inhibitor. Refine SG was applied at 16 and 32 g/ac. The resulting injury from this product was not acceptable and ranged from 33 to 65% in comparison to the untreated control. Yield was was reduced by 8 to 17 Ton/ac.

Trial 3 – **Annual grass herbicide-fungicide tankmix evaluations.**

In this trial grass herbicides were tank-mixed with several fungicides to determine if there was antagonism/synergism to weed control and any crop tolerance concerns. The grass herbicides tested were Excel Super (0.271 L/ac), Venture L (0.243 L/ac), and Poast Ultra (0.126 L/ac). The fungicides tested were Kocide 2000, Quadris, and Cabrio. Average yields in the weed-free control and herbicide only controls averaged 34 Ton/ac. Weed control was not compromised when the herbicides were tank-mixed with the fungicides. Except there was a decrease in crabgrass control (40% reduction) and tomato yield (5 Ton/ac) when Poast was tankmixed with Kocide or Quadris.

Trial 4 – **Annual grass herbicide-insecticide tankmix evaluations.**

In this trial grass herbicides were tank-mixed with several fungicides to determine if there was antagonism/synergism to weed control and any crop tolerance concerns. The grass herbicides tested were Excel Super (0.271 L/ac), Venture L (0.243 L/ac), and Poast Ultra (0.126 L/ac). The insecticides tested were Admire and Matador. Average yields in the weed-free control and herbicide only controls averaged 24 Ton/ac. Weed control was not compromised when the herbicides were tank-mixed with the insecticides except when Poast Ultra was tank-mixed with Matador (35% reduction in crabgrass control). A direct comparison between herbicide only treatments and the appropriate tank-mix treatments showed no differences in yield.

Trial 5 – **The effect of copper fungicides with and without Dithane on Prism efficacy.** The efficacy of Prism was tested when tankmixed with Parasol, or Kocide 2000 with and without Dithane. Average yields in the weed-free control were 24 Ton/ac. Weed control and yield did not differ among treatments.

TITLE OF PROJECT: Re-evaluation of planting densities for processing tomatoes

NAME OF CONTRIBUTOR(S) AND THEIR AGENCY:

J.W. Zandstra and R.C. Squire. Ridgetown Campus, University of Guelph, Ridgetown, Ontario, NOP 2CO.

Janice Leboeuf, OMAFRA, Ridgetown. 120 Main St. E. Ridgetown ON N0P 2C0

METHODS:

The commercial processing tomato varieties TSH 29, HZ 5108, and HZ 9706 were re-evaluated for a second year at plant populations of 8 000, 10 000, 12 000 and 18 000 plants/acre; the variety CC 337 was included in 2013. Transplants were sourced from commercial transplant producers. Plots were established by handon a Brookston clay loam sand spot phase soil on the Ridgetown Campus research farm. The site was fertilized with 90 kg nitrogen/ha (actual - as calcium ammonium nitrate); phosphorous and potash was applied as per soil tests and the trial was established on 21 May, 2013.

Bravo fungicide as applied on a weekly basis for disease control. Weeds were controlled by applying Dual (1.6 kg/ha ai) and Sencor (0.3 kg/ha ai) ppi, and Sencor (0.15 kg/ha ai) post every 2 weeks. Weed escapes were controlled by cultivation and hoeing.

DATA COLLECTION: Plant fresh weights were taken on 5 plants per plot, 4 weeks after transplanting and then again weekly for two weeks. Flower counts began when they appeared, and continued weekly for 2 weeks. Plots were harvested (8 plants per plot) and fruit was graded into red, green and processing green fruit and expressed as tons/acre.

EXPERIMENTAL DESIGN AND DATA ANALYSIS:

The experiment was established as a randomized complete block design with 4 replications. A plot consisted of 1 bed (2 rows), 26' (8.0 m) in length. Transplants were established in double rows which were spaced 45 cm apart. A protected LSD was used to separate treatments with significant differences. Means followed by the same letter within a column do not differ significantly (P = 0.05).

RESULTS AND DISCUSSION:

Most varieties demonstrated smaller plant size and delayed flowering as populations increased. Ripe fruit yields only increased significantly when populations increased with HZ9706 (Table 9). No significant total yield differences were noted with any variety across the populations evaluated; however yields tended to maximize at 10,000 plants per acre with HZ9706, and between 10,000 and 12,000 plants per acre with CC337. The total yields of HZ 5108 and TSH 29 appeared largely unresponsive to plant populations in 2013.

Integrated Management of Bacterial Spot in Ontario Processing Tomatoes
By: Cheryl Trueman, M.Sc., Ridgetown Campus, University of Guelph
Fall 2013

The Ontario processing tomato industry regularly experiences yield losses due to the presence of bacterial spot. Bacterial spot may be caused by at least four different bacterial spot causing Xanthomonads (BSX) pathogens, the most aggressive of which is *Xanthomonas gardneri*.

In plant disease management theory, we can approach the management of diseases using three main strategies:

1. Reduce the amount of primary inoculum.
2. Reduce the rate of infection of the pathogen.
3. Reduce the duration of the epidemic.

