Canadian Agri-Science Cluster for Horticulture 3

Update to Industry

2019-2020

Activity title:
Development of Regional Management Strategies and Decision Making Tools for Control of Colorado Potato Beetle

Name of Lead Researcher:
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Names of Collaborators and Institutions:
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Activity Objectives (as per approved workplan):
OBJECTIVES: Our overall objective is to reduce economic losses to potato in Canadian growing regions due to herbivory by the Colorado potato beetle (CPB). Specifically, we aim to determine local susceptibility of CPB populations to several classes of insecticides through a national resistance-monitoring network, improve resistance management, better characterize the molecular basis of developing resistance, and develop novel extension tools to improve management practices. To accomplish this, the deliverables are divided into four objectives as follows:

1. Determine susceptibility of Colorado potato beetle populations to multiple classes of insecticides in different potato growing regions in Canada;
2. Develop an interactive online mapping tool for growers to access results of susceptibility surveys to inform local decision making for optimal insecticide selection;
3. Identify molecular signatures of insecticide resistance that can be used to monitor the occurrence and spread of resistance in regional CPB populations and identify new pest control targets;
4. Develop a novel resistance monitoring tool for extension and diagnostic labs as a within-season decision making tool, based on molecular signatures of developing resistance

Research Progress to Date (use plain language):
1. Determine susceptibility of Colorado potato beetle populations to multiple classes of insecticides in different potato growing regions in Canada.
A total of thirty-one populations of Colorado potato beetle were obtained from five provinces – AB (0), MB (9), ON (6), QC (9), PE (3), and NB (4 – all AAFC property) - for insecticide resistance screening in 2019. As in 2018, susceptibility to six insecticides in three classes were evaluated - the spinosyn insecticides spinosad (ENTRUST™ 80) and spinetoram (Delegate™), the neonicotinoid insecticides thiamethoxam (ACTARA® 240 SC) and clothianidin (TITAN™), and the anthranilic diamides chlorantraniliprole (CORAGEN™) and cyantraniliprole (VERIMARK™).

For each population, 60 larvae were screened for susceptibility to each insecticide class. Excellent progress was made for 2019, testing was completed for 29 of 31 populations, while partial testing was achieved with two populations. The latter 2 populations were received late as summer adults, for which egg laying is often limited. Results are assigned to three susceptibility categories as shown in Table 1.

Table 1. Susceptibility of each Colorado potato beetle population from 2019 collections to each of six insecticides. 60 larvae per population were tested per insecticide, with the exception of populations QUE-7 and QUE-8 where * indicates fewer larvae were available for testing.

Province	Code	Susceptibility (> 70% Mortality)	Reduced Susceptibility (70-30% Mortality)	Resistance (< 30% Mortality)
Manitoba	MB-1	Delegate	Entrust, Coragen, Verimark	Actara, Titan
	MB-2		Actara, Titan Delegate, Coragen	Entrust, Verimark
	MB-3		Actara, Titan, Entrust, Delegate, Coragen	Verimark
	MB-4	Actara	Titan, Entrust, Delegate, Coragen, Verimark	
	MB-5	Delegate	Actara, Titan, Entrust, Coragen	Verimark
	MB-6	Delegate	Entrust	Actara, Titan, Coragen, Verimark
	MB-7		Entrust, Delegate, Verimark	Actara, Titan, Coragen
	MB-8	Entrust, Delegate	Actara, Coragen	Titan, Verimark
	MB-9	Delegate	Titan, Entrust, Coragen, Verimark	Actara
Ontario	ON-1	Actara, Titan, Delegate, Coragen	Entrust, Verimark	
	ON-2	Entrust, Delegate, Verimark	Actara, Titan, Coragen	
	ON-3	Entrust, Delegate	Actara, Coragen	Titan, Verimark
	ON-4	Actara, Titan	Entrust, Delegate	Coragen, Verimark
	ON-5		Actara, Titan, Delegate	Entrust, Coragen, Verimark
	ON-6	Delegate	Entrust, Coragen, Verimark	Actara, Titan
Quebec	QUE-1	Delegate	Actara, Coragen, Entrust, Titan, Verimark	
	QUE-2	Coragen, Verimark	Actara, Delegate, Entrust, Titan,	
	QUE-3	Coragen, Verimark	Actara, Delegate, Entrust, Titan	
	QUE-4	Actara, Coragen, Titan, Verimark	Delegate	Entrust
	QUE-5	Delegate	Actara, Coragen, Entrust, Titan, Verimark	
	QUE-6	Titan	Actara, Coragen, Delegate, Entrust, Verimark	
	QUE-7		Entrust*, Delegate*	
	QUE-8		Actara*, Delegate, Entrust, Titan*, Verimark*	
	QUE-9	Verimark	Actara, Coragen, Delegate, Entrust, Titan	
New Brunswick**	NB-1	Actara, Coragen, Delegate, Entrust, Titan, Verimark		
	NB-2	Actara, Coragen, Entrust, Delegate, Titan, Verimark		
	NB-3	Coragen, Titan, Verimark	Actara, Delegate, Entrust	

