Exclusion fence technique for cabbage maggot management in Brassica vegetable crops

Brassica vegetable crops in all production regions in Canada suffer from losses attributed to the cabbage maggot (CM) (also known as cabbage root maggot), *Delia radicum L.* Only two insecticides, diazinon and chlorpyrifos, both organophosphates, are currently registered to control this pest in Canada. However, following a re-evaluation by Health Canada's Pest Management Regulatory Agency (PMRA), diazinon products will be phased out in stages between the end of 2014 and end of 2016. The PMRA has also implemented various interim mitigation measures for the use of chlorpyrifos while its re-evaluation is ongoing. In addition, previous research has confirmed that resistance to chlorpyrifos is spreading within CM populations in British Columbia (BC). Stakeholders identified the development of alternative control options as critical to help growers cope with the loss of these pesticide uses and transition away from pesticide dependence.

Investigating the use of physical barriers as an approach to avoid damage by this pest was among the actions identified within the context of the Pest Management Centre's Reduced-Risk Strategy for Cabbage Maggot Management in Brassica Crops. The goal of the strategy is to develop tools which may ultimately be combined into an integrated approach to manage this pest.

Photo credits: Carolyn Parsons (AