Title: Managing plant-parasitic nematodes in tomatoes in Ontario, Stage 1: Population dynamics, effects on yield and threshold development (2015-2017)

Research team: Katerina Jordan (Associate Professor, U of G, Plant Agriculture), Cheryl Trueman (RCUG), Janice LeBoeuf (OMAFRA), Mike Celetti (OMAFRA), Steve Loewen (RCUG) and Tyler Blauel (MSc Student, U of G, Plant Agriculture)

Objectives:

1) Determine the **population dynamics** of plant-parasitic nematodes (PPN) in tomato production systems, both fresh and processing;

2) Assess potential **effects of nematode feeding on plant health and yield** and ultimately to begin developing **updated thresholds** for specific nematode genera of importance identified in Objective 1, and;

3) **Compare nematode extraction methods** for accuracy in predicting nematode population levels in soils

Objectives for Year 1 (2015): focus on first objective

- Twenty-five fields in the Norfolk, Chatham-Kent and Essex regions were sampled. Each field sampled three times: May/June, July, Aug/Sept.
- The sugar centrifugal floatation method of nematode extraction was chosen to assess nematode populations as this method is better at ensuring that all plant-parasitic nematodes present in the soil are collected and not just the mobile ones.

Results:

- Plant-parasitic nematodes were found in all of the fields sampled. Threshold values could not be determined because extractions were done using a different method from that on which threshold values are determined.
    - We did not see high nematode population levels throughout the three regions, but there were certainly hot spots of nematode activity in each region.
- The most prevalent PPN were spiral and stunt nematodes, but many fields also had lesion, root-knot and cyst nematodes present in the soil.
- PPN values were higher in the May collection period than in the July period.
- Regional variation was also observed with the highest number of total PPN found in the Chatham-Kent region – both in mineral and organic matter-rich soils. The fewest total PPN were observed in the fresh tomato fields of Norfolk. Root-knot nematode was higher in Norfolk fields.

Conclusions, Year 1: This season's data collection is just the beginning of data collection for this project and suggests that nematodes are indeed present in some fields in high enough numbers to cause primary damage, but that we still need to determine ideal sampling periods to be able to give growers better recommendations. Once we are able to better correlate nematode population levels with season, soil properties and management practices, we will be able to provide better recommendations for growers, both with respect to sampling timing and also with respect to management.

Table 1. Summary of plant parasitic nematodes[a] (nematodes/kg soil) extracted from tomato soils using the sugar-centrifugal method in southwestern Ontario, 2015.

	Root lesion		Root-knot		Cyst [b]		PPN	
Region	May	July	May	July	May	July	May	July
Essex	36	17	49	18	364	240	969	571
Kent	80	401	94	5	293	117	1649	1394
Kent-Organic soil	43	126	34	18	172	211	1342	814
Norfolk	47	60	112	60	153	83	689	362

[a] Levels of spiral and stunt nematodes were omitted because their threshold value is much higher and population levels were not nearing threshold values at any locations.
[b]Species of cyst nematode is unknown at this time.

Objectives for Year 2 (2016): focus on objectives one and three

- Develop a survey for 2015 grower co-operators to fill out online that will allow us to correlate some of the numbers that we observed with various management practices and environmental conditions.
- Sampling will be repeated in 25 fields three times (May, July, October) throughout the season, however, 10-15 of these fields will be sampled five times (May, June, July, August, October) instead of three times. Timing of sampling in 2015 could have led to the variability observed among regions and time of year. Part of ensuring better timing for sampling will be to collect data on growing degree days (GDD) for the remaining two years of the project.
- Tomato roots will be collected from the top 10-15 high PPN fields during the August sampling period to assess nematode abundance in the roots. Nematodes will be extracted from roots using the shaker root extraction method.
- The twenty-five tomato fields will be sampled in the Norfolk, Chatham-Kent, and Essex regions. Six fields will be fresh market tomato fields and nineteen were processing tomato fields.
- Again, the sugar centrifugal floatation method of nematode extraction will be used to assess nematode populations as this method is better at ensuring that all plant-parasitic nematodes present in the soil are collected and not just the mobile ones.
- Compare the sugar-centrifugation extraction method and the more commonly used Baermann-pan method to determine which of the two is more accurate at predicting nematode populations in the soil.
- The ten fields with high PPN populations will be used to conduct the soil nematode extraction methods comparison, comparing two sugar centrifugal floatation (SCF) methods (one with the standard #400 sieve and another with a #500 sieve) and the Baermann-pan (BP) method. This will be conducted twice over the season.