	NB-4	Coragen, Delegate, Titan, Verimark	Actara, Entrust	
Prince Edward Island	PE-1	Delegate, Titan	Actara, Coragen, Entrust, Verimark	
	PE-2	Coragen, Delegate, Entrust, Verimark	Actara, Titan	
	PE-3	Actara, Coragen, Delegate, Entrust, Titan, Verimark		

** as we did not secure support from a growers' association in NB, in fairness to the participating growers associations in other provinces, we restricted our sampling in NB in 2019 to AAFC properties only.

In Manitoba, over half (five of nine) of CPB populations showed resistance to at least one neonicotinoid, while another four populations showed reduced susceptibly, and only one population showed full susceptibility to the neonicotinoid Actara®. Six populations showed resistance to at least one anthranilic diamide, usually Verimark®. Four populations showed reduced susceptibility to Delegate™, while the remaining five were susceptible. Seven populations showed reduced susceptibility to Entrust® and one showed development of resistance to Entrust®.

In Ontario, three of six populations showed reduced susceptibility to Actara®, one showed development of resistance, and two showed full susceptibility. For Titan™, two populations showed development of resistance, two showed reduced susceptibility, and two showed full susceptibility. Resistance to anthranilic diamides was found in three of six populations tested, and in two cases, resistance was found to both Coragen® and Verimark®. One population each maintained full susceptibility to either Coragen® or Verimark® but not both insecticides. Only one populations showed development of resistance to the spinosyn Entrust®, while three populations showed reduced susceptibility and two showed full susceptibility. Four of six populations were fully susceptible to Delegate™ and two showed reduced susceptibility.

In Québec, resistance was only detected in one of nine populations, to the spinosyn Entrust®. The remaining populations showed the development of reduced susceptibility to Entrust® and most showed reduced susceptibility to Delegate™ as well. Most populations showed reduced susceptibility to the neonicotinoids, but no resistance was detected. For the anthranilic diamides, roughly equal numbers of populations showed full susceptibility as those which showed reduced susceptibility.

The two maritime populations showed similar results. New Brunswick populations were all collected from AAFC fields. Two of four populations were fully susceptible to all insecticides tested, while the other two showed reduced susceptibility to Actara® and Entrust®, and additionally one showed reduced susceptibility to Delegate™. In PEI, one population tested showed full susceptibility to all insecticides tested. Another showed reduced susceptibility to both neonicotinoids and the other showed reduced susceptibility to at least one insecticide in each class.

2. Develop an interactive online mapping tool for growers to access results of susceptibility surveys to inform local decision making for optimal insecticide selection

Substantial progress was made on the mapping tool in 2019-2020. AAFC Fredericton Biologist Sheldon Hann initiated development of the GIS mapping tool in ESRI's ArcGIS using data from both 2018 and 2019 surveys. ArcGIS was chosen as it is supported and extensively used by academia, industry and government and non-government agencies. The platform's living atlas and ability to access open data enhances end-user experience with easy-to-use navigation and reliable up-to-date data sources. The web layers are currently in the development phase within AAFC's Enterprise license in the ArcGIS Online environment. The current Web Mapping Application is available offline for research purposes and we are preparing for initial releases to project partners by 2022. The Web Mapping Application will provide growers/industry the ability to access and obtain detailed results from the susceptibility survey in a form that is accessible and easy-to-navigate. While the demo map below shows point locations, we are working on methods to ensure specific locations of field sites remain protected.

