Activity 13
Yield Impacts and Insecticide Management of Swede Midge in Canola
Annual Report – March 31, 2016

Overall Objective

The purpose of this activity is to develop effective integrated pest management practices for swede midge in canola, with the objectives to:

1. Evaluate the effects of the timing of swede midge infestations on canola damage and yield.
2. Evaluate insecticide efficacy and timing of insecticide applications for reducing swede midge damage in spring canola.
3. Develop insecticide timing recommendations for canola growers.

It is anticipated that this activity will result in recommendations on how to time insecticide applications most effectively in order to combat swede midge impacts on canola yield.

The results of this research will be combined with existing knowledge of swede midge ecology and other management tactics (e.g. crop rotation, weed management) to develop a comprehensive integrated pest management program for the swede midge in canola.

Audience

The target audience for information arising from this project includes canola growers, crop scouts, crop consultants, crop agronomists, and extension personnel, as well as scientists involved in entomology and pest management. A concerted, and very successful, effort was made to inform stakeholders about the biology and management of the swede midge throughout the project.

Performance Measures

New/Improved Practices

Two practices were developed through this activity:

1. Adoption of pheromone-based swede midge monitoring by canola growers and crop advisors throughout swede midge-affected areas, targeting the most vulnerable vegetative stages of canola.
2. Improved ability to time insecticide applications appropriately to protect most vulnerable growth stages (early and late vegetative stage) of canola.

New/Improved Knowledge

A single infestation with swede midge at the early bud stage can result in reduced pod set and reduced seed weight on primary and secondary racemes. Infestation of a plant at this stage with 100 females can result in an 8 day delay in plant maturation.

Informational Items

Four informational items were developed:

1. Hallett, R.H. 2016. "Northern Swede Midge Populations and Ontario Swede Midge Research." Ontario Canola Growers Association, January 2016 Newsletter, p. 10.
2. Hallett, R.H. 2016. "Swede Midge – A Highly Successful Invasive Species." Ontario Canola Growers Association, January 2016 Newsletter, p. 11.
3. Canola Council of Canada. 2015. Seed early to reduce swede midge damage. Integrated Pest Management Research Summary 3.10. Canola Digest Science Edition, p. 24-25.
4. Canola Council of Canada. 2015. Development of pest management decision-making protocols for the swede midge in canola. Research Briefs: Growing Forward 2 Projects. *Canola Digest Science Edition*, p. 42.

Information Events

During the year six presentations were given at research conferences, extension conferences and invited seminars:

1. Hallett, R.H. 2015. "Ecology and management of the swede midge, an invasive pest of Brassica crops". Department of Plant and Soil Science, University of Vermont, 6 November 2015.
2. Hodgdon, E., Chen, Y. and R.H. Hallett. 2015. Why "when" and "where" matters: characterizing mating behavior of swede midge, *Contarinia nasturtii* (Diptera: Cecidomyiidae). Entomological Society of America Annual Meeting, 15-18 Nov, Minneapolis, MN. (Paper). (approximately 30 attendees)
3. Hallett, R.H. 2015. Challenges presented by the swede midge, an invasive pest of crucifers. Entomological Society of Canada Annual Meeting, 8-11 Nov 2015, Montreal, QC. (*Invited speaker*, Symposium on "The impact of invasive species on the Canadian landscape", organized by B. Mori). (approximately 30 attendees)
4. Hallett, R.H. and J. Williams. 2016. The Swede Midge: *It's got a lot of gall!* Ontario Canola Growers Annual Meeting, 27 Jan, Alliston, ON. (Invited presentation, 30 minutes). (approximately 100 attendees)
5. Williams, J. and R.H. Hallett. 2015. The swede midge in canola: Insecticide application timing. Eastern Canada Oilseeds Development Alliance Canola Workshop, 29 April, 2015, Montreal, ON. (approximately 20 attendees)
6. Hallett, R.H., and J. Williams. 2015. Swede Midge Research Update. Canola Industry Meeting, December 1, 2015, Markdale, ON. (approximately 25 attendees)

The impact of these presentations is expected to have a wider reach than just attendees. There are approximately 750 canola growers in Ontario and it is anticipated approximately 20% of them will make use of the 2014 Swede Midge Management recommendations. Further, there are approximately 120 crop consultants and agronomists who provide recommendations and advice to growers on crop and pest management, with the expectation that approximately 90% will make use of the Swede Midge Management recommendations.