Results:

- Plant-parasitic nematodes were found in all of the fields sampled. There were certain fields representing high populations of specific genera and overall PPN.
- Genera diversity and abundance varied between fields and regions, however, cyst and *Tylenchus* spp. nematodes tended to be the most abundant plant-parasitic genera on average. Other more prevalent plant-parasitic genera included spiral and lesion nematodes.
- PPN numbers of each genus varied throughout the year but there were more PPN recorded on average in the August collection period.

- Regional variation was, again, observed but this year the highest number of total PPN was found in the Essex and Chatham-Kent regions. The fewest total PPN were recorded in the fresh market tomato fields of Norfolk. The highest number of root-lesion nematodes, on average, were found in Chatham-Kent region, while the highest number of root-knot nematodes were found in Norfolk region.
- Five PPN genera were found in the tomato root extractions, including spiral, stunt, lesion, *tylenchus*, and root-knot nematodes, and lesion nematodes were the most abundant on average.
- From the first extraction methods comparison, the sugar centrifugal floatation method with the #400 and #500 sieve extracted significantly more spiral, *Tylenchus* spp., lance, and total PPN overall compared to the Baermann-pan method. Comparisons between all other genera were insignificant.
- From the second extraction methods comparison, the Baermann-pan method extracted significantly more root-lesion and free-living nematodes, while the sugar centrifugal floatation method with both the #400 and #500 sieve extracted more lance nematodes. Comparisons between all other genera were insignificant.
- When data from the two extraction method comparisons were combined, the Baermann-pan method extracted significantly more non-parasitic nematodes than both sugar centrifugal floatation methods and more root-lesion nematodes than the sugar centrifugal floatation method with the #400 sieve. The sugar centrifugal floatation methods extracted more spiral nematodes and total PPN.

Conclusions, Year 2: This year's data collection found PPN to be present in all fields sampled with some populations high enough to potentially cause primary damage, verifying the results found in 2015. The variation and inconsistencies between PPN genera populations throughout the season makes it difficult to recommend a preferred sampling time; however, based on our results to date, August sampling presents the highest number of PPN on average. Ideally, it would best to conduct soil sampling either pre- or post-harvest to allow growers to plan ahead to incorporate management practices. When extracting PPN from the soil, both the sugar centrifugal floatation and Baermann-pan methods are better for extraction certain genera. However, the sugar centrifugal floatation method can be relied on as a fast and accurate method for extracting most plant-parasitic nematode genera from soil, including non-mobile nematodes, and should be used as the standard for soil nematode extractions.

Figures representing results from Year 2 of the study (2016)

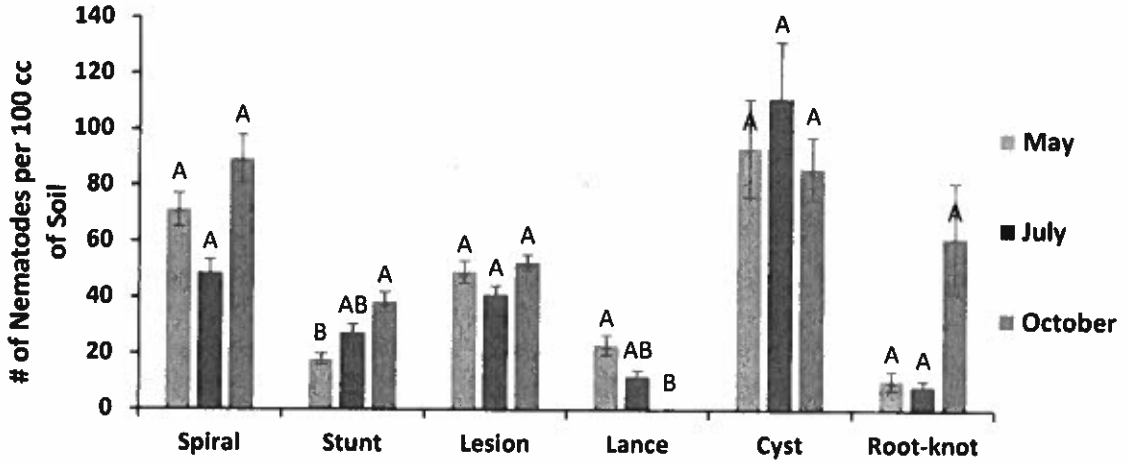

Figure 1. Average population of spiral, stunt, lesion, lance, cyst, and root-knot nematodes from all 25 tomato fields sampled in May, July, and October. Letters denote significant differences among means of each nematode genus.