For diseases such as bacterial spot with a polycyclic disease cycle (ie. compound interest disease), reducing the amount of primary inoculum is only effective if it can be reduced to extremely low levels because the infection rate of bacterial spot is so high. For example, infested seed is thought to be a primary source of inoculum for bacterial spot. Even with a disinfestation protocol that is 99.999% effective, 1 out of 100,000 seeds may carry BSX. This equates to approximately 1 plant in 350 288-cell trays as a possible source of inoculum. Thus, from an Ontario perspective, it may be best to assume that seed is infested at an extremely low, but important level, every season.

This leaves us to identify the best methods to reduce the rate of infection of BSX and to reduce the duration of the epidemic – in other words, we should try to slow the reproduction and spread of BSX as long as possible to delay the development of the 'critical mass' that leads to plant infection and symptom development. A focus on tomato transplant production may provide the greatest value to the Ontario industry. Previous research by Diane Cuppels (AAFC) demonstrated that BSX overwintering in Ontario is a) minimial, b) random (not associated with severely infected fields from the previous year), and c) and does not occur for more than one winter. Dr. Sally Miller (Ohio State) currently has a Ph.D. student who is evaluating the overwintering potential of *X. gardneri* in Ohio.

The current approach to bacterial spot management in tomato transplant production involves regular applications of copper hydroxide coupled with irrigation management strategies that avoid excessive periods of leaf wetness, the later of which can be hard to achieve. The current lack of tools in the transplant production toolbox warrants further investigation into integrated bacterial spot management strategies at the beginning of the tomato season.

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The following areas of research may provide benefits to the industry over the long-term by identifiying methods to either a) reducing levels of primary BSX inoculum in transplant production, or b) identifying sources of primary BSX inoculum. We do not currently have the capacity at Ridgetown Campus to complete all of this work; however, we can begin to move in the right direction to address these research questions with support from the industry. There may also be opportunities to leverage additional funding and/or collaborate with other research institutions to complete some of this work, as I am planning to do in my proposal relating to the topics in bullet #1 (please refer to the separate research proposals for additional details to those listed below).

1. Integration of multiple modes of action for BSX suppression in tomato transplant production.

Research Question	Potential Benefits to the Industry
Can initial inoculum levels of BSX be reduced by applying products with multiple modes of action to tomato transplants? (ie. reduce or delay population growth on plants produced from infested seed)	Eliminating or reducing populations to extremely low levels using combinations of products and applications timings (ie. disinfectant Kleengrow, seed treatment with Actigard, copper, etc.) may delay BSX population growth. This in turn may delay the development of disease symptoms in the field and reduce economic losses to growers.
Can healthy transplants be maintained by protecting tomato transplants using multiple modes of action? (ie. protect healthy transplants from colonization and infection)	Similar benefits to above.

2. Monitoring of copper resistance in BSX populations living as epiphytes on tomato transplant surfaces and early detection of BSX populations in transplant greenhouses.

Research Question	Potential Benefits to the Industry
Are BSX isolated on plant leaf surfaces resistant to copper?	It would be beneficial to know the level of copper resistance in BSX populations found in transplant greenhouses. If copper products are used to manage bacterial spot during seed production, it may be possible that populations of BSX have some tolerance to copper before the production season begins. This might also be true if BSX are capable of overwintering in Ontario greenhouses.

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Is it possible to use infrared imaging or other sensing tools to identify transplants under stress (ie. potentially with BSX) prior to symptom development?	It might be useful to explore whether remote sensing tools such as infrared imaging are capable of detecting plant stress related to BSX colonization. This would allow for early detection of outbreaks in transplant greenhouses.

3. Overwintering potential of BSX in transplant greenhouses.

Research Question	Potential Benefits to the Industry
Can BSX overwinter in transplant greenhouses?	Our current assumption is that the capacity of BSX to overwinter in Ontario fields is very limited; however, no one has evaluated the capacity of BSX to overwinter in more sheltered greenhouse environments. If that capacity exists, it could be a potentially important source of inoculum and the industry might benefit from additional research on greenhouse disinfestation methods.

2013 Research Report: Pest management in Ontario processing tomatoes

Prepared for the Ontario Tomato Research Committee (OTRI)
October 31, 2013

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Acknowledgements: In addition to the Ontario Tomato Research Committee we would like to thank the following groups and organizations for their financial or in-kind support: OMAF, University of Guelph, the numerous agricultural companies that donated seed and/or products for testing. Additional funding for some treatments was received from Syngenta Canada and Dow Agrosciences. We greatly appreciate your support of the vegetable pest management program at Ridgetown Campus.

