Use of Exclusion Fencing as Cabbage Maggot Control
Integrated Pest Management
2011 - 2014

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Executive Summary

The cabbage maggot, *Delia radicum*, is one of the most damaging pests to cole crops in NL. Small amounts of tunneling in rutabaga render the crop unmarketable. There is one registered pesticide Active Ingredient (Chlorpyrifos) to control of cabbage maggot in cole crops; resistance has been reported.

The objective of this research project was to find alternative methods to control/manage root maggot in NL rutabagas and cole crops. Exclusion fences are specialized, temporary fences which are placed around the perimeter of a field to exclude insects. They were first developed by Dr. R. Vernon at AAFC in British Columbia as a means to prevent adult cabbage maggot flies from entering Cruciferae fields. The exclusion fences tested in this project was developed by Dr. Vernon in conjunction with a manufacturer in British Columbia called the Telstar Ecofence.

Infestation indices were calculated both inside and outside the exclusion fencing. Farm 1 in 2011 had an infestation index of 100 outside the fencing and 30 inside the fencing. Farm 1 in 2013 had an infestation index of 35 outside the fencing, an infestation index of 18 along the inside perimeter of the fencing, and an infestation index of 10 inside the fencing. The marketable yield on Farm 1, in 2011, was 425 grams outside the fencing and 600 grams inside the fencing.

Although fencing is fairly inexpensive, set-up and removal of fencing can be labour intensive to apply to an area. Use of rebar and proper spacing proved to be very important factors in ease of set-up and removal. Fencing may not be recommended for use in stony soil, as placement of rebar may be an issue. The mesh used on the fences is relatively inexpensive, though it does not fare well in NL weather conditions (ie. wind). This mesh, if not repairable, may need to be replaced yearly or biennially.

With limited testing, to date, this technology appears to be a promising alternative pest management strategy. Marketable yields both inside and outside the fencing were comparable, leading to the conclusion that the fencing did not compromise the yields and, in fact, reduced cabbage maggot damage. Additional research is recommended and analysis needs to be completed to make sound decisions and recommendations.
Introduction

The cabbage maggot, *Delia radicum*, is one of the most damaging pests to cole crops in Newfoundland and Labrador. It is one of the most economically hindering due to plants being killed, weakened, stunted, yields drastically reduced or unmarketable (Anon, 2004). In Canada there is only one registered pesticide, chlorpyrifos (Lorsban/Pyrinex) for use on rutabaga and cole crops for control of cabbage maggot. Resistance has been occurring throughout Canada and is suspected on some NL farms. Research to find alternative ways to control cabbage maggot in rutabaga and cole crops, is both essential and urgent. Research on integrated pest management techniques need to be done. Through the use of IPM, a more sustainable form of crop production may be achieved, with the use of pesticide controls being a last resort.

Identification of the cabbage maggot may be used to monitor the presence of populations throughout cropping systems. The adult is a two-winged, ash-grey fly with black stripes on the mid-section. Larvae are white, legless maggots. They are wedge-shaped with dark feeding hooks at the front end. Pupae are 6mm long, oval, hard and dark brown in color (Anon, 2004).

Pupae overwinter in the soil near the roots of the host plant. In the spring, adult flies emerge and crawl to the surface. The mated females fly close to the ground near host plants and lay oval shaped white eggs at the base of the stem or in crevices in the soil nearby. The eggs hatch 3-7 days after being laid. Maggots then enter the roots of the host plant and feed by rasping the plant tissue with a pair of hook-like mouthparts. The larvae mature in 3-4 weeks then pupate. Flies emerge from the pupae after approximately 2-3 weeks. There are two to three generations of root maggot each year in NL (Fig.1).
The objective of this research project was to find alternative methods to control/manage root maggot in NL rutabagas and cole crops. Exclusion fences are a newly developed technology which may become available if research conducted can prove the advantages of use.