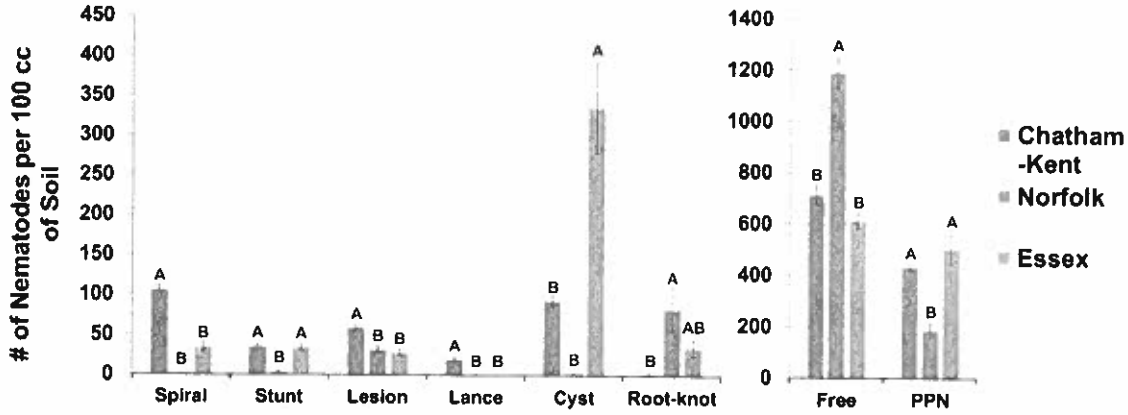

Figure 2. Average number of spiral, stunt, lesion, lance, cyst, root-knot, free-living, and total plant-parasitic nematodes (PPN) identified in Chatham-Kent, Norfolk, and Essex regions throughout the 2016 sampling season. Letters denote significant differences among means of each nematode genus.

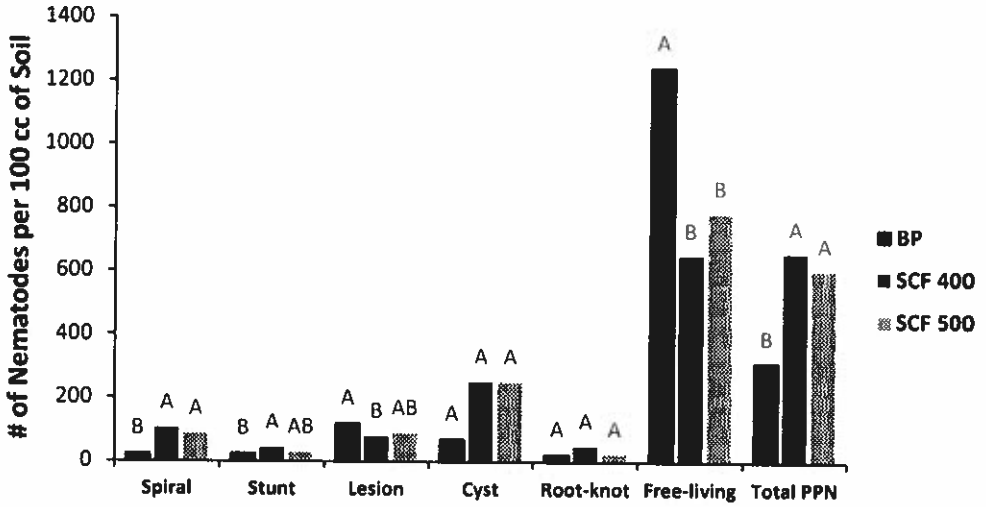

Figure 3. Combined average number of spiral, stunt, lesion, cyst, root-knot, free-living, and total plant-parasitic nematodes (PPN) extracted using the Baermann-pan (BP) method and sugar centrifugal floatation (SCF) method with a #400 and #500 sieve. Letters denote significant differences between means of each nematode genus.