Key Findings / Summary of Results

Project 1: Pest management strategies for foliar disease and fruit rots in processing tomatoes

<u>Objective</u>: Evaluate fungicides for fungal disease management under Ontario conditions. (p. 6-11)
We were able to successfully inoculate the trial with *A. solani* in order to evaluate the effect of foliar fungicides on early blight defoliation. The results indicate that all fungicides tested (Bravo 500, Bravo ZN, Echo 90 DF, Quadris, Inspire, Quadris TOP, Cabrio, Fontelis, Scala, Lance, Reason, 496/A + 496/B) were effective at reducing defoliation except for Taegro. The most effective fungicides for management of early blight were Quadris TOP, Bravo 500, Bravo ZN, Quadris, Inspire, Cabrio, Scala, Lance, Reason, and Echo 90 DF. All fungicides except for Scala, Lance, Reason, 496/A + 496/B and Taegro reduced the severity of anthracnose on tomato fruit. Inspire reduced the severity of anthracnose, but not the incidence of anthracnose. The most effective fungicides for anthracnose management were Quadris, Cabrio, Bravo 500, Bravo ZN, Quadris TOP, Fontelis, and Echo 90 DF, in other words, fungicides with active ingredients that included chlorothalonil or a member of the Group 11 (QoI) fungicides. Fungicides that most effectively managed both early blight and anthracnose were: Quadris TOP, Quadris, Cabrio, Bravo 500, Bravo ZN, and Echo 90 DF.

<u>Objective</u>: Evaluate the influence of fungicide selection and the timing of the last fungicide application on the incidence and severity of tomato fruit rots under delayed-harvest conditions under a 7 to 10 day spray program. (p. 12-16)

Preliminary results indicate that applying fungicides up to 28 days before harvest is as or more effective than continuing applications up to 7 or 14 days before harvest for management of fruit rots. In addition, applications of Quadris alternating with Bravo were more likely to result in a reduction in fruit rot than applications of Bravo alone when fruit were overripe. The causal agent of anthracnose can infect green fruit, thus, fungicide applications during early stages of fruit development may be more critical than late-season fungicide applications. Infection of fruit by *Alternaria* spp. causing black mould occurs when fruit are ripe whereas infection by *Alternaria solani* (*Alternaria tomatophila*), which is also the causal agent of early blight, can occur on green or red fruit. It is not clear why anthracnose and black mould incidence was higher when fungicide applications ended 7 days before harvest compared to 28 days before harvest for some spray programs and ripeness treatments. If similar results are obtained in future years of study, the mechanism for this response warrants further investigation. It is also important to note that late season applications of broad-spectrum fungicides such as Bravo are beneficial for other reasons, such as prevention of late blight (*Phytophthora infestans*).

Project 2: Development of pest management strategies for bacterial disease on processing tomato using copper and other tools

<u>Objective</u>: Evaluate the influence of the number of applications of copper (ie. Kocide) on bacterial disease management, 2012-2013. (p. 17-21)

Field applications of Kocide 2000 suppressed bacterial spot early in the season in 2012, but had no effect on bacterial spot suppression in 2013. There was no effect of Kocide 2000 applications in the field on defoliation in either year. The incidence of bacterial spot on fruit was not affected by the number of Kocide 2000 applications in 2012. In 2013, the nontreated control, 6 applications, and 11 applications had a lower incidence of bacterial spot on fruit than 3 applications of Kocide 2000 when Kocide 2000 was also applied to transplants. There were no differences among treatments for tomato yield.

Current OMAF recommendations suggest applying copper to greenhouse transplants at 5-day intervals, and to make at least three copper applications after transplanting in the field. Greenhouse copper applications did not impact plant growth and development or bacterial disease levels in these trials. Greenhouse copper applications are used preventatively to suppress bacterial disease on transplants. There may have been no effect of these applications on bacterial disease because the transplants were pathogen-free prior to inoculation in the field, after the residual activity of the greenhouse applications had ended.

OMAF recommends three applications of a copper-based bactericide such as Kocide 2000 after transplanting in the field. This was effective in suppressing early season bacterial spot in 2012, when conditions in June were relatively dry, but was not effective in 2013, when precipitation was above average. Kocide 2000 was not effective at reducing late season defoliation from bacterial spot, regardless of how many applications of copper were made in a season. Thus, our results suggest that season-long applications of Kocide 2000 are not beneficial for bacterial spot suppression when high populations of the causal agent, *X. gardneri*, are present in June. In fact, these results, along with other trial results from recent years, suggest that any field applications Kocide 2000 applications provided limited and inconsistent suppression of bacterial spot. Recommendations for bacterial spot will be reviewed this winter with OMAF vegetable specialist, Janice LeBoeuf.

Objective: Evaluate the efficacy of copper alternatives for bacterial disease management, evaluate the influence of Agral 90 applications on bacterial disease severity, and evaluate the influence of the addition of Bravo to product for bacterial disease control.

Trial 1: Evaluation of products for bacterial spot management in tomato **(p. 22-26)**
Applications of Kocide + Actigard were the only treatment to reduce both early season and late season disease severity in this trial. Applications of Kocide + Actigard have been the most consistent treatment for suppression of bacterial spot early in the season over the past few years. The AUDPC for early season bacterial spot incidence was lower for treatment Kocide + Actigard than the nontreated control, 496/A + 497/B, Regalia Maxx, Serenade Max, and Taegro. None of the treatments reduced the amount of defoliation below the level in the nontreated control, except for treatments Actigard and Kocide + Actigard on Aug 27. There were no differences among treatments for tomato yield or bacterial spot incidence on fruit. Treatments evaluated in this trial were eight applications of Kocide, Actigard, Kocide + Actigard, 496/A + 497/B, 496/A + 497/B + Actigard, Regalia Maxx, Serenade Max, and Taegro.

