Project Title

Quantitative soil survey of *Phytophthora capsici* in processing tomato, cucumber, and pepper fields.

Research Agency/location

Ontario Ministry of Agriculture, Food and Agribusiness – various locations in Essex, Kent, Lambton, Elgin, Norfolk, Middlesex, and Huron counties.

Lead and Key Investigators

Amanda Tracey, Vegetable Crops Specialist
Elaine Roddy, Vegetable Crops Specialist

Objective

Phytophthora capsici is a highly destructive pathogen that impacts a range of processing vegetable crops, including tomatoes, peppers, cucumbers, squash, and pumpkins. This soil-borne disease is particularly challenging to manage due to limited chemical control options, which only provide suppression rather than reliable control. Effective cultural control measures, such as crop rotation, proper drainage, and/or hilling, are essential for mitigating the spread of the disease and should be prioritized when selecting fields for planting.

This project aimed to assess whether growers could submit soil samples before planting to identify the presence of *P. capsici* oospores and determine their concentration. This information would help inform field selection and management decisions to reduce disease impact. At the outset of the project, this soil test was not offered by the University of Guelph – Agriculture and Food Laboratory. However, the test has now been validated and is available to growers for a fee.

Additionally, the project sought to survey key processing vegetable production areas for tomatoes, peppers, cucumbers, squash, and pumpkins to evaluate the current distribution of the disease. It also aimed to assess the reliability of the soil test, addressing concerns about the potential for false negatives as highlighted in the original proposal.

Materials and Methodology

Between May 24 and August 21, 2024, a total of 84 fields were sampled, including 40 tomato, 17 cucumber, 15 pepper, and 11 pumpkin/squash fields. For each field, two composite soil samples were collected, each consisting of 10-15 12-inch soil cores. One sample was taken from low-lying areas, where *Phytophthora capsici* is more likely to be

present, and the second sample was obtained from the remaining higher ground of the field. The soil cores were thoroughly mixed and stored in sealed containers or bags in a refrigerator until they were shipped to the Agriculture and Food Laboratory (AFL) in Guelph, ON, for analysis.

To prevent cross-contamination, the soil core sampler was washed with soap and water between field locations. Field history data were also collected for some fields, depending on grower availability.

The AFL validated a real-time PCR method for the quantitative detection of *P. capsici* in soil during the spring of 2024. This method enabled the quantification of pathogen DNA concentration in each sample. Soil samples were delivered to the laboratory biweekly throughout the growing season for evaluation using this technique.

The AFL provided a detailed report of the results in September 2024. It should be noted that the laboratory uses only a small quantity of soil for testing, which introduces a potential risk of false negatives.

Results/Conclusions

Throughout the growing season, a total of 168 soil samples were collected from 84 distinct processing vegetable fields, with only 7 samples testing positive for *Phytophthora capsici* (Table 1). Of these 7 positive samples, 5 were obtained from low-lying areas and 2 from elevated areas. Notably, only one field yielded positive results from both low and high areas. These findings support the initial hypothesis that lower areas of fields are more likely to harbor *P. capsici* spores, in alignment with the pathogen's biological characteristics. *P. capsici* produces three types of spores, including zoospores, which are flagellated and capable of swimming toward host crops in saturated soils and standing water, conditions typically found in lower field areas.

When analyzing the results by crop type, tomato fields were more frequently associated with positive *P. capsici* detections (Fig. 1), and the concentration of spores was generally higher (Table 1), with an average of 53.2 pg/g of soil. This could be attributed to two factors: 1) a higher number of tomato fields were sampled compared to other crops, and 2) many tomato growers employ a 3- or 4-year crop rotation, often including another host crop. The shorter rotation cycle likely contributes to the increased accumulation of *P. capsici* spores in the soil.

The survey data also indicate a higher frequency of positive results in Kent County (Fig. 2), which can be explained by two related factors: 1) Kent County is the primary production region for the surveyed processing vegetable crops, and 2) a greater number of sites were sampled in Kent County relative to other regions.

When examining the correlation between the timing of sample collection and the occurrence of positive results, a clear seasonal trend emerges. No positive samples were detected in May, while the number of positive samples steadily increased in June

(1), July (2), and August (4) (Fig. 3). These results align with findings from other large-scale studies, which demonstrate that temperature influences the activity of *P. capsici* in soil and water, making pathogen detection more likely at higher temperatures, typically observed in July and August (Sanogo et al., 2023). This suggests that growers should test potential tomato, pepper, cucumber, and squash/pumpkin fields in August before the year they plan to plant the field.