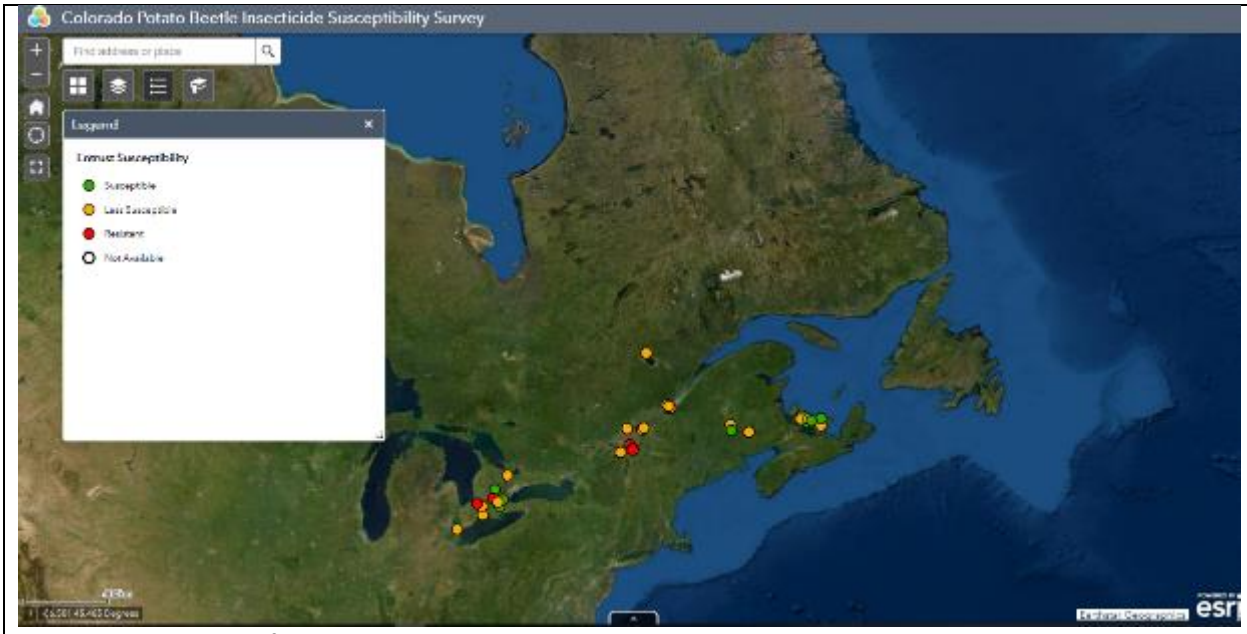

Figure 1: Screenshot of the web-based GIS mapping tool, the Colorado Potato Beetle Insecticide Susceptibly Survey. The mapping tool is still in the development phase. Shown here for illustrative purposes is the distribution of susceptibility in central and eastern Canada to the spinosyn Entrust®.

Objective 3: Identify molecular signatures of insecticide resistance that can be used to monitor the occurrence and spread of resistance in regional CPB populations and identify new pest control targets

We initiated molecular diagnostic testing of CPB from populations submitted in 2018 and 2019. Individual adults from various CPB populations assayed for resistance to six insecticides (as above in Objective 1) were selected for molecular diagnostic analyses based on resistance levels observed. The populations with highest priority for testing were those exhibiting strong resistance activity to spinosyn and diamide insecticides, as the molecular basis of resistance to neonicotinoids has been relatively well characterized in prior research. These priority populations included two resistant populations from Ontario (ON-4 and ON-5) and one resistant population from Québec (QC-4). Sensitive populations to use as baselines for comparison were also selected (ON2 for Ontario and QC5 for Québec). Insect tissues were dissected from groups of five adults for each population and pooled before RNA extraction to make up a replicate. Three replicates were collected for each population. All samples were assessed for quality and submitted to a sequencing facility for library preparation and mass sequencing. Once all sequence data is received, bioinformatics analysis will be initiated to compare the gene expression profiles characteristic of each population to identify genes whose expression correlates with the presence of insecticide resistance. Insecticide resistant populations were also identified from insects collected in Manitoba (MB-2, MB-6, MB-7), however, no fully sensitive populations were found that could be used as control comparators. This highlights a need to locate susceptible populations of CPB in Manitoba. Insects from these three Manitoba populations were processed to collect RNA but will not be sequenced. Instead, quantitative PCR will be used to evaluate whether any genes identified as overexpressed in the Ontario or Québec populations are also linked to resistance in these geographically separate populations. More in depth analysis can be undertaken if any of the Manitoba populations show clear similarities in gene expression with the sequenced populations. Data from 2019 molecular investigations are being processed and analyzed in the summer and fall of 2020.

Extension Activities (presentations to growers, articles, poster presentations, etc.):

Presentations

1. Vickruck, J. Krolikowski, S., Scott, I., MacKinley, P., Hann, S. and C. Moffat. *Development of Regional Management Strategies and Decision Making Tools for Control of Colorado Potato Beetle*. Joint Annual Meeting of the Entomological Society of Canada, Canadian Society for Ecology and Evolution, and the Acadian Entomological Society, Fredericton, NB, 20 August 2019. 200 attendees.