Trial 2: Evaluation of Bravo, Quintec, and Agral 90 for bacterial spot management in tomato **(p. 27-31)**
There was no difference among treatments for the incidence of leaves with bacterial spot symptoms early in the season. The AUDPC for defoliation was lower for treatment Kocide 2000 + Dithane than in the nontreated control, indicating some suppression of bacterial spot defoliation late in the season. There was no difference among treatments for red or green tomato yield or the incidence of bacterial spot on tomato fruit. Bravo 500 had fewer field rots than the nontreated control, possibly because of the additional chlorothalonil above and beyond maintenance applications of Quadris that were applied for early blight and late blight prevention. Agral 90 did not increase disease incidence. Ontario processing tomato growers need more effective management strategies to prevent losses from bacterial spot when symptoms develop early in the season. Possible methods to achieve this may include additional tools for reduction or elimination of bacterial populations on tomato transplants. Treatments evaluated in this trial were eight applications of Kocide, Kocide + Dithane, Bravo, Kocide + Bravo, Quintec, Kocide + Quintec, Kocide + Dithane + Quintec, Agral 90.

Project 3: The development of pest management strategies for bacterial disease on processing tomato using alternative methods

Objective: Evaluate Ridgetown Campus breeding lines with tolerance to vine decline for tolerance to bacterial spot (p. 32-36)
This trial was completed to explore whether breeding line rootstocks identified by the Ridgetown Campus tomato breeding program (S. Loewen) as tolerant to vine decline also confer tolerance to bacterial spot, possibly through an induced resistance mechanism resulting from positive root associations with soil microorganisms. In previous work, P279 and Q183 rootstocks with an H2401 scion were identified as high performers and H2401 and TI01-0004 were identified as low performers in vine decline affected soils. In this trial grafting H2401 on different rootstocks did not improve tolerance to bacterial spot compared to H2401 grafted on its own rootstock. In fact, H2401 demonstrated better season-long tolerance to bacterial spot infection on foliage than the three breeding lines evaluated in this trial. The trial was conducted at a different location than the previous research by Loewen. It is possible that differences in microbial communities exist among sites, however, this likely would not impact the result we found that nongrafted H2401 was more tolerant of bacterial spot than the other nongrafted lines that were tested.

Another interesting observation was that the early-season disease severity for nongrafted lines Q183 and P279 were equivalent; however, line Q183 was less tolerant to bacterial spot later in the season than P279. In the future, it may be worthwhile to examine breeding lines for defoliation tolerance to bacterial spot through field screening, and to explore the genetic mechanisms behind this response.

Objective: Evaluate use of plant growth regulators and plant defense activators for management of bacterial disease: please refer to the 3-page results summary (p. 37-39). A full report has also been submitted to OPVG and is available for review.

C. Trueman, UGRC

Ontario Tomato Research Institute

Impact of Soil Amendments on Processing Tomato Yield and Quality.

2013 Research Report:

Researcher: Dr. Laura L. Van Eerd
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In August 2009, processing tomato growers in southwestern Ontario noticed unusual crop symptoms, which resulted in an estimated 30% or higher yield loss. This was later termed 'vine decline' and appears to be associated with a root disease complex. Management of a disease complex is challenging because conditions that suppress one fungus may amplify others and crop rotation is unlikely to suppress vine decline due to the very wide host range. Results by C. Trueman and K.L. Conn in 2010-2011 suggest very limited disease suppression with fumigation at high rates in commercial fields and in micro-plots (which were sealed to prevent fumigant vapour loss) as well as with chemical or biological controls in greenhouse screening tests. Without resistant varieties, there is a need to assess alternative methods to suppress vine decline disease complex.

Objective:

In Kent and Leamington growing regions, in commercial processing tomato fields with vine-decline disease complex, the objective of this research was to evaluate the impact of various soil amendments and transplant treatments on processing tomato yield and quality. The rationale was that these treatments would modify the species of bacteria and fungi in the rhizosphere (soil around the tomato root) and minimize pathogens colonizing tomato roots.

Methods:

The experiment was a randomized complete block design with four replications, and 4 soil amendment treatments (Table 1) at two commercial processing tomato fields near Leamington and Lighthouse Cove with an expected high risk of vine decline disease complex in 2011-13. Only one site was planted in 2011 at Lighthouse Cove and in 2013, the site at Dover was abandoned due to flooding. At all sites, the plot size was 20x15 ft, with 3 sets of twin rows of tomatoes. Harvest area was 2 m (double row bed) to assess tomato yields (red, breaker, processing green, grass green and rot) and quality (Agtron colour, soluble solids, pH) analyzed by S.A. Loewen's research team. Ethrel® was not applied to the trial area.

