Activity 14, Potato 13
**Wireworm Control in Potatoes and Strategic Rotational Crops in Canada**

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**Activity Objectives**
**Sub-Activity 1**: Potato efficacy trials for wireworm control completed in BC and PEI.
**Sub-Activity 2**: Wheat seed-treatment trials for wireworm control completed in BC and PEI.
**Sub-Activity 3**: Evaluate mustard seed-meal as a soil amendment to control wireworms.
**Sub-Activity 4**: Attracting and killing click beetles using pheromone granules and entomopathogens.
**Sub-Activity 5**: Trap development for monitoring wireworms to predict crop damage.
**Sub-Activity 6**: National wireworm survey continued and DNA barcoding initiated.

**Research Progress to Date**
**Sub-Activity 1**: CRDA-BC trials in 2014 (10 treatments) were re-sampled in spring 2015 to determine wireworm mortality in the 2014 treatments. Some new proprietary products again gave excellent blemish protection and high mortality, and are excellent candidates for future work and registrations. Results with Capture 2EC, provisionally registered, were similar in effectiveness to Thimet as in previous years. In 2015, a new potato trial tested 14 products, with some new products equal to Thimet in reducing tuber blemishes to industry standards. In PEI, an insecticide trial (8 treatments) testing similar insecticides to the BC trial was completed in 2015, with similar tuber protection from the highly destructive exotic wireworm, *Agriotes sputator* occurring with certain proprietary chemicals.

**Sub-Activity 2**: CRDA-Studies to identify methods of controlling wireworms in cereal rotation crops (with potatoes) were conducted in BC (3 studies), Alberta (2 studies) and PEI (1 study) in 2015. Previous studies conducted in 2014 were re-sampled in 2015 to determine wireworm mortality. Some new proprietary products provided excellent stand protection and wireworm mortality, and are excellent candidates for continued work. All field treatments tested in 2015 were also evaluated for lethal and non-lethal effects (i.e. repulsion, immobilization, etc.) in laboratory bioassays in Agassiz. Field spray trials (6) to kill click beetles in cereal crops and grassland were conducted in Agassiz and PEI.
Matador 120EC provided 52%, 42% and 100% kill of *Agriotes sputator*, *A. obscurus* and *A. lineatus*, respectively, and additional work will be done with this and other insecticides in 2016 toward obtaining Minor Use registrations. Spraying for adults will reduce egg laying in fields in highly infested areas such as PEI.

**Sub-Activity 3: CRDA** - A replicated trial using mustard as a nurse crop with six treatments was established in a wireworm infested field in Canoe Cove, PEI. Tubers were harvested and evaluated for wireworm damage. Results showed that mustard seed planted between the rows gave significant reduction in tuber damage at the earliest seeding date compared to the control treatment. A reduction in damage was also found at the other seeding dates. Further studies are required to refine this strategy. Trials will continue in 2016. Grower fields where mustard was planted in 2014 and potatoes in 2015 were monitored. Bait samples were collected in the spring of 2015. Potato tuber samples were collected and assessed for damage. Results show a significant decrease in damage irrespective if the mustard crop was clipped, disked or harvested for seed compared to the barley check. A biology study with beetles was started; beetle males and females were collected and brought back to the laboratory. Beetles were maintained in the laboratory in containers with soil and allowed to lay eggs, the time of egg laying was determined. Results show that egg laying began at the end of May the first larvae were found on June 4th.

**Sub-Activity 4: CRDA** - Pheromone granules were invented in developing a highly efficacious ‘attract and kill’ (AK) control tactic using *Metarhizium*. Weather-proofing the granules will additionally enable a mating disruption control strategy. A refined ‘autodissemination’ control strategy will weather-proof the AK tactic. Lowest effective rates of pheromone and *Metarhizium* were determined to minimize cost. Oil emulsion formulations for *Metarhizium* were developed, enabling farmers to spray all three species of European click beetles in BC and PEI. Degree-day infection models were derived to predict biocontrol efficacy according to temperature and season. Met52 was found to most effectively kill *A. sputator*, and LRC112 to kill *A. obscurus* and *A. lineatus*, with minor use registration of Met52 initiated, as well as licensing and Cat. A registration of LRC112. The intense flight of Vancouver Island *A. lineatus* was discovered as a new phenomenon, and related to spring temperature. Their spread and extended season was identified as a concern. CA - Pheromone granules increased beetle walking speed, beetle-beetle encounters, and contact with *Metarhizium*. Beetle attraction to pheromone was not affected by wind speed or light, but was affected by beetle collection period. Beetles were attracted to pheromone granules from 14m. Beetles were infected from *Metarhizium* spores deposited from inoculated beetles indicating that the disease can spread and increase efficacy.