One of the more surprising findings was the low percentage of positive results. Only 4.2% of the samples tested positive for *P. capsici*, despite the high prevalence of symptoms typically observed in the field. This suggests that the testing procedure may yield a significant number of false negatives. Given that only a small portion of soil from each field is tested in the laboratory, it is likely that a greater proportion of fields contain *P. capsici* spores than the results indicate. Due to the high risk of false negatives, this test will not be recommended to growers at this time.

Future research should focus on 1) exploring alternative sampling methods and/or timing to reduce false negatives, and 2) establishing a threshold for growers to help identify fields at risk of *P. capsici* contamination, guiding decisions on crop selection and field management.

References

Sanogo, S., Lamour, K., Kousik, C.S., Lozada, D.N., Parada-Rojas, C.H., Quesada-Ocampo, L.M., Wyenandt, C.A., Babadoost, M., Hausbeck, M.K., Hansen, Z., Ali, E., McGrath, M.T., Hu, J., Crosby, K., and Miller, S.A. 2023. *Phytophthora capsici*, 100 Years Later: Research Mile Markers from 1922 to 2022. Phytopathology 113:924-930.

Appendix

Table 1: qPCR results for *P. capsici* soil samples collected from May to August 2024

Submitter Sample ID	P. capcisi qPCR Result	P. capcisi DNA concertration in soil sample (pg/g soil)	Crop	County	Collection Date
SQ001-HG	NEG	NA	Squash/pumpkin	Elgin	05/24/2024
SQ001-LG	NEG	NA	Squash/pumpkin	Elgin	05/24/2024
TO-001-HG	NEG	NA	Tomato	Kent	06/10/2024
TO-001-LG	NEG	NA	Tomato	Kent	06/10/2024
TO-002-HG	NEG	NA	Tomato	Kent	06/10/2024
TO-002-LG	NEG	NA	Tomato	Kent	06/10/2024
TO-009-HG	NEG	NA	Tomato	Kent	06/11/2024
TO-009-LG	NEG	NA	Tomato	Kent	06/11/2024
TO-010-HG	NEG	NA	Tomato	Kent	06/11/2024
TO-010-LG	NEG	NA	Tomato	Kent	06/11/2024
TO-011-HG	NEG	NA	Tomato	Kent	06/12/2024
TO-011-LG	NEG	NA	Tomato	Kent	06/12/2024
TO-012-HG	NEG	NA	Tomato	Kent	06/12/2024
TO-012-LG	NEG	NA	Tomato	Kent	06/12/2024
CU-001-HG	NEG	NA	cucumber	Lambton	06/13/2024
CU-001-LG	NEG	NA	cucumber	Lambton	06/13/2024
CU-002-HG	NEG	NA	cucumber	Lambton	06/13/2024
CU-002-LG	NEG	NA	cucumber	Lambton	06/13/2024
PE-004-HG	NEG	NA	pepper	Lambton	06/13/2024
PE-004-LG	NEG	NA	pepper	Lambton	06/13/2024
PE-005-LG	NEG	NA	pepper	Kent	06/17/2024
PE-005-HG	NEG	NA	pepper	Kent	06/17/2024
TO-003-HG	POS	**10.7**	tomato	Kent	06/18/2024
TO-003-LG	NEG	NA	tomato	Kent	06/18/2024