Exclusion fences (Fig. 2) are specialized, temporary fences which are placed around the perimeter of a field to exclude insects. They were first developed by Dr. R. Vernon at AAFC in British Columbia as a means to prevent adult cabbage maggot flies from entering Cruciferae fields. There has been extensive testing of the fences in British Columbia and a modified "Vernon-fence" is used commercially in rutabaga fields in Norway. The exclusion fences to be tested in this project were developed by Dr. Vernon in conjunction with a manufacturer in British Columbia called the Telstar Ecofence; these have to be tested under NL conditions as their effectiveness is affected by terrain and possibly weather. The impact of moose or extreme wind on these fences is unknown.
Funding & Partnerships

The “Use of Exclusion Fencing as Cabbage Maggot Control: Integrated Pest Management 2011 - 2014” project was funded by the Agriculture Research Initiative. In kind contribution was provided by Agriculture and Agri-Food Canada (AAFC), and numerous vegetable producers across Newfoundland and Labrador. Work was administered by the Newfoundland and Labrador Department of Natural Resources, aided by cooperating AAFC staff and producers.

Methodology

In 2011, Farm 1 (Wooddale, Central NL) and Farm 2 (Markland, Eastern NL), were utilized to analyze exclusion fencing for ease of use and cabbage maggot control. Farm 1 utilized the Telstar Eco Fence on a 30m by 30m plot. Rutabagas were seeded prior to set-up of the fence. Farm 2 also utilized the Telstar Eco Fence, although two plots measuring 30 meters by 30 meters were set-up and late cabbage was transplanted in the field before set-up of the fences. In 2012, another location on Farm 1 was utilized as a test site for the Telstar Eco fencing. The plot size measured 16.5 meters by 48.5 meters. Rutabagas were seeded prior to set-up of the fence.

The producers chose rutabaga/cabbage variety and planting method. Directly following planting/transplanting, the row covers and exclusion fences were set-up.
on farm. Immediate set-up was completed to prevent infestation by cabbage maggot. Set-up of the fences was completed by the project team.

Research sites were frequently monitored and visual observations were recorded including stressed plants, weather, and presence cabbage maggot adults, larvae and eggs. 4” x 6” yellow sticky traps were used as a means of monitoring adult cabbage maggot flies. Sticky traps were set-up inside and outside the fence at predetermined locations. In 2011, a total of 37 traps were arranged to capture flies on the four outer sides of the fence as well as on 8 transects inside the field. Inside traps were 1, 5, 10 and 15m from the fence edges. In 2013, a total of 8 traps were arranged to capture flies at two locations outside of the fencing and 6 inside. Traps were placed just above canopy level and changed on a weekly basis. Traps were dried for 2-3 days and placed in cool room until identification.

In addition to the sticky traps in 2011, there were a total of 29 egg sampling sites inside the fence. At each egg sampling site, the bases of five plants were visually inspected for the presence/absence of Delia eggs. Eggs inspections were completed weekly. As there were very few eggs being recorded at Farm 2, egg sampling was reduced to a random selection of five of the 29 sites.

Harvest of the plots was conducted and a 0-4 (0, 1, 2, 4) damage scale was used for evaluations (King and Forbes, 1954). This method of evaluation is based on the number of knife cuts required to remove the maggot damaged tissues from mature roots (maximum of 4 cuts). Roots requiring 2 or fewer cuts to remove the maggot damaged tissues were considered marketable. After separation of the four categories, the infestation index was calculated for each plot. This was done by multiplying the appropriate factor by the percentage of roots in that category, adding all of the categories together for that plot and then dividing this sum by the total number of categories.

**Results & Discussion**

Farm 1 participated in the exclusion fencing trial in 2011-2012. The infestation index was measured to be higher on the outside perimeter of the fence, than the inside. The outside perimeter of the fence had an infestation index of 100. Inside the exclusion fence, the infestation index was 30 (Fig. 3).
Figure 3: Infestation index of exclusion fencing at Farm 1, 2011.