2. Bastarache, P., Dumas, P. and Morin, P. Jr. *Modulation of alpha-crystallin B in response to various challenges in the Colorado potato beetle* Leptinotarsa decemlineata. Joint Annual Meeting of the Entomological Society of Canada, Canadian Society for Ecology and Evolution, and the Acadian Entomological Society, Fredericton, NB, 20 August 2019. 200 attendees.

3. Dumas, P. and Morin, P. Jr. *Quantification and dsRNA-based targeting of heat shock proteins in Colorado potato beetles* (Leptinotarsa decemlineata) *submitted to temperature or insecticide stress*. Joint Annual Meeting of the Entomological Society of Canada, Canadian Society for Ecology and Evolution, and the Acadian Entomological Society, Fredericton, NB, 20 August 2019. 60 attendees.

4. Krolikowski, S., Scott, I., MacKinley, P., Hann, S. and C. Moffat. *Development of Regional Management Strategies and Decision Making Tools for Control of Colorado Potato Beetle*. Ontario Pest Management Conference, Guelph, ON, 5 November 2019. 60 attendees.

5. MacKinley, P., Hann, S., Krolikowski, S., Vickruck, J., Moffat, C. et Scott, I. 2019. *Etude sur la résistance aux insecticides chez les populations de doryphore du Québec*. Colloque Pomme de Terre, Levis, QC, , 22 Novembre 2019. 60 attendees.

Report

Vickruck, J., Scott, I., Krolikowski, S., MacKinley, P., Donly, C., Hann, S., and C. Moffat. *Canada wide evaluation of the susceptibility of Colorado potato beetle larvae to six registered insecticides*. AAFC Pest Management Centre Research Report: 2019-04-C. *3pp*.

Early Outcomes (if any) or Challenges:

Project partners in Manitoba, Ontario, Québec and PEI show high engagement with the project and we are very pleased to have such high levels of ongoing participation. We will be reminding our partners that to proceed with Objectives 3 and 4, related to the molecular signatures of insecticide resistance, we need to include populations where resistance is not suspected in our testing. We need susceptible populations to act as controls, otherwise we cannot determine which molecular signatures are due to insecticide resistance or other local population factors. Reduced susceptibility and development of resistance to both the anthranilic diamides and neonicotinoids are primary concerns for Manitoba stakeholders. Reduced susceptibility and development of resistance to the spinosyns in Québec Colorado potato beetle populations is an issue of high concern due to the reliance organic growers have on this insecticide class. We have seen substantial engagement from Québec stakeholders in 2019, including several conference calls with stakeholders, and attending regional stakeholder meetings to present our work. At their request, we are also working on an article for inclusion in Québec grower magazine, and will also include the English version in grower magazines for other regions. Efforts for PEI in 2020 will focus on areas of particular concern to stakeholders on the island. In discussion with stakeholders in multiple regions, we are re-evaluating which products we test for 2020 or 2021 for select growing regions and finding ways to increase the response to the insecticide use survey completed by growers.

We did not receive any CPB populations from Alberta in 2019. Alberta populations overall showed high levels of susceptibly to all classes of insecticides tested in 2018. As well, we are aware of some staff turnover with our project partners (Scott Meers retired at the end of 2019). These two factors together may explain why we did not receive samples in 2019. We have reached out to partners in Alberta in May 2020 in the hopes of receiving populations in 2020 and onward.

COVID-19

AAFC Research and Development Centres ceased all but critical services mid-March due to COVID-19. At this point (May 2020), only limited on-site field work activities have been approved for AAFC researchers, in addition to critical activities such as insect rearing which have continued through the closure. No laboratory activities are approved at this time. We are in communication with AAFC management to determine if we will be able to undertake activities related to Objective 1 and 3 this year, both of which require lab work. In mid-May, we reached out to project partners in all growing regions to discuss plans for 2020. We have communicated that at most, we

will be able to conduct 30% of planned testing for 2020, and therefore stakeholders expect to send us a reduced set of priority populations for resistance testing. The stakeholders we have reached are also aware that at this time we have no guarantees we will be able to make any progress on Objectives 1 and 3 in 2020, as we need to await direction from AAFC management on plans to re-initiate lab work. We will provide an update to those who receive CPB collection kits by late June.

Key Message(s):

Excellent progress has been made in 2019 thanks to participation from project partners across Canadian potato growing regions and our fantastic technical staff and students. We continue to monitor insecticide resistance of Colorado potato beetle, work towards meeting each project deliverable on time and provide updates to industry. We are always happy to be contacted to further discuss the project outcomes and regional stakeholder needs.

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