PE-006-LG	NEG	NA	pepper	Kent	06/18/2024
PE-006-HG	NEG	NA	pepper	Kent	06/18/2024
TO-007-LG	NEG	NA	tomato	Essex	06/19/2024
TO-007-HG	NEG	NA	tomato	Essex	06/19/2024
TO-008-LG	NEG	NA	tomato	Essex	06/19/2024
TO-008-HG	NEG	NA	tomato	Essex	06/19/2024
TO-23-LG	NEG	NA	tomato	Kent	06/20/2024
TO-23-HG	NEG	NA	tomato	Kent	06/20/2024
TO-24-LG	NEG	NA	tomato	Kent	06/20/2024
TO-24-HG	NEG	NA	tomato	Kent	06/20/2024
TO-017-LG	NEG	NA	tomato	Kent	06/21/2024
TO-017-HG	NEG	NA	tomato	Kent	06/21/2024
TO-013-LG	NEG	NA	tomato	Kent	06/21/2024
TO-013-HG	NEG	NA	tomato	Kent	06/21/2024
TO-016-LG	NEG	NA	tomato	Kent	06/24/2024
TO-016-HG	NEG	NA	tomato	Kent	06/24/2024
TO-018-LG	NEG	NA	tomato	Kent	06/24/2024
TO-018-HG	NEG	NA	tomato	Kent	06/24/2024
TO-019-LG	NEG	NA	tomato	Kent	06/24/2024
TO-019-HG	NEG	NA	tomato	Kent	06/24/2024
TO-004-HG	NEG	NA	tomato	Kent	06/28/2024
TO-004-LG	NEG	NA	tomato	Kent	06/28/2024
TO-005-HG	NEG	NA	tomato	Kent	06/28/2024
TO-005-LG	NEG	NA	tomato	Kent	06/28/2024
TO-006-HG	NEG	NA	tomato	Kent	06/28/2024
TO-006-LG	NEG	NA	tomato	Kent	06/28/2024
TO-014-LG	POS	**8.8**	tomato	Essex	07/02/2024
TO-014-HG	NEG	NA	tomato	Essex	07/02/2024
TO-015-HG	NEG	NA	tomato	Essex	07/02/2024
TO-015-LG	NEG	NA	tomato	Essex	07/02/2024
CU-006-HG	NEG	NA	cucumber	Kent	07/03/2024
CU-006-LG	NEG	NA	cucumber	Kent	07/03/2024
PE-007-HG	NEG	NA	pepper	Kent	07/03/2024
PE-007-LG	NEG	NA	pepper	Kent	07/03/2024
TO-025-HG	NEG	NA	tomato	Kent	07/05/2024
TO-025-LG	NEG	NA	tomato	Kent	07/05/2024
TO-027-HG	NEG	NA	tomato	Kent	07/05/2024
TO-027-LG	NEG	NA	tomato	Kent	07/05/2024
TO-020-HG	NEG	NA	tomato	Essex	07/08/2024
TO-020-LG	NEG	NA	tomato	Essex	07/08/2024
TO-021-HG	NEG	NA	tomato	Essex	07/08/2024
TO-021-LG	NEG	NA	tomato	Essex	07/08/2024
TO-022-HG	NEG	NA	tomato	Essex	07/08/2024
TO-022-LG	NEG	NA	tomato	Essex	07/08/2024
TO-026-HG	NEG	NA	tomato	Kent	07/08/2024
TO-026-LG	NEG	NA	tomato	Kent	07/08/2024
CU-005-HG	NEG	NA	cucumber	Kent	07/09/2024
CU-005-LG	NEG	NA	cucumber	Kent	07/09/2024
PE-001-HG	NEG	NA	pepper	Huron	07/12/2024
PE-001-LG	NEG	NA	pepper	Huron	07/12/2024
PE-002-HG	NEG	NA	pepper	Huron	07/12/2024
PE-002-LG	NEG	NA	pepper	Huron	07/12/2024
PE-003-HG	NEG	NA	pepper	Huron	07/12/2024
PE-003-LG	NEG	NA	pepper	Huron	07/12/2024
TO-028-HG	NEG	NA	tomato	Kent	07/17/2024
TO-028-LG	NEG	NA	tomato	Kent	07/17/2024
TO-029-HG	NEG	NA	tomato	Kent	07/17/2024
TO-029-LG	NEG	NA	tomato	Kent	07/17/2024
TO-030-HG	NEG	NA	tomato	Kent	07/17/2024
TO-030-LG	POS	**121.2**	tomato	Kent	07/17/2024