The average marketable weight of rutabaga (g) was calculated for Farm 1 in 2011. Inside the fence, on average, the marketable weight of each rutabaga was 600g. Along the outside perimeter of the fence, the average marketable weight of each rutabaga was 425g (Fig. 4).

Figure 4: Average marketable weight of rutabaga (g) inside and outside the exclusion fencing at Farm 1, 2011.

Farm 2, in 2011, was not reported due to extensive club root disease in the research plots. Damage ratings were difficult to conduct due to the extent of this disease. At harvest, some of the large clubbed roots were broken off and left in the ground. When looking at these roots, with the naked eye, a lighted hand lens and a microscope, it was difficult to identify root maggot damage within the clubbed
roots; there were many growth cracks and club root growths on the stems and roots of the cabbage plants, which made harvest and analysis difficult.

Farm 1 participated in the exclusion fencing trial in 2013-2014. The infestation index was measured to be higher on the outside perimeter of the fence, than the inside. The outside perimeter of the fence had an infestation index of 35. Inside perimeter of fencing, the infestation index was 18. Inside the exclusion fence, the infestation index was 10 (Fig. 5).

![Infestation index of exclusion fencing at Farm 1, 2013.](image)

Exclusion fencing (Telstar Eco Fence) was used on Farms 1 and 2 in 2011-2012 and Farm 1 in 2013-2014. The set-up of the fencing (Fig. 6) was somewhat labour intensive. The second fence was erected in half the time following learned techniques from the first fence set-up. Rebar is forced into the soil (Fig. 6) for the fence to sit atop, and sections of fence are placed onto it. Plastic spacers are placed in-between the overhang and the fence to hold out the overhang trap (Fig. 7).
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Figure 6: Installing rebar using a fencing spacer, at Farm 1, 2011.

Figure 7: Illustration of fencing keeping flies outside (left); Telstar Eco Fence overhang (right).

The Telstar Eco Fencing proved to be useful in excluding the cabbage maggot from inside the fencing. The overhang on the outside of the fencing was useful in trapping insects that would climb up the fence, so they could not get over the fence and into the plots (Fig.7). The rutabaga and late cabbage from the fencing trial had comparable marketable weights inside and outside, leading to the conclusion that the fencing did not compromise the yields and, in fact, reduced cabbage maggot damage.

Staff and producers identified several potential issues when using this technology including:

- Installing rebar into stony ground could prove to be difficult as rebar is hammered in;
- Sections of fencing is heavy and somewhat difficult/awkward to move;
Fencing tears easily during installation, although fixing is easy as well using the appropriate methods;

When stabilizing the fence with rope during set-up, they were tied off to posts at each corner. This proved difficult to set-up, as the overhang was in disarray and would not work to keep out adult cabbage maggot flies in this state. The fence was meant to be wrapped around the post and secured for stability and cabbage maggot fly control (Fig. 8).

Figure 8: Issues with the exclusions fencing: corner of the exclusion fencing (left), moose track outside and inside the fencing (right).

There were numerous issues found during the growing season and harvest. Farm 2, in 2011, had further damage due to club root disease. This disease made damage rating and categorizing very difficult (Fig. 9). In 2013, moose were common at the research site. The moose entered the fencing area through the corner between the post and fence, although surprisingly no damage was done to the fencing (Fig. 10). Another concern was in high winds, the rebar would work back and forth and the fence would actually bend with the wind. The fence would return to the original position after the wind storm was over.
Figure 9: Cabbage root infested with club root, Farm 2.

Figure 10: Moose track outside the fencing and inside (top right).