Highlights

Problem Statement

The swede midge (SM) is an invasive pest of cruciferous plants. Over the past 3-4 years, SM incidence and damage to canola has increased to economically damaging levels throughout Ontario canola production regions. SM is widespread and problematic in Quebec where it has been found since 2004, and in 2012 damage was observed for the first time in canola fields in Saskatchewan. Depending upon infestation timing, swede midge can impact yields by killing the growing point, preventing bolting of the main flowering stem, and killing developing flower buds. SM has multiple and overlapping generations each year, and canola is susceptible in multiple growth stages; thus, it is critical to develop decision-making tools, such as action thresholds, that can be used to optimize the timing of insecticide applications for yield protection.

Background Information

Pheromone-based action thresholds have been developed for the swede midge in cole crops, which are cost-effective and which can help to dramatically reduce pesticide applications in cabbage. However, swede midge populations based on pheromone trap monitoring can be much higher in canola than cole crop fields. In addition, only 1-2 insecticide applications per season are likely feasible economically in canola, making the availability of effective decision-making tools for optimal timing of insecticide applications critical. Decision-making about the timing of insecticide applications in canola will likely need to be based on both crop stage and swede midge populations (as determined by pheromone-based monitoring), in order to achieve both effective and economically viable control of the swede midge.

Research in this activity focussed on determining the optimal timing of insecticide applications with respect to plant growth stage.

Activities

In 2015, application timing trials were conducted on 6 grower fields with Matador and Coragen, to evaluate the efficacy of application made during three plant growth stages: Early (early rosette stage, 1 to 3 leaf stage); Mid (late rosette stage, 7 to 9 leaf stage); and Late (early secondary bud stage). Treatments included insecticide application at: 1. Early; 2. Mid; 3. Early + Mid; 4. Early + Mid + Late; and 5. Untreated Control. Pheromone monitoring traps were installed at each of these sites, traps were monitored twice a week, new SM damage to 100 plants was assessed each week, and yields determined at harvest.

Lab experiments were conducted to evaluate density-dependent effects of swede midge infestation on canola damage, growth and yield parameters, by caging plants at the early bud stage (i.e. mid plant stage) with 0, 5, 10, 50 or 100 female midges.

Main Conclusions

Overall, results suggest that multiple insecticide applications are required to reduce swede midge damage and the percentage of plants damaged. Single applications of insecticide at the early or mid plant stage timings can be as effective as multiple applications under some circumstances, related to swede midge numbers and emergence dynamics at the time of application. The late timing alone is not an effective treatment for reducing damage.

Both lab and field trials indicate that the pheromone-based action threshold approach has potential for management of swede midge in canola, as density-dependent differences are seen in damage, growth and yield. The relationship between midge numbers used in lab assays and trap captures in the filed needs to be determined, in order to establish the action threshold.

An application at the early timing should be made by growers when a cumulative total of 20 or more midges are captured (based on 4 pheromone traps per field, and beginning swede midge counts at the cotyledon stage) prior to the 4-leaf stage. Thereafter, an application at the late vegetative stage should be made if swede midge pressure remains high in the field.

