Canadian Agri-Science Cluster for Horticulture 3

Update to Industry

2018-2019

Activity title: Integrated management of the pepper weevil, an invasive pest of greenhouse pepper crops in Canada
Name of Lead Researcher: Dr. Roselyne Labbe, AAFC
Names of Collaborators and Institutions: Félix Longpré, Insect rearing biologist, London Research and Development Centre, Agriculture and Agri-Food Canada Cara McCreary, Greenhouse Vegetable Integrated Pest Management Specialist, Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) Miyuki Santiago, Business Development, Koppert Biological Systems Niki Bennett, Science Coordinator, Ontario Greenhouse Vegetable Growers **Potential collaborators:** Dr. Cynthia Scott-Dupree, Bayer Chair in Sustainable Pest Management School of Environmental Sciences University of Guelph Bruce Power, Canadian nuclear generator, providing isotopes for potential Sterile Insect Technique research.
Activity Objectives (as per approved workplan): 1. Develop improved rearing methods for the pepper weevil. 2. Evaluate reduced-risk conventional and biopesticides for the management of the pepper weevil. 3. Evaluate non-target impacts of management products on beneficial insects used in greenhouse pepper biological control. 4. Establish the efficacy of parasitoid *Jaliscoa hunteri* for the management of the pepper weevil. Establish and compare the efficacy of rearing methods for *J. hunteri* production. Explore alternate crop delivery methods for *J. hunteri.* 5. Establish colonies of another potential biological control agent of the pepper weevil such as *Pteromalus anthonomi*. Study the life history of this species and assess its efficacy in managing pepper weevil in laboratory trials.

Research Progress to Date:

The pepper weevil is an important invasive pest in Canada and represents a major hurdle towards achieving sustainable pest management on greenhouse and field pepper crops. This project plays an important role in assessing and developing potential tools that may one day become essential to suppress this pest in Canada. Through product testing trials, sixteen agents have been assessed for their efficacy to control the pepper weevil, with eight qualifying for further rounds of greenhouse cage trial testing. This work provides the experimental evidence required to greatly accelerate the rate of registering new agents available to growers in Canada for control of the pepper weevil on greenhouse pepper crops. Furthermore, current non-target testing will serve to identify which of these agents are compatible with existing biocontrol programs targeting other pepper pests. Efforts are also underway to evaluate the potential for biological control of the pepper weevil by parasitoid *Jaliscoa hunteri*, a parasitoid we first discovered in Canada in 2016 and one known to attack and kill the pest at the hard to target larval stage. In the context of this work, a number of rearing innovations have been achieved that facilitate the production of, and optimize parasitism of pepper weevil by this wasp. Together, it is anticipated that the knowledge generated from this project will serve to both better understand the biology of the pepper weevil as well as evaluate the efficacy of its control agents, leading to the development of more sustainable management tools for pepper growers in Canada.

Specific progress:

1. Develop rearing methods for the mass rearing of the pepper weevil using artificial media.

Over the course of this current project year, a number of advances in the rearing systems involved in this project have been achieved. These include prolonging the lifespan of adults in the colony through the incorporation of fresh pepper foliage maintained in a water wick to preserve freshness. We have also tested mixes of pepper types in colony cages to optimize pepper weevil reproductive capacity. Pepper preservation has also been increased, by washing these in a dilute bleach solution prior to entering the colony cages.

We are also testing a caged plant rearing system, which achieves more oviposition on fruits relative to in colony containers. This affords weevils more buds and naturally occurring fruit for feeding, as well as fresh foliage.

Preliminary assays were also conducted testing oviposition behaviour by pepper weevil on leaf balls. This method eliminates the need for oviposition on fresh peppers, with subsequent development of larvae on an artificial diet. However, it was found that subsequent manipulations required to complete the pepper weevil developmental cycle was quite demanding and did not result in a great increase in the number of eggs collected.

Rearing of the pepper weevil parasitoid on its alternate host *Callosobruchus maculatus* has seen a significant innovation. We have constructed a sieve with a container and trap that allows for the instant separation of either *Callosobruchus* or *Jaliscoa* from chickpeas. This greatly reduces the work involved in rearing these species and could also contribute to a more efficient mass production system for *Jaliscoa hunteri* in future.

Alternate hosts of the pepper weevil parasitoid, *Jaliscoa hunteri* are also currently being reared at the Harrow and London Research and Development Centres. These include, *Callosobruchus maculatus*, *Callosobruchus chinense*, *Lasioderma serricorne* and *Sitophilus oryzae*. Work is underway that will compare their relative suitability as hosts for *Jaliscoa hunteri*, as well as how well these wasps transition to pepper weevil as a host. Evidence suggests that secondary hosts more closely related to pepper weevil should result in greater parasitism, and this hypothesis will be tested.

2. Evaluation of reduced risk conventional and biopesticides for the management of the pepper weevil.

Laboratory bioassays have been conducted that test the efficacy of agents for the control of pepper weevil.

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Through five rounds of laboratory trials, a total of 16 agents have been assessed. Of these, a total of eight agents have achieved an over 60% pepper weevil mortality threshold, which was required for us to pursue current greenhouse testing. In this testing, we were able to assess not only the direct mortality of weevils attributed to these control agents, but also the indirect effects such as reduced crop feeding potential and reductions in weevil fecundity. Together, this work will considerably increase our understanding of the mechanisms of action for control agents, and will greatly accelerate the registration of new products, including reduced-risk microbial agents for pepper weevil management in Canada.

3. Evaluation of non-target impacts of management products on beneficial insects used in greenhouse pepper biological control.
The work associated with this objective will begin as scheduled the current 2019-20 fiscal year.