Submitter Sample ID	P. capcisi qPCR Result	P. capcisi DNA concertration in soil sample (pg/g soil)	Crop	County	Collection Date
CU-008-LG	NEG	NA	cucumber	Elgin	07/18/2024
CU-008-HG	NEG	NA	cucumber	Elgin	07/18/2024
PE-008-HG	NEG	NA	pepper	Lambton	07/19/2024
PE-008-LG	NEG	NA	pepper	Lambton	07/19/2024
CU-007-HG	NEG	NA	cucumber	Lambton	07/19/2024
CU-007-LG	NEG	NA	cucumber	Lambton	07/19/2024
SQ-006-HG	NEG	NA	squash	Middlesex	07/22/2024
SQ-006-LG	NEG	NA	squash	Middlesex	07/22/2024
SQ-005-HG	NEG	NA	squash	Middlesex	07/22/2024
SQ-005-LG	NEG	NA	squash	Middlesex	07/22/2024
SQ-007-HG	NEG	NA	squash	Middlesex	07/22/2024
SQ-007-LG	NEG	NA	squash	Middlesex	07/22/2024
TO-034-HG	NEG	NA	tomato	Kent	07/23/2024
TO-034-LG	NEG	NA	tomato	Kent	07/23/2024
CU-003-HG	NEG	NA	cucumber	Elgin	07/25/2024
CU-003-LG	NEG	NA	cucumber	Elgin	07/25/2024
CU-004-HG	NEG	NA	cucumber	Elgin	07/25/2024
CU-004-LG	NEG	NA	cucumber	Elgin	07/25/2024
PE-010-HG	NEG	NA	pepper	Elgin	07/25/2024
PE-010-LG	NEG	NA	pepper	Elgin	07/25/2024
CU-009-HG	NEG	NA	cucumber	Elgin	07/25/2024
CU-009-LG	NEG	NA	cucumber	Elgin	07/25/2024
SQ-002-HG	NEG	NA	squash	Kent	07/26/2024
SQ-002-LG	NEG	NA	squash	Kent	07/26/2024
TO-035-HG	NEG	NA	tomato	Kent	07/26/2024
TO-035-LG	NEG	NA	tomato	Kent	07/26/2024
CU-010-HG	NEG	NA	cucumber	Elgin	07/29/2024
CU-010-LG	NEG	NA	cucumber	Elgin	07/29/2024
PE-011-HG	NEG	NA	pepper	Elgin	07/29/2024
PE-011-LG	NEG	NA	pepper	Elgin	07/29/2024
CU-011-HG	NEG	NA	cucumber	Elgin	07/29/2024
CU-011-LG	NEG	NA	cucumber	Elgin	07/29/2024
TO-031-HG	NEG	NA	tomato	Middlesex	07/31/2024
TO-031-LG	NEG	NA	tomato	Middlesex	07/31/2024
TO-032-HG	NEG	NA	tomato	Middlesex	07/31/2024
TO-032-LG	NEG	NA	tomato	Middlesex	07/31/2024
TO-033-HG	NEG	NA	tomato	Middlesex	07/31/2024
TO-033-LG	NEG	NA	tomato	Middlesex	07/31/2024
PE-015-HG	NEG	NA	pepper	Elgin	08/01/2024
PE-015-LG	NEG	NA	pepper	Elgin	08/01/2024
CU-015-HG	NEG	NA	cucumber	Elgin	08/01/2024
CU-015-LG	NEG	NA	cucumber	Elgin	08/01/2024
CU-016-HG	NEG	NA	cucumber	Elgin	08/01/2024
CU-016-LG	NEG	NA	cucumber	Elgin	08/01/2024
PE-012-HG	NEG	NA	pepper	Elgin	08/08/2024
PE-012-LG	NEG	NA	pepper	Elgin	08/08/2024
CU-018-HG	NEG	NA	cucumber	Elgin	08/08/2024
CU-018-LG	NEG	NA	cucumber	Elgin	08/08/2024
PE-014-HG	NEG	NA	pepper	Elgin	08/08/2024
PE-014-LG	NEG	NA	pepper	Elgin	08/08/2024
SQ-008-HG	NEG	NA	squash	Elgin	08/09/2024
SQ-008-LG	NEG	NA	squash	Elgin	08/09/2024
SQ-009-HG	NEG	NA	squash	Elgin	08/09/2024
SQ-009-LG	NEG	NA	squash	Elgin	08/09/2024
SQ-011-HG	NEG	NA	squash	Elgin	08/09/2024
SQ-011-LG	POS	**20.3**	squash	Elgin	08/09/2024
CU-017-HG	NEG	NA	cucumber	Elgin	08/12/2024
CU-017-LG	NEG	NA	cucumber	Elgin	08/12/2024
PE-013-HG	NEG	NA	pepper	Elgin	08/12/2024
PE-013-LG	NEG	NA	pepper	Elgin	08/12/2024
CU-012-HG	NEG	NA	cucumber	Elgin	08/12/2024
CU-012-LG	NEG	NA	cucumber	Elgin	08/12/2024
CU-013-HG	NEG	NA	cucumber	Elgin	08/13/2024
CU-013-LG	NEG	NA	cucumber	Elgin	08/13/2024
CU-014-HG	NEG	NA	cucumber	Elgin	08/13/2024
CU-014-LG	NEG	NA	cucumber	Elgin	08/13/2024
SQ-010-HG	NEG	NA	squash	Elgin	08/13/2024
SQ-010-LG	NEG	NA	squash	Elgin	08/13/2024
SQ-003-HG	NEG	NA	squash	Norfolk	08/16/2024
SQ-003-LG	NEG	NA	squash	Norfolk	08/16/2024
SQ-004-HG	NEG	NA	squash	Norfolk	08/16/2024
SQ-004-LG	NEG	NA	squash	Norfolk	08/16/2024
PE-009-HG	NEG	NA	pepper	Norfolk	08/16/2024
PE-009-LG	POS	**15.5**	pepper	Norfolk	08/16/2024
TO-036-HG	NEG	NA	tomato	Norfolk	08/20/2024
TO-036-LG	NEG	NA	tomato	Norfolk	08/20/2024
TO-037-HG	NEG	NA	tomato	Norfolk	08/20/2024
TO-037-LG	NEG	NA	tomato	Norfolk	08/20/2024
TO-038-HG	NEG	NA	tomato	Kent	08/21/2024
TO-038-LG	NEG	NA	tomato	Kent	08/21/2024
TO-039-HG	NEG	NA	tomato	Kent	08/21/2024
TO-039-LG	NEG	NA	tomato	Kent	08/21/2024
TO-040-HG	POS	**101.4**	tomato	Kent	08/21/2024
TO-040-LG	POS	**24**	tomato	Kent	08/21/2024