Results:

Only 2013 data presented in Table 1 (See Executive Summary for all three years). Results in 2011 and 2013 were similar to 2012 but there were no significant differences among treatments. In 2011, there was high vine decline pressure and high field variability throughout the trial and the entire commercial field. In 2011, there was a split fruit set, thus, total yield, rather than marketable yield, was more representative of true grower yield. In 2012-13, there were very few foliar symptoms and very few rots at harvest. In all years, poultry manure appeared to delay maturity as indicated by higher grass green fruit. In 2012, applying a soil amendment increased total yield compared to both the untreated control. Results were consistent at both sites in 2012 under low vine decline pressure. As expected, there were differences between years in fruit quality (Agtron colour, soluble solids, pH), but treatments did not affect fruit quality in all three years. Over all seasons and sites, yield of processing tomato with soil amendments of poultry manure, mushroom compost, TerraBioGen's thermophilic compost, and MPT MustGRO® mustard seed meal was the same as or better than the unamended control. Dr. George Lazarovits' team at A&L Laboratories collected soil, plant and root samples from this trial in all years to evaluate the effect of these amendments on root pathogens (OMAF final report due Spring 2014). It is anticipated that this collaboration will provide not only on short-term strategies but also insights into the vine decline complex.

Table 1. In 2013, impact of soil amendments on processing tomato yield at Leamington commercial field site with suspected vine decline disease complex.

Treatment	Rationale for the treatment	Timing	Rate	Marketable yield (t/ac)	total yield (t/ac)
Control -no amendment	Nothing applied	-	-	44.6 ns	47.2 ns
Spent mushroom compost	California organic producers use a lot of compost and seem to have lower corky root	PPI***	10 ton/ac	48.2	51.9
MPTMustGRO® mustard seed meal	Biofumigant –contains similar compound as Vapam®	PPI + 1" irrigation	2 ton/ac	47.6	50.6
TerraBioGen's thermophilic composting	Liquid and solid pellets from TerraBioGen's thermophilic composting. Favourable results shown with potatoes.	1) Seedling 2) PPI 3) Post	1) Root drench 2) 200 kg/ac 3) drench 5 gal/ac	46.5	48.9
Poultry manure	Suggested success in California	PPI	5 ton/ac	51.5	58.1

*ns indicates not significant. Within each column, treatments with a different letter were significantly different at p=0.05.

**this treatment was not included in 2011.

***PPI, Preplant Incorporated. Treatment was applied at least 2 wk before transplanting and incorporated the same day.

We gratefully thank grower cooperators and funding by OTRI and OMAF and MRA.

Ontario Tomato Research Institute

Impact of Transplant Treatments on Crop Productivity.

2013 Research Report:

Researcher: Dr. Laura L. Van Eerd
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In August 2009, processing tomato growers in southwestern Ontario noticed unusual crop symptoms, which resulted in an estimated 30% or higher yield loss. This was later termed 'vine decline' and appears to be associated with a root disease complex. Management of a disease complex is challenging because conditions that suppress one fungus may amplify others and crop rotation is unlikely to suppress vine decline due to the very wide host range. Results by C. Trueman and K.L. Conn in 2010-2011 suggest very limited disease suppression with fumigation at high rates in commercial fields and in micro-plots (which were sealed to prevent fumigant vapour loss) as well as with chemical or biological controls in greenhouse screening tests. Without resistant varieties, there is a need to assess alternative methods to suppress vine decline disease complex.

Objective:

In Kent and Leamington growing regions, in commercial processing tomato fields with vine-decline disease complex, the objective of this research was to evaluate the impact of various soil amendments and transplant treatments on processing tomato yield and quality. The rationale was that these treatments would modify the species of bacteria and fungi in the rhizosphere (soil around the tomato root) and minimize pathogens colonizing tomato roots. .

Methods:

The experiment was a randomized complete block design with four replications, and three transplant treatments (Table 1) at two commercial processing tomato fields near Leamington and Lighthouse Cove with an expected high risk of vine decline disease complex in 2011-13. Only one site was planted in 2011 at Lighthouse Cove and in 2013, the site at Dover was abandoned due to extreme water surplus (flooding). At all sites, the plot size was 20x15 ft, with 3 sets of twin rows of tomatoes. Harvest area was 2 m (double row bed) to assess tomato yields (red, breaker, processing green, grass green and rot) and quality (Agtron colour, soluble solids, pH) analyzed by S.A. Loewen's research team. Ethrel® was not applied to the trial area.

Results:

Only 2013 data presented in Table 1 (See Executive Summary for all three years). Results in 2011 and 2013 were similar to 2012 but there were no significant differences among treatments. In 2011, there was high vine decline pressure and high field variability throughout the trial and the entire commercial field. In 2011, there was a split fruit set, thus, total yield, rather than marketable yield, was more representative of true grower yield. In 2012-13, there were very few foliar symptoms and very few rots at harvest. In 2012, the TerraBioGen's thermophilic compost treatment, which included a transplant seedling root drench and solid and liquid soil amendments in the field, had higher total yield compared to both the untreated control and the microbial transplant root drench (Table 1). Other soil amendments also had higher yields than the untreated control (see report 1). Results were consistent at both sites in 2012 under low vine decline pressure. As expected, there were differences between years in fruit quality (Agtron colour, soluble solids, pH), but treatments did not affect fruit quality in all three years. Dr. George Lazarovits' team at A&L Laboratories collected soil, plant and root samples from this trial in all years to evaluate the effect of these amendments on root pathogens (OMAF final report due Spring 2014). It is anticipated that this collaboration will provide not only on short-term strategies but also insights into the vine decline complex.