4. Establish the efficacy of parasitoid *Jaliscoa hunteri* for the management of the pepper weevil. Establish and compare the efficacy of rearing methods *for J. hunteri* production. Explore alternate crop delivery methods for *J. hunteri.*
One of the possible means of targeting immature life stages of the pepper weevil includes parasitism by the native North American parasitoid, *Jaliscoa hunteri*. Towards assessing the efficacy of this agent for the control of the pepper weevil, two commercial greenhouse trials were performed either just prior to this reporting period in October 2017 and one within it starting in September 2018. In these trials, weekly releases of up to 30, 000 adult *J. hunteri* wasps were conducted on weevil infested three acre greenhouse pepper crops. These trials, which lasted three and seven weeks respectively, allowed for the monitoring of emergence of pepper weevil adults from up to 200 peppers per week, in both treatment and control greenhouses. In 2017, after three weeks of wasp introduction, an overall 44% reduction in pepper weevil infestation in the treatment relative to the control was achieved. In 2018, an average of 39% reduction of pepper weevil emergence was achieved as well as a period of three weeks in which no weevil adults emerged from peppers in the *J. hunteri* block. These trials also allowed us to compare the value of inoculative (2018) versus inundative (2017) releases of the wasp, from which we can conclude that the earlier wasps are released after weevil infestation is initially detected, the better. Together, these trials show the biological control potential of *J. hunteri*, which may one day serve as a novel commercial tool for pepper weevil management in North America. Future work will further elucidate the mechanism of parasitoid activity by *Jaliscoa hunteri* in laboratory and greenhouse trials.

5. Establish colonies of another potential biological control agent of the pepper weevil such as *Pteromalus anthonomi*. Study the life history of this species and assess its efficacy in managing pepper weevil in laboratory trials. Conduct greenhouse trials to assess the efficacy of this parasitoid at reducing pepper crop yield loss.
The work associated with this objective will begin as scheduled the current 2019-20 fiscal year.

Extension Activities (presentations to growers, articles, poster presentations, etc.):
Labbé, R., Hilker, R., Gagnier, D., McCreary, C., Gibson, G.A.P., Fernandez-Triana, J. Mason, P.G. and Gariepy, T.D. 2018. Natural enemies of *Anthonomus eugenii* (Coleoptera: Curculionidae) in Canada. Canadian Entomologist. 150(3): 404-411.

Messelink, G., Labbé, R.M., Marchand, G. and Tavella, L. 2019. Integrated Pest Management in Sweet Peppers. In: Pest and Disease Management in Greenhouse Crops [Eds M.L. Gullino, R. Albajes, P. Nicot, J.C. van Lenteren].

Labbé , R. 2018. Parasitoids of the pepper weevil across North America: Identity, behavior and biological control potential. 24th International Pepper Conference. Fort Myers, Florida, USA. (Invited Speaker).

Labbé, R. Gagnier, D. Fernandez, C., Rizzato, R. 2018. Efficacy of the parasitoid *Jaliscoa hunteri* for the suppression of the pepper weevil, *Anthonomus eugenii* on greenhouse pepper crops. Entomology 2018. Vancouver, BC. (Oral Presentation).

Fernandez, D.C., VanLaerhoven, S.L., and Labbe, R. 2018. Oviposition preference and potential alternate hosts of *Anthonomus eugenii* in southern Ontario. Entomology 2018. Vancouver, BC. (Oral Presentation).

Russell, C., Labbé, R. and Hallett, R. 2018. Improved monitoring of pepper weevil (*Anthonomus eugenii*) using semiochemicals. Entomology 2018. Vancouver, BC. (Oral Presentation).

Labbé, R.M. 2018. Can parasitic wasps effectively kill the pepper weevil? Article in: Greenhouse Canada Magazine. Published September 24, 2018.

Labbé, R.M. 2019. Biological and conventional control of the pepper weevil. University of Guelph, School of Environmental Sciences, Invited lecture given in the context of ENVS 4100: Integrated Management of Invasive Insect Pests. (March 25, 2019)

Labbé, R. 2018. Biological control of greenhouse pests. Ontario Ministry of Agriculture Food and Rural Affairs. Greenhouse Vegetable Course, Harrow, ON (Invited Speaker).

Early Outcomes (if any) or Challenges:

As we continue to work with the pepper weevil, its unique biology, the mechanisms of control agents and the efficacy of its parasitoid are becoming better understood. It is anticipated that this work will have important implications on the development of best practices for pepper weevil management in Canada.

In addition to the work outlined above, and with the prospect of the difficulty of establishing a colony of parasitoid wasp Pteromalus anthonomi (objective 5), we are currently pursuing an opportunity to collaborate with Dr. Cynthia Scott-Dupree at the University of Guelph to not only develop an artificial diet for pepper weevil rearing, but also to investigate the value of the Sterile Insect Technique for pepper weevil suppression. This possibility represents an exciting new way to manage this pest and may yield results that are of value to Canadian greenhouse growers.

Key Message(s):

The knowledge generated from this project will serve to better understand the biology of the pepper weevil, as well as to establish the efficacy of its control agents. For instance, we now have a list of effective microbial and conventional agents for the control of the pepper weevil, an important step towards the registration of new agents for pepper weevil suppression in Canada. These agents are also being tested for their compatibility with existing biocontrol agents which will help growers decide which agents are best suited either for actively growing crops versus those that are best used at the crop clean-up stage. Finally, our exploration of the biological control potential of wasps such as *Jaliscoa hunteri* offers yet another way to manage the pepper weevil, particularly at hard to target larval life stages within the pepper fruit. Together, these tools are essential to the development of best practices for pepper weevil management, and it is anticipated that these will lead to more sustainable means for future management of this pest in Canada.

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