Outcomes

Introduction

The swede midge is an invasive fly that has recently become one of the most important pest species for canola growers in Ontario. The swede midge was first recorded from the Prairies in 2007 and since then has spread widely across Saskatchewan and Manitoba. Controlling swede midge can be challenging due to the cryptic feeding habits of damage-causing larvae, their short residency on host plants, and the delayed onset of damage symptoms. Canola crops can experience high pressure throughout the growing season due to the four overlapping generations of swede midge in Ontario. Swede midge feed on young, fast growing tissue, meaning that canola is susceptible to damage through several growth stages. Prior research suggests there are several key growth stages of canola most susceptible to swede midge infestation. Therefore, using canola growth stage to time insecticide applications may be an effective method for reducing damage by swede midge larvae.

Objectives

This activity will contribute to the development of effective integrated pest management practices for swede midge in canola by evaluating insecticide efficacy and timing of insecticide applications for reducing swede midge damage in spring canola, and by developing decision-making protocols for the timing of insecticide applications against the swede midge, based on crop stage.

The results of this research will be combined with existing knowledge of swede midge ecology and other management tactics (e.g. crop rotation, weed management, etc.) to develop a comprehensive integrated pest management program for the swede midge in canola.

Approach/Methodology

This work has been conducted primarily through field trials at grower sites. In 2015, foliar insecticide applications were made by technicians involved in this project rather than relying on custom-applicators. In 2015, we also included lab experiments to determine density dependent effects of swede midge on canola damage, growth and yield parameters.

The results of this research will be used to develop recommendations on the optimal timing of insecticide applications, and the impact of swede midge on canola yields. These results will be combined with existing knowledge of swede midge ecology and other management tactics (e.g. crop rotation, weed management, etc.) to develop a comprehensive integrated pest management program for the swede midge in canola.

Deliverables/Outputs

This Activity has produced:

- Data on the efficacy of pesticides for management of the swede midge in canola.
- Recommendations on how to time insecticide applications most effectively in order to combat swede midge impacts on canola yield.
- Decision-making protocols for the timing of insecticide applications against the swede midge, based on crop stage.

This research will enhance current integrated pest management systems in canola through development of pest management recommendations for the timing of insecticide applications based on crop stage. This project will increase capacity in the canola sector to address an invasive species that is increasingly problematic in canola and will lead to information and tools that will help maximize canola productivity.

Year 3 Activities & Results

Plant Stage-based Insecticide Timing Trials

Plots were demarcated in six canola grower fields in southern Ontario. Plots included four replicates of five treatments. Treatments included applications of either lambda-cyhalothrin (Matador® 120 EC) or chlorantraniliprole (Coragen®) at: i) an early timing (growth stage 2.1-2.3 with a total cumulative trap capture of 20 males), ii) a mid-timing (growth stage 2.7-2.9), iii) both the early- and mid-timing, iv) both the early, mid and a late timing (growth stage 3.2-3.3), as well as v) an untreated control. One hundred plants per treatment were rated weekly for the presence of new swede midge damage. The percentage of plants exhibiting new swede midge damage was then calculated. At each field, four pheromone traps were placed around the perimeter. Sticky cards within the traps were replaced twice weekly and the number of captured male swede midge was recorded.

There were significant differences in damage and yield among treatments at one site only. At that site yield was highest following the mid application and damage was the lowest on a single date following the early + mid application. There was generally the highest level of new damage during the late vegetative-early bud stage (mid to late June) and a decline in new damage into the flowering stage.

The greatest percentage of new damage generally occurred during the late vegetative to early bud stage and decreased successively as plants began flowering following the bolting stage. The late vegetative stage and early bud stage is important to protect from damage due to the negative yield implications following death of the primary raceme and growth point on canola plants. Overall, swede midge damage had little impact on average yield at grower sites save for one site which recorded swede midge number consistently above the recommended action threshold of 5 males/trap/day. At this site, the early and mid-application timing had a positive effect on both damage reduction and yield.