Table 1. In 2013, impact of transplant treatments on processing tomato yield at Leamington commercial field site with vine decline disease complex.

Treatment	Rationale for the treatment	Timing	Rate	Marketable yield (t/ac)	Total yield (t/ac)
Control -no amendment	Nothing applied	-	-	44.6 ns	47.2 ns
Microbial Pseudomonad	Microbe out-competes pathogens and colonizes root	Transplanting	Root drench	41.8	44.3
TerraBioGen's thermophilic composting	Liquid and solid pellets from TerraBioGen's thermophilic composting. Favourable results shown with potatoes.	1) Seedling 2) PPI 3) Post	1) Root drench 2) 200 kg/ac 3) drench 5 gal/ac	46.5	48.9

*ns indicates not significant. Within each column, treatments with a different letter were significantly different at p=0.05.

**this treatment was not included in 2011.

***PPI, Preplant Incorporated. Treatment was applied at least 2 wk before transplanting and incorporated the same day.

We gratefully thank grower cooperators and funding by OTRI and OMAF and MRA.

Impact of Soil Amendments and Transplant Treatments on Processing Tomato Productivity and Vine Decline Disease Complex.
Final Report 2013

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In August 2009, processing tomato growers in southwestern Ontario noticed unusual crop symptoms, which resulted in an estimated 30% or higher yield loss. This was later termed 'vine decline' and appears to be associated with a root disease complex. Management of a disease complex is challenging because conditions that suppress one fungus may amplify others and crop rotation is unlikely to suppress vine decline due to the very wide host range. Results by C. Trueman and K.L. Conn in 2010-2011 suggest very limited disease suppression with fumigation at high rates in commercial fields and in micro-plots (which were sealed to prevent fumigant vapour loss) as well as with chemical or biological controls in greenhouse screening tests. Without resistant varieties, there is a need to assess alternative methods to suppress vine decline disease complex.

Objective: In Kent and Leamington growing regions, in commercial processing tomato fields with vine-decline disease complex, the objective of this research was to evaluate the impact of various soil amendments and transplant treatments on processing tomato yield and quality. The rationale was that these treatments would modify the species of bacteria and fungi in the rhizosphere (soil around the tomato root) and minimize pathogens colonizing tomato roots. .

Methods: The experiment was a randomized complete block design with four replications, and 6 treatments (Table 1) at two commercial processing tomato fields near Leamington and Lighthouse Cove with an expected high risk of vine decline disease complex in 2011-13. Only one site was planted in 2011 at Lighthouse Cove and in 2013, the site at Dover was abandoned due to extreme water surplus (flooding). At all sites, the plot size was 20x15 ft, with 3 sets of twin rows of tomatoes. Harvest area was 2 m (double row bed) to assess tomato yields (red, breaker, processing green, grass green and rot) and quality (Agtron colour, soluble solids, pH) analyzed by S.A. Loewen's research team.

Results: In 2011, there was high vine decline pressure and high field variability throughout the trial and the entire commercial field. In 2011, there was a split fruit set, thus, total yield, rather than marketable yield, was more representative of true grower yield. In 2012-13, there were very few foliar symptoms and very few rots at harvest. Ethrel® was not applied to the trial area. In all years, poultry manure appeared to delay maturity as indicated by higher grass green fruit. In 2012, applying a soil amendment increased total yield compared to both the untreated control and the microbial transplant drench (Table 1). Results were consistent at both sites in 2012 under low vine decline pressure. Results in 2011 and 2013 were similar to 2012 but there were no significant differences among treatments. As expected, there were differences between years in fruit quality (Agtron colour, soluble solids, pH), but treatments did not affect fruit quality in all three years. Over all seasons and sites, yield of processing tomato with soil amendments of poultry manure, mushroom compost, TerraBioGen's thermophilic compost, and MPT MustGRO® mustard seed meal was the same as or better than the unamended control. Dr. George Lazarovits' team at A&L Laboratories collected soil, plant and root samples from this trial in all years to evaluate the effect of these amendments on root pathogens (see report 3). It is anticipated that this collaboration will provide not only on short-term strategies but also insights into the vine decline complex.

Table 1. In 2011-13, impact of soil amendments and transplant treatments on processing tomato yield at Leamington and Lighthouse Cove commercial field site with vine decline disease complex.