**Sub-Activity 5: CRDA** - A state-of-the-art apparatus for measuring CO₂ production was constructed, together with automation of mathematical models to efficiently process experimental data. The CO₂ production of a number of substrates was determined, as well as for competing vegetation and edaphic variables. Field experiments testing probe trap configurations and CO₂-generating substrates failed to generate results because of a poor trapping season. CA - monitoring wireworms and click beetles was carried out to predict wireworm feeding damage to potatoes the following year, with two years data for each activity (monitoring, damage assessment). 2015/2016 represented the second year of monitoring and the first year of damage assessment with sufficient data acquired. All data will be analyzed and presented in the final project report.

**Sub-Activity 6: CRDA** - Approximately 1,680 larvae were identified in 2015, mostly from BC, Ontario and PEI, and identified by Dr. van Herk. About 30 different species were submitted to the Hanner lab in Guelph for photography and DNA sequencing. Full length barcodes were obtained from 89 of 95 specimens. GIS (ARC INFO) maps of all species collected in this survey from 2004-2015 have now been made, which will assist in development of regional species-specific IPM programs for wireworms.
Extension Activities

Peer reviewed publications


Information items

- Vernon, RS, Kabaluk, T, Noronha, C. 2015. Interim and Final reports on Canadian Agri-cluster for Horticulture 2 Wireworm activities to CHC.
- Vernon, RS, van Herk, WG. 2015. Efficacy of various wheat seed insecticides for management of wireworms (Agriotes obscurus) in the field. Interim and Final Reports for Industry Partner 1 (Confidential).
- Vernon, RS, van Herk, WG. 2015. Efficacy of various wheat seed insecticides for management of wireworms (Agriotes obscurus) in the field. Interim and Final Reports for Industry Partner 2 (Confidential).
- Vernon, RS, van Herk, WG. 2015. Efficacy of various wheat seed insecticides for management of wireworms (Agriotes obscurus) in the field. Interim and Final Reports for Industry Partner 3 (Confidential).
Vernon, RS, van Herk, WG. 2015. Effects of various wheat seed insecticides on the behaviour and mortality of wireworms (Agriotes obscurus) in the laboratory. Interim and Final Reports for Industry Partner 2 (Confidential).


Kabaluk, T. and Wong, J. 2015. The effect of pheromone rate on click beetle (Agriotes obscurus) attraction, conidia dose, and beetle mortality when used as an attract and kill application with Metarhizium brunneum LRC112. AAFC Internal Report.

Kabaluk, T. and Ruau, S. 2015. Effect of seasonal temperatures on Metarhizium (LRC112 and Met52) disease development in Agriotes obscurus and A. lineatus click beetles, and a degree day infection model. AAFC Internal Report.


Leung J., Cory J., Kabaluk T., Janmaat A. 2016. Can pheromone enhance the transmission of Metarhizium brunneum in Agriotes obscurus click beetles? Entomological Society of Canada Annual Meeting, Montreal, QC.

Information events


Noronha: PEI Wireworm information day sponsored by the PEI Potato Board. March 14, 2016. Presentation: Wireworm Research Activities in PEI in 2015 and Advances in Click Beetle Trapping.
Early Outcomes (if any) or Challenges
Biocontrol products for click beetle control, while preliminary, are well-developed, with groundwork for their registration established. Pheromone granules were additionally found to offer possibilities for a mating disruption strategy (together with Vernon). Knowledge on the biology of *Agriotes sputator* is currently lacking. Our study is providing valuable information that can be used to develop new control techniques and improve currently used strategies. In addition to bifenthrin, the screening of new, proprietary products suggests they may, if ultimately registered, provide a low risk, cost effective alternative to Thimet, and longer-term solutions to wireworms in all crops in Canada.

Key Message(s)
The biological control of all three click beetle species appears likely with the two main strategies under development. The groundwork for registration will expedite the transition from research to end-use by farmers. We have increased knowledge of *Agriotes lineatus* biology, having identified an aberrant ecotype on Vancouver Island. Pheromone granules could enable click beetle mating disruption as a new control strategy. Our studies have identified new, highly effective chemical controls and attract-and-kill application methods for wireworms in potatoes and rotational crops such as wheat. Data will be used in obtaining registrations for new products that will result in low-dose, low-risk and economical approaches for wireworm management that will ultimately replace the higher risk approaches currently in place. The effectiveness of crop rotations and nurse crops of mustard in reducing tuber damage provides growers with an important and immediately available cultural IPM tool in managing wireworms in PEI.

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