Canadian Agri-Science Cluster for Horticulture 3

Update to Industry

2019-2020

Activity title: Optimizing *Delia* pest monitoring and management in vegetable brassicas
Name of Lead Researcher: Jade Savage, Bishop's University
Names of Collaborators and Institutions: Anne-Marie Fortier, Phytodata, QC; François Fournier, Collège Montmorency, QC; Renee Prasad University of the Fraser Valley, BC
Activity Objectives (as per approved workplan): The overarching goal of our project is essentially to improve management practices for *Delia* pests of vegetable brassicas in Canada. To reach that goal, we have developed specific objectives that are addressed by the following **five activities**: 1. Document and compare the relative contribution of different *Delia* species and genetic lines to crop damage in 6 Canadian provinces (BC, ON, QC, NS, NB, PEI) 2. Develop threshold-based models for conventional management of *Delia* pests 3. Document the development, host preferences and reproductive compatibility of two genetic lines of *D. platura* (N-line and H-line) 4. Investigate selected soil parameters as oviposition stimulants in two genetic lines of *D. platura* 5. Validate and optimize the sterile insect release (SIR) method for *D. radicum*.
Research Progress to Date (use plain language): **Activity 1.** During the summer of 2019, we collected *Delia* larvae in vegetable brassica crops across Canada. A total of 6 566 larvae were collected. The participating provinces are prepared for a second and final year of *Delia* sampling in the summer of 2020. The data from this activity will be analyzed in 2021 and results will be shared with the industry through reports and presentations. **Activity 2.** The main goal of this activity is to develop a sequential sampling method to effectively and efficiently monitor *Delia* pests. During the summer of 2019, we aimed at determining the optimal number and location of sampling sites to predict damage at harvest. We were able to successfully monitor two brassica fields (one rutabaga, one cabbage) for *Delia* eggs and larvae during the 2019 field season (July to September). Both fields were rectangular in shape (area=4.9 & 1.0 ha), allowing for seven transects to be placed, each with 10 sampling positions per transect (70 sampling points per field). The first and last transects were across the two edge rows, and the first and last sampling positions along a transect were at the row ends. This allowed for a uniform sampling grid with 70 independent data points per field. Sampling for eggs, maggots and obvious damage was conducted on six dates during the season, and root damage (two plants per sampling site) was recorded at harvest. A subsample of maggots from each field were reared to adulthood to confirm their identification to *D. radicum*. Preliminary results for this activity can be found below in the *Early Outcomes* section.

Activity 3. A laboratory reared *Delia platura* N-line colony has been established and the H-line colony has been genetically refreshed with field collected materials during summer 2019. General production parameters also suggest important biological differences between both genotypes. This has allowed us to begin to study their developmental characteristics in relation to temperature. For the H-line, average time to 50% egg hatch decreased with temperature from 166,4 h at 10°C; 95,3 h at 15°C; 50,2 h at 20°C and 35,6 h at 25°C,that is approximately 8, 2 and 1,4 days respectively. High temperature of 30°C appears to be slightly detrimental to egg hatch with a longer period needed (39,2 h) to reach 50% hatch.

Larval developmental time was significantly affected by genotype but not by sex. Lower developmental temperatures for larvae are estimated at 6,1°C for the H-line and at 7,8°C for the N-line. This is the first significantly different biological parameter documented between the genotypes. Developmental time of adults from pupae was not significantly affected by sex and genotype. Since not all temperatures have been tested for the the N-line separate developmental are estimated for both lines The estimated developments thresholds for adult production from a pupae is 6,7°C for the H-line vs 8,6°C for the N-line.

Activity 4. Soil humidity and temperature had a significant impact on H-line egg hatching rate, which varied between 27 and 85% depending on soil conditions. Optimal hatching rates were observed at 60% humidity level for all temperature, from 85% at 15°C to 75% at 30°C. Humidity levels above 60% resulted in hatching rates superior to 72% for all soil temperatures except for 30°C where it declined from 68% to 54% between 80% and 150% soil humidity levels. Dry soil conditions (0 and 20%) had a major negative impact on egg hatching rates, especially at temperatures above or equal to 20°C, where they varied between 27 and 67%. Soil temperature of 15°C was the most favorable to egg survival at all soil humidity levels, hatching rates ranging between 73% and 85% under the various soil humidity conditions.

Activity 5. The first step towards validating and optimizing the sterile insect release method for *D. radicum* is to successfully maintain a *D. radicum* colony. For that matter, we have been working on the evaluation of artificial diet recipes for *D. radicum* large scale rearing. In 2019, 25 experiences were carried out, each with five to eight treatments including the standard rutabaga and variants of different artificial diet recipes. We compared the number and weight of pupae produced on artificial diets with pupae produced on natural rutabaga. We also evaluated egg inoculation rates (number of eggs per gram of diet). The two diets that gave the best results were tested at a larger scale using large trays, which is optimal for mass rearing of *D. radicum*, and compared with rutabaga over three generations. For the first generation, we evaluated adult mortality, the number of eggs laid per female and the percentage of fertile eggs in large tray artificial diets and natural rutabaga. During the second generation we experienced contamination in the diet trays, which caused high mortality rates; however, we were able to recuperate enough eggs to evaluate the performance of diets for the third generation. Results from the diet trials are presented below in the *Early Outcomes* section.