Treatment	Rationale for the treatment	Timing	Rate	Lighthouse Cove		Leamington		Lighthouse Cove		Leamington	
				2011	2012	2012	2013	2011	2012	2012	2013
				Marketable Yield (t/ac)				Total Yield (t/ac)			
Control -no amendment	Nothing applied	-	-	16.6 ns*	50.5 ns	52.8 ab	44.6 ns	28.1 ns	58.8 b	59.4 b	47.2 ns
Microbial Pseudomonad	Microbe out-competes pathogens and colonizes root	Transplanting	Root drench	25.2	51.5	54.1 ab	41.8	34.4	62.0 b	59.9 b	44.3
Spent mushroom compost	California organic producers use a lot of compost and seem to have lower corky root	PPI***	10 ton/ac	17.0	51.8	59.1 a	48.2	30.3	65.8 a	67.7 a	51.9
MPT MustGRO® mustard seed meal	Biofumigant –contains similar compound as Vapam®	PPI + 1" irrigation	2 ton/ac	17.8	56.5	56.1 ab	47.6	32.0	68.2 a	65.4 a	50.6
TerraBioGen's thermophilic composting	Liquid and solid pellets from TerraBioGen's thermophilic composting. Favourable results shown with potatoes.	1) Seedling 2) PPI 3) Post	1) Root drench 2) 200 kg/ac 3) drench 5 gal/ac	18.6	52.1	63.3 a	46.5	32.8	64.6 a	69.7 a	48.9
Poultry manure	Suggested success in California	PPI	5 ton/ac	**	52.4	46.1 b	51.5	**	70.2 a	65.1 a	58.1

*ns indicates not significant. Within each column, treatments with a different letter were significantly different at p=0.05.
**this treatment was not included in 2011.
***PPI, Preplant Incorporated. Treatment was applied at least 2 wk before transplanting and incorporated the same day.

We gratefully thank grower cooperators and funding by OTRI and OMAF and MRA.

Processing tomato breeding research report to the Ontario Tomato Research Institute, November 2013.

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1. Brief review of program background

Between 1984 and 2002 at AAFC-GPCRC Harrow, modern cultivated varieties of tomato were hybridized with wild species of tomato. These crosses represent a source of new genetic variation to increase genetic diversity of breeding lines and Ontario processing tomato cultivars developed from them. Work at Ridgetown continues to focus on backcrossing and selection to combine this new genetic variation with commercially adapted traits for Ontario.

2. Summary of program objectives

(a) To release breeding lines with increased genetic diversity. More genetic diversity among cultivars is associated with reduced risk of disease epidemics, and greater crop tolerance to weather extremes.

(b) To extend the harvest season by gathering data on earliness of individual breeding lines (date of 80% red ripe) and the ability of breeding lines to hold fruit quality once fruit are ripe (number of weeks fruit quality is retained following 80% red ripe maturity), to inform decisions for selection.

(c) To develop various sub-projects (e.g. to enhance nutritional value of processing tomatoes by increasing lycopene levels, or levels of anthocyanins; e.g. new traits or combinations of traits from wild species)

(d) To measure soluble solids on advanced breeding lines to support decision-making. Soluble solids are an important quality component of tomatoes for sauces and paste since the concentration of tomato solids represents a significant energy requirement in the manufacture of these products. Measurements on the natural tomato soluble solids content of advanced breeding lines can assist when selecting parents for the development of new breeding lines.

(e) To identify molecular markers in Ridgetown breeding lines identified as performing well under vine decline disease complex field conditions, to support future breeding and selection work.

3. Release of breeding lines

Seventy-six F_7 generation breeding lines, selected in fall 2012, were released in time for 2013 field planting. Most of these breeding lines built on the work done at AAFC-GPCRC, Harrow. We are continuing our work to develop a greater number of lines combining backgrounds of multiple wild species as illustrated in Table 1.

Table 1. Number of breeding lines released in 2013 with wild tomato species, either alone or in combination, in the recent pedigree.

Wild tomato species in the recent pedigree	Number of lines released in 2013
Solanum habrochaites	23

S. habrochaites and *S. pennellii*	11
S. habrochaites and *S. pimpinellifolium*	2
S. habrochaites and *S. galapagense*	2
S. habrochaites and S. corneliomulleri	1
S. habrochaites, S. pennellii and S. corneliomulleri	1
S. habrochaites, S. peruvianum and *S. chilense*	3
S. habrochaites, S. chilense and *S. lycopersicoides*	2
S. habrochaites, S. peruvianum, S. chilense and *S. pennellii*	1
S. peruvianum	1
S. pennellii	1
S. corneliomulleri	1
S. corneliomulleri and *S. pennellii*	1

4. Extending the harvest season: Maturity dates and field-holding ability

In 2013 we collected 80%-red-ripe maturity dates on all selections and this proved to be an unusual challenge this past year. Our earliest plantings were affected by frost at the end of May. The growing season tended to be relatively cool and wet. We observed that many breeding lines developed an unusual type of split-set. These lines tended to have a relatively large number of red-ripe fruit, and larger-than-usual numbers of breakers that didn't ripen until the original red-ripe fruit were starting to rot. Similarly, these lines tended to have large numbers of processing green fruit with few, if any fruit, transitioning to breakers. There were some lines that were merely advanced a generation, due to their poor response to the conditions we experienced this past season.