Figure 1: Positive qPCR results categorized by the crop that was grown in the sampled fields.

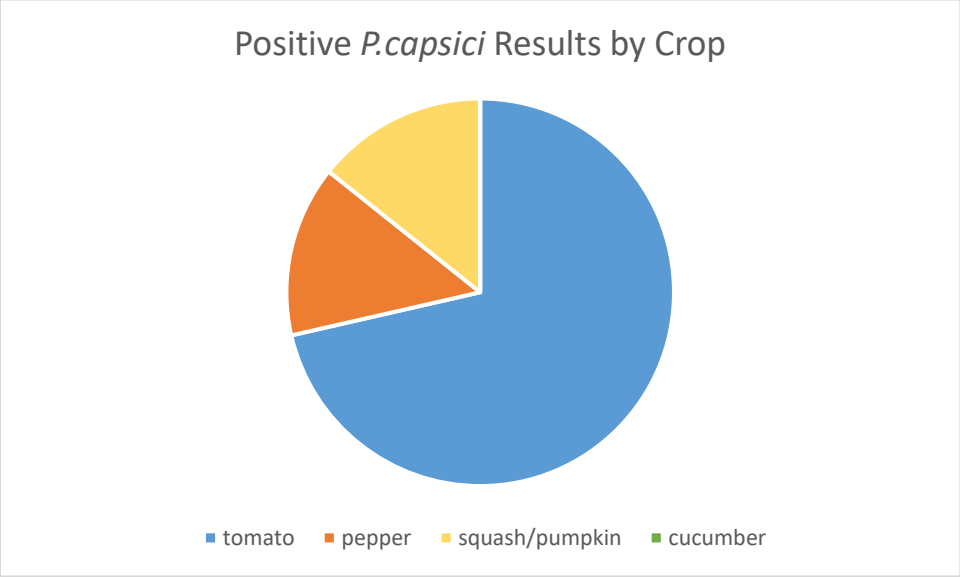

Figure 2: Positive qPCR results categorized by the County in which the sampled fields were located.

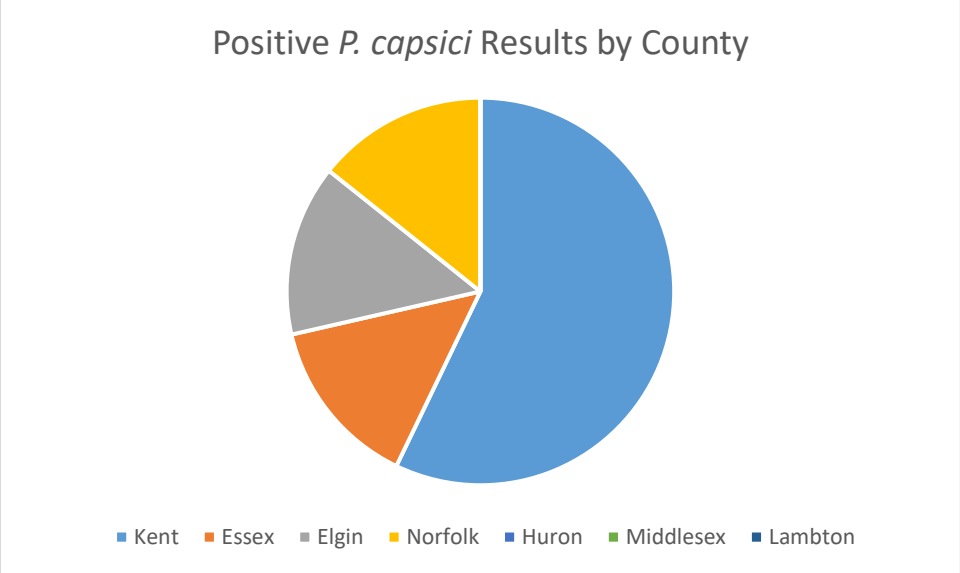

Figure 3: Positive qPCR results based on the month the soil samples were collected.