Burial of the mesh along the edges is an important action that needs to be done when using this fencing. Cabbage maggot flies could crawl under fencing if not secured properly (Fig. 11).
Adult flies were monitored through the use of 4” x 6” yellow sticky traps (Fig. 13). In 2011, a total of 37 traps were arranged to capture flies, and in 2013, a total of 8 traps were arranged to capture flies. Traps were placed just above canopy level and changed on a weekly basis. Identification of the adult cabbage maggot fly is difficult and can only be completed by a trained professional. When identifying cabbage maggot flies, specimens had to be compared to already identified males and females. *Delia radicum* is very similar to *Delia platura*, *Delia floralis*, and *Delia planipalpis* (Fig. 13).
Figure 13: Yellow sticky cards placed inside exclusion fencing trial plot (left); Delia identification sheet, AAFC, St. John’s, NL (right).

In addition to the sticky traps in 2011, there were a total of 29 egg sampling sites inside the fence. As there were very few eggs being recorded at Farm 2, egg sampling was reduced to a random selection of five of the 29 sites.

Figure 14: Cabbage maggot found during add sampling.

Conclusions
Although fencing is fairly inexpensive, set-up and removal of fencing can be labour intensive to apply to an area. Use of rebar and proper spacing proved to be very important factors in ease of set-up and removal. Fencing may not be recommended for use in stony soil, as placement of rebar may be an issue. Fence posts, which are placed over the rebar, are made of aluminum and would withstand NL weather conditions well although posts bending in the wind may become an issue. The mesh used on the fences is relatively inexpensive, though it does not fare well in NL weather conditions (ie. wind). This mesh, if not repairable, may need to be replaced yearly to biennially.

Shipping costs of this fencing would have to be considered. This fence is produced in British Columbia, thus shipping may be a large expense. As well, cost of purchasing rebar, to hold the fence, may prove to be expensive.

It is recommended that a minimum size of 30 meters by 30 meters be placed inside exclusion fencing. The larger the area enclosed, the more useful this technology is. Setting up a large-scale fence where a tractor can be driven through would be of great importance for the implementation on-farm by vegetable producers. Additionally, exclusion fencing may hold promise in (smaller scale) organic vegetable production. With limited testing, to date, this technology appears to be a promising alternative pest management strategy. Marketable yields both inside and outside the fencing were comparable, leading to the conclusion that the fencing did not compromise the yields and, in fact, reduced cabbage maggot damage. Additional research is recommended and analysis needs to be completed to make sound decisions and recommendations.

It should also be noted that identification of Delia sp. has proven to be rather difficult. It is recommended that adult identification should only be undertaken by a trained professional.
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References


Forestry and Agrifoods Agency
Appendix A:

Cabbage Maggot Management Demo
Ms. Leah Madlove, DNR and Dr. Peggy Dixon, AAFC

The cabbage maggot, *Deltamorphia
cucurbitae*, is a serious pest of Cole crops. We are looking at two physical
management strategies as a means to manage this insect.

Row Covers
- A 2-year, Atlantic-wide project being tested in NS, NB, PEI, and NL.
- Physically excludes female flies from laying eggs on crop plant
- Testing two mesh types and installation systems—Wondermesh and ProteinNet
- Grower co-operators—Barry Adams (Wooddale), Dave Dwyer (Shearstown),
  Dwight Eveleigh (Comfort Cove)

Exclusion Fences
- Developed in British Columbia by AAFC researcher Bob Vernon
- Theory of exclusion based on fly behaviour
- Treating the *Deltamorphia cucurbitae* under NL conditions in collaboration
  with Agriculture and Agrifood Canada
- Grower co-operators—Karen Durfee (Marland) and Kent Fudge
  (Wooddale)

Figure 2: Story by Deana Stokes Sullivan (reporter). 2011. Story published in the main St. John’s, NL paper, “The Telegram”, following an interview with P. Dixon. Title: Inside the mind of a fly. Published Tuesday, August 16, 2011.
Scientists evaluate options in battle against cabbage maggot

By HEATHER JONES

Scientists are evaluating options in the ongoing battle against the cabbage maggot. While it may look like a common housefly, Delia radicum can wreak havoc on entire radish and cole crops. The insect lays its eggs in the soil next to the plant and its larvae feed on the roots. And there have been reports of resistance to the latest imported insecticide.