A first complete essay on diapause induction has been conducted with *D. radicum*. Pupae of parental generation were exposed to early fall weather conditions, with short photoperiod (12 hours) in combination with alternating temperature (15°C at night and 20°C during the day) during adult emergence and oviposition. Collected eggs were used to produce pupae on rutabagas and reared at constant 15°C until complete pupae formation. No adult emergence was observed during the first 28 days following pupae harvest, an indication that pupae were probably in diapause. Adult fly emergence began as soon as after 8 weeks of cold storage. Emergence rates increased with cold storage duration and attained a maximum of 75% for one replicate after 20 weeks of cold storage. Emergence rates then declined with cold storage period greater than 20 weeks. There was a lot of adult mortality at the time of emergence, with 4 to 39% of flies failing to completely emerge from their pupal cases. These observations are indications that diapause induction and/or completion, and/or cold storage conditions were not optimal. A new experiment has begun with colder conditioning of the parental generation (10°C night and 15°C day) and larval development (10°C).

Nearly 4 million cabbage flies were produced, sterilized and released in daikon (eight fields), cauliflower (three fields) and Napa cabbage (one field) fields during the 2019 summer season, for a total of 66.9 hectares. The sterile flies were released on a weekly basis over a period of 21 weeks. Pairs of fields (sterile insect technique vs conventional or untreated) were compared; three for daikon, one for cauliflower and one for Napa. Eggs were scouted twice a week during the egg-laying peak by inspecting 10 consecutive plants in 10 permanent plots randomly selected in each field. All the eggs were collected, identified and incubated to evaluate the hatching rate. Yellow sticky traps were installed in field borders and changed twice a week to evaluate the sterile versus wild fly ratio. At harvest, 20 consecutive plants were evaluated in 10 randomly selected plots in each field to estimate the percentage of cabbage maggot damage. Results are presented below in the *Early Outcomes* section.

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

We presented the progress and early outcomes of this project at four events this year: the Entomological Society of Canada Annual Meeting, Journées PRISME, the Ontario Pest Management Conference and the Horticultural Growers' Short Course at the Pacific Agriculture Show. The details for each presentation are listed below.

1. Fortier, A.-M. Presentation at the 'Journées PRISME', Sherrington, QC – Feb. 19th 2020. Titled : *Delia spp : mise-à-jour sur nos avancées.*
2. Fortier, A.-M., Savage, J. and Van der Heyden, H. Poster presentation at the Entomological Society of Canada annual meeting, Fredericton, NB – Aug. 18th 2019. Titled: *A new HRM-based assay suggests a different temporal distribution pattern between genetic lines of Delia platura.*
3. Harris, E., Blatt, S. Poster presentation at the Entomological Society of Canada annual meeting, Fredericton, NB – Aug. 18th 2019. Titled: *Abundance versus precision: an oviposition analysis of Delia radicum and Delia platura on crucifer crops in Nova Scotia.*
4. Fortier, A.-M. Presentation at the Ontario Pest Management Conference, Guelph, ON – Nov. 5th 2019. Titled: *The sterile onion fly success story.*
5. Prasad, R. and W. van Herk. Presentation for the Horticultural Growers' Short Course at the Pacific Agriculture Show, Abbotsford, BC – Jan. 28th 2020. Titled: *Cole crop IPM in the Fraser Valley.*

In total, these presentations reached out to 260 people including producers and farm advisors, technicians, research professionals, professors and graduate students across Canada.

Early Outcomes (if any) or Challenges:

Activity 1. With regards to *Delia* sampling in the 6 Canadian provinces, a few challenges were encountered:

1. Samples from British Columbia were collected in the field but lost post collection due to storage problems. Of the potential 80 samples from BC only 13 could be sent for identification. The BC collaborators have developed a better system for summer 2020 to avoid storage problems.
2. During the 2019 sampling season, Ontario had very low *Delia* density in sampled fields. For the 2020 sampling season, Ontario will sample fields with a higher organic content, and known *Delia* damage in attempt to increase *Delia* larvae collection.
3. The fields selected for monitoring in Nova Scotia and Prince Edward Island were quite small, not allowing the PEI and NS collaborators to sample 200 plants per week, like the other provinces. We had agreed that these two provinces could follow a modified protocol, flagging egg-infested plants to later return and collect the larvae. While this method maximized the number of larvae collected and provided valuable information on the presence of *Delia* species, this method was not perfect and limited the amount of information that could be extracted from the collected data. We have therefore modified this method for the 2020 sampling season in order to maximize the amount of information collected per sampling effort.
4. Preparation for the 2020 summer sampling season is complete and is proceeding according to plan for BC, QC and PEI. However, due to **COVID-19**, our AAFC partners in ON, NB and NS will have a delayed start to the field season, and a reduction in their access to grower fields, therefore reducing their sample sizes for the 2020 season.