Objectives for Year 3 (2017): All three objectives to be completed at the conclusion of this year

- A survey will be distributed to the 2016 grower co-operators to fill out online which will allow us to correlate some of the numbers that we observed with various management practices and environmental conditions.
- Soil sampling was repeated in 25 new tomato fields once again following a similar sampling schedule to 2016, whereby 10 fields will be sampled five times throughout the year while the remainder are sampled three times to confirm the results found in 2016.
- Again, the twenty-five tomato fields were sampled in the Norfolk, Chatham-Kent, and Essex regions. Six fields will be fresh market tomato fields and nineteen were processing tomato fields.
- The sugar centrifugal floatation method of nematode extraction was used to assess nematode populations.
- Tomato roots were collected from the top 10 high PPN fields during the July and August sampling period to assess nematode abundance in the roots. Nematodes were extracted from roots using the shaker root extraction method.
- Both fresh and processing tomato cultivars will undergo tolerance tests to determine the effects of nematode feeding on plant health and yield after inoculation with lesion and root-knot nematodes.
- Threshold trials will also be conducted on two common tomato cultivars using lesion and root-knot nematodes to begin to develop more accurate threshold levels.
- Our nematode extraction comparison has continued in an attempt to optimize the sugar centrifugation method in the hopes that it could be the most accurate predictor of soil nematodes.

Results:

- Plant-parasitic nematodes were found in all of the fields sampled. There were certain fields representing higher populations of specific genera and overall PPN.
- Genera diversity and abundance varied between fields and regions
- Cyst nematodes, again, tended to be the most abundant plant-parasitic genera on average. Other more prevalent plant-parasitic genera included spiral and lesion nematodes.
- PPN numbers of each genus varied throughout the year but there were more PPN recorded on average in the July collection period (October samples are still being analyzed).
- Regional variation was, again, observed but this year the highest number of total PPN, to date, was found in the Essex and Chatham-Kent regions. The fewest total PPN were recorded in the fresh market tomato fields of Norfolk. The highest number of lesion nematodes, on average, were found in Chatham-Kent region, while the highest number of root-knot nematodes were found in Essex region.
- Five PPN genera were found in the tomato root extractions, including spiral, stunt, lesion, *tylenchus*, and root-knot nematodes, and lesion nematodes were the most abundant on average.
- Average lesion nematode populations were also higher in August compared to the July sampling period.
- Tolerance and threshold trials are currently underway. Root-knot and lesion nematodes were successfully cultured using bioassay and carrot disc culturing methods, respectively, for the purpose of inoculation. Results will be analyzed in December.
- Sugar centrifugal floatation optimization experiments identified areas of nematode loss in steps of the extraction protocol. Further results on the alterations in the protocol made to optimize the soil extraction method will be analyzed in November.

Conclusions, Year 3: This year's data collection found PPN to be present in all fields sampled with some populations high enough to potentially cause primary damage, particularly in the root extraction results. This helps verify results found in 2016. Still, the variation and inconsistencies between PPN genera populations throughout the season makes it difficult to recommend a preferred sampling time; however, based on our results to date, July and August sampling presents the highest number of PPN on average. Ideally, it would best to conduct soil sampling either pre- or post-harvest to allow growers to plan ahead to incorporate management practices. In addition, the results from the threshold and tolerance trials will help to provide additional management options for growers to use when they encounter a field with high PPN populations.

Figures representing results from Year 3 of the study (2017)

Table 2. Summary of plant parasitic nematodes[a] (nematodes/100 cc soil) extracted from tomato soils using the sugar-centrifugal method in southwestern Ontario, 2017.

	Root lesion		Root-knot		Cyst		PPN	
Region	May	July	May	July	May	July	May	July
Essex	19	5	20	1	312	189	478	282
Chatham-Kent	54	50	5	0	127	75	419	348
Norfolk	50	27	2	1	0	0	86	68

[a] Levels of spiral and stunt nematodes were omitted because their threshold value is much higher and population levels were not nearing threshold values at any locations.