Agriculture & Agri-Food Canada entomologist Dr. Peggy Dixon has been studying the cabbage maggot for almost two decades while at university and at the Atlantic Coastal Climate Crop Research Centre (ACCRC) in St. John’s, Newfoundland & Labrador.

Working with Labé Murdere of NL Agrifoods, she tested three pesticide-free techniques this year on farms throughout the province—exclusion fencing, relay cropping, and crop rotation—to prevent and control cabbage maggot infestations.

The test fields varied in size. “We have a couple of organic farms with small fields and large farms able to give us almost an acre just for the trials.”

Four foot-high exclusion fences (that look like common door screens) were set up on an Annapolis Potsowata farm with steady down soil and on a farm in Woodville where the soil is sandy loam.

Most cabbage maggots will not crawl above 2 feet when searching for a location to deposit their eggs. AACP scientist Dr. Rob Verissimo, who developed the exclusion fences, found that in British Columbia 80-95 per cent fewer eggs were laid on crops inside the barriers.

Dr. Dixon explained that the purpose of the NL trial was to test exclusion fences under weather conditions not found in BC.

“We have had at least a couple of tropical systems and extreme winds this season. The fences at both locations stayed up. Our site had a bit of dusting in the fence after a severe wind and rain event. The mesh was pulled onto one of the posts and tore. It was removable, then tape but a farmer would need to inspect his fence after any severe weather event.”

“One other thing we noticed was that the wind caused the net to move back and forth, which enlarged the holes in the ground that the insects were in, and caused the pests to drop a few inches. This reduced the effective height of the fence—a couple of inches might be okay but this could be a problem if they dropped more than that and the pests could get inside the fence more easily.”

The entomologist noted that a user would also have to consider landscape, topography, winds and anything that would influence the flight of the fly.

She said the trial crops were not been harvested but if the fences work in NL, scientists would evaluate the price of various construction materials.

RELAY CROPPING

This year’s cold, wet spring delayed planting in the region and only one farm in Labrador tested relay cropping.

AACCAC technicians Dr. Carolin Parsons studied spinach, beets, carrots and two lettuce varieties in relay crops in between rows of confederate as research for her PhD.

“The lettuce was most effective but other crops would work,” Dr. Dixon said. “The main point is to have something that grows quickly so it is present when the first generation of cabbage maggot is laying eggs but can then be harvested as there isn’t an explosive population. The critical thing is to balance good cabbage maggot control with little or no plant competition.”

The entomologist said, “The leaves of the relay-crop plants must have a certain architecture, or shape, to confine the fly. For example, Dr. Parsons found that carrots were not a good relay-crop candidate probably because of their feathery leaf shape.”

She said depending on field size and production practices relay cropping could be financially viable. The determining factors would be whether a farmer could handle planting two crops together and harvesting them at different times.

CROP COVERS

Dr. Dixon said two European crop covers, Wundermuffn from Scotland, and Frontline (distributed by Dubois Agrinovation in Quebec) were used in trials on 8 commercial farms in the Atlantic region.

The past Atlantic crop cover study on farms in Nova Scotia, in New Brunswick and Newfoundlad & Labrador and in Prince Edward Island, was funded through the Pest Management Centre’s (AACP) Particle Risk Reduction: Strategic.

Figure 3: Story by Heather Jones (reporter). 2011. Scientists evaluate options in battle against cabbage maggot. The Farm Focus (Atlantic Canadian Farming Monthly Newspaper); published December 2011.
Figure 4: Update: Cabbage maggot control and integrated pest management. Invited presentation at the NL Horticulture Producers Association Annual Conference, "Horticulture: Producing Quality-Farming Safely". Gander, NL March 2012.
Figure 5: Exclusion fencing as a physical barrier to control cabbage maggot (*Delia radicum*) Poster presented at 2013 Research and Development Symposium.