Activity 2. Formal data processing to determine the optimal number of sampling sites to predict damage at harvest from sampling conducted in the growing season is still underway, but initial results indicate that crop damage is significantly higher at the field edges, even in these relatively small plantings.

Activity 3. The establishment of a laboratory colony of the N-line of *Delia platura* has been more tedious than expected and has delayed some of the experiments. This colony will allow us to characterize its developmental and preference parameters and to compare them with those of the H-line. Egg, larval and pupal developmental time have been established for the N-line and larval developmental time for the H-line. This information is useful for the prediction of natural population development. A significant difference has been found in the larval temperature developmental thresholds, a first confirmation that we may have two distinct biological lines, or maybe two distinct species of *Delia* coexisting in the field. Future experiments on cross fertilization will allow us to confirm their status.

Activity 4. Egg survival in relation to muck soil humidity and temperature has been established for the H-line of *D. platura*. The eggs displayed survival rates above 70% in most humidity and soil temperature combinations. Soil temperature of 15°C was the most favorable to egg survival at all soil humidity levels. Optimal egg hatch rates were observed at all temperatures at 60% soil relative humidity (weight: weight). Egg hatch rates declined at high humidity levels (80 to 150%) at 30°C and dry soil conditions (0 and 20% relative humidity) were more detrimental to egg hatch at temperatures of 20°C to 30°C where they varied between 27 and 67%. This information combined with the egg developmental time and the future experiment of plant colonization with 1st instar larvae at various soil humidity and temperature conditions will provide field scouts with a comprehensive tool for the prediction of field damage from both lines of *Delia platura*.

Activity 5. The elaboration of artificial diet recipes for *D. radicum* mass rearing is progressing well and promising results were obtained. For the first generation, the number of pupae harvested from diet trays compared to rutabaga was not significantly different; however, the pupae produced on diet trays were larger in size than the pupae produced on rutabaga. For the second generation, the number of pupae harvested from the diet trays was much lower than from rutabaga due to significant contamination of the diet trays with *Penicillium sp*. Hatching rate of eggs produced by second generation adults was higher than that of adults reared on rutabaga. These results indicate that the artificial diet recipe produces similar, if not better results (larger pupae and better hatching rates) than rearing *D. radicum* on natural rutabaga diet. Developing a cost effective and successful diet is critical for the mass rearing of *D. radicum* for the sterile insect release technique.

Diapause induction in *Delia radicum* pupae appears to have been achieved with the exposition of the parental generation to low temperature and short day photoperiods (15-20°C and 12:12 night: day). However, low emergence rates, significant rates of flies failing to complete their emergence, and long temporal pattern of emergence suggest that diapause induction and/or cold storage were not optimal. A second experiment is underway with cooler conditions. Controlling diapause induction is an asset for the mass production and long term storage of flies in a sterile insect control program.

For this project, we began the release of sterile *D. radicum* flies during the summer of 2019 in Quebec. In the laboratory, male and female sterility, as well as male competitiveness was verified for each of these releases. Laboratory experiences confirmed that for the irradiation dose used, sterilization was extremely successful (100% for males and 99% for females) and sterile males were able to compete with non-sterile males for females. However, adult emergence was lower in irradiated pupae compared to non-irradiated pupae. In the field, preliminary results for plant damage between untreated daikon fields and those where sterile cabbage maggot flies were released indicate a significant decrease in damage for fields where sterile cabbage maggot flies were released. No maggot damage was observed in Napa cabbage, and for cauliflower, damage was similar in the field with releases compared to that under conventional control.

Key Message(s):

With this project, we are actively working to improve management practices for *Delia* pests of vegetable brassicas in Canada. We initiated a vast sampling of *Delia* larvae across the country that will allow us to draw an accurate portrait of *Delia* infestation. We expanded our knowledge on the conditions required to establish an N-line seedcorn maggot colony, and we progressed in the validation and optimization of the sterile insect release method for cabbage maggot by narrowing down possibly suitable artificial diets, as well as pinpointing key elements of the rearing conditions to work on in order to better control diapause.

This project is generously funded through the Canadian Agri-Science Cluster for Horticulture 3, in cooperation with Agriculture and Agri-Food Canada's AgriScience Program, a Canadian Agricultural Partnership initiative, the Canadian Horticultural Council, and industry contributors.

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

CANADIAN AGRICULTURAL PARTNERSHIP
Innovate. Grow. Prosper.

Canadian Horticultural Council | Conseil canadien de l'horticulture
The voice of **Canadian fruit and vegetable growers**