5. Summary of field selections 2013

Nine acres of breeding plots were established on a farm on Selton Line, northwest of Ridgetown. There were 643 breeding lines from F_2 to F_6 generations planted (compared to 1,201 planted in 2012). The F_6 to F_3 generations originated from selections made at Ridgetown during fall 2012, and which were subsequently retained following screening for disease resistance during the winter. A large number of lines selected in 2012 was temporarily shelved and will be re-incorporated into the breeding program in future years. A total of 641 selections were made in fall 2013. Field selection work began on August 20 and was completed on September 19 although seed-saving and note-taking in other trials was not completed until October 22.

6. Sub-projects on specific traits

As an outcome of a project initiated in 2007, we began to release some of the first lines with alternative fruit colours combined with other traits necessary for processing. One of the lines released had yellow fruit (*r*), and one of the lines had orange fruit (*t*). The objective of this work is to enable the processing industry to develop and test potential interest in a multi-coloured, diced tomato product.

We are continuing to work with high-pigment genes attempting to overcome some of the defects associated with these genes. They provide a means to increase lycopene and beta-carotene significantly compared to normal tomatoes. We now have lines with the high-pigment genes combined with mid-season maturity and acceptable yield. We are continuing our backcrossing and selection to improve plant performance further.

We have a series of lines with high-anthocyanin fruit combining *Atroviolacea* (*Atv*) and *anthocyanin fruit* (*aft*) in a processing background, and originating from the semi-wild lines we have been working with. They yield very well but require larger fruit size before they are ready for release.

7. Soluble solids measurement

We measured natural tomato soluble solids (NTSS) on the 2013 cohort of selections. Samples were collected when each selection reached 80% red ripe, and measurements were taken on 2 check varieties that same day and at a similar stage of maturity for comparison. The data on individual lines will be used where appropriate to guide choices for future use of those lines.

8. Vine decline disease complex

This past year we have been developing two segregating mapping populations to conduct future QTL studies with the goal of identifying molecular markers associated with traits that contribute to good plant performance under vine decline field conditions. Breeding lines P279 and Q183 performed as well as the best commercial greenhouse tomato rootstocks in 2011 and 2012 under vine decline field conditions. Breeding line TI01-0004 was the worst-performing breeding line in that trial.

While we were preparing the mapping populations for trials to begin in 2014, we planned to take advantage of the 2013 season to test another hypothesis that Verticillium may have a role in vine decline.

In earlier work done on vine decline disease complex there was some evidence that Verticillium may have a role in the development of this problem. To investigate this further, the ideal way to conduct this type of work in the field would require a series of near-isogenic lines, with each possible combination of the Verticillium resistance alleles present or absent. Many years would be required to develop this type of gene knockout series and so, similar to our previous studies, we used grafting. Our objective was to determine if there were any differences among root genetics on the productivity of tomato plants, when grown in a soil believed to be prone to vine decline.

The common scion on all grafted plants was H2401, a vine-decline-susceptible, F_1 hybrid used in previous experiments. Assuming that specific rootstock-scion interactions were negligible, since all above-ground plant parts were the same, any differences in measured performance could be attributable to root genotype.

Table 2. Rootstock treatments used in the 2013 grafted-plants trial.

Name	Verticillium race 1	Verticillium race 2
Italian Winter	highly susceptible	highly susceptible
Heinz 1706	resistant	susceptible (although not verified experimentally)
Campbell-28	susceptible	resistant (to NC isolates)
Heinz 1350	resistant	resistant (to NC isolates)
P279AAABA (best-performing Ridgetown line in previous vine decline studies)	unknown	unknown
TI01-0004AAAAA (worst-performing Ridgetown line in previous vine decline studies)	unknown	unknown
Heinz 2401 (included in the trial as an ungrafted control)	unknown	unknown

The experiment was planned as a randomized complete block design with 7 treatments and 5 replications. Due to a low survival rate following grafting for this trial, plots comprised single rows of 10 plants each, with guard rows of ungrafted H2401 plants on either side. Five plants from the centre of each treatment row were planned for measurements.

In early August the trial site was subjected to excessive rainfall and flooding. We attempted to salvage parts of the trial that were less-affected by flooding and due to our randomization we had at least 3 plots of each treatment that were unaffected. While we collected quantitative data on average plant height and width, the numbers of band lesions, root restrictions and other irregular lesions on the roots, we could not detect any trends that provided a basis to either continue or discontinue this line of inquiry further. We collected qualitative data (ie. discolouration present or absent) on root discolouration. While we observed some differences in the means, we were not able to draw reliable conclusions from the results.

9. Plans for 2014

Working with the O.T.R.I., we reduced the field space devoted to our breeding program from 2012 to 2013 and we plan to retain this smaller plot area for the next four years. Our goal over the next 4 years is to develop expertise in the use of genomics technologies and combine this with our traditional field-based selection to enable our selection to be more precise. We plan to begin studies to identify molecular markers associated with good plant performance under vine decline disease complex field conditions.