Density-dependent impacts of swede midge on canola

When given a choice in the laboratory, swede midge prefers to oviposit on plants at the 7-leaf and early bud stages, rather than on plants that have started to flower. Most oviposition at the early bud stage was on secondary racemes rather than the primary raceme, suggesting a preference for oviposition on secondary growth points in the early bud stage and older growth. Given no choice, females will oviposit on less favourable canola growth stages; however, there may be increased risk of larval mortality due to desiccation or starvation, if oviposition occurs on plants with relatively little meristematic tissue.

In laboratory studies examining density-dependent effects of swede midge following a single infestation with 0 to 100 females on plants at the early bud stage, the total number of pods produced and total seed weight produced on primary and secondary racemes significantly declined with increasing swede midge density. Seed weight per pod on primary racemes and production of secondary racemes were also negatively related to swede midge density.

Consequently, total pods produced and total seed weight per plant declined by approximately 30 and 35%, respectively. Development of plants from the early bud stage to flowering took approximately one week longer on plants subjected to high densities of midges than for un-infested controls. Thus, swede midge infestation at the bud stage has significant negative effects on canola yield and development, with the primary raceme being most severely impacted. Delays in maturation could lead to complications at harvest, and their contribution to yield could be lost at harvest due to stunted height and underdeveloped seeds or pods.

Graduate Student, Jonathon Williams, completed his MSc thesis on this project in April 2015. He is now employed as a contract technician on this project.

Issues

Lower swede midge numbers than in previous years combined with optimal early growing conditions seemed to result in reduced yield and damage impacts from swede midge even in areas with numbers above the recommended threshold.

A single mid application timing could not be completed at one grower field due to weather and field moisture saturation. Only the early and late timings were applied at that field.

Note: I also received CCC-GF2 funding (2013-2018), which is primarily concerned with the development of pheromone-based action thresholds (Project AIP-CL08, Activity 3.6, *Development of Pest Management Decision-making Protocols for the Swede Midge in Canola*). As stated in my original proposal, CCC-GF2 support was used to support expansion of the insecticide timing trials in the ECODA-GF2 project in 2013 and 2014. In 2014, CCC-GF2 support allowed me to expand from 3 experimental treatments in 2013 to 6 experimental treatments in 2014; and to conduct trials with both Matador and Coragen. In 2015, insecticide timing trials were conducted on grower fields, and lab experiments were added.

Lessons learned

With optimal early growing conditions, canola in southern Ontario may be capable of outpacing swede midge emergence and damage resulting in high yields despite swede midge presence. In these cases additional insecticide applications may have limited impact and may be unnecessary.

There is also the potential for a more efficient damage rating system in canola, as we have found that percent damage measures are as informative as consolidated damage ratings. Damage ratings of individual canola plants and racemes are the greatest use of time for this project. In 2015, only new damage was assessed, in order to measure insecticide efficacy more efficiently.

Future Work

We have continued to refine recommendations for swede midge management in canola. Results from the first two years of this project have led to recommendations for insecticide applications to be targeted at the early and mid application timings, and no longer include the late application timing alone. This approach should also be the most cost-effective and logistically feasible for growers, and help to limit pesticide use in canola agroecosystems, until a pheromone-based action threshold can be developed.

Inclusion of lab-based experiments was not originally planned, but these experiments have provided important insights related to density-dependent effects of swede midge on canola growth and yield that will be important in future development of a pheromone-based action threshold.

Future research aims to elucidate the correlation between pheromone trap captures and larval load within canola fields. Improved estimation of larval presence and abundance within fields could lead to refined targeting of insecticide applications during vulnerable growth stages and increased larval mortality.

The pre-bolting plant growth stages appear to be most susceptible to swede midge impacts on yield. Further study of the relationship between insecticide timing and pest pressure during susceptible plant stages is needed to further refine the recommendations.

Development of a pheromone-based action threshold for swede midge during susceptible plant stages will be the focus of continued research in my CCC-GF2 project, and will build on the important results achieved by this ECODA-GF2 activity from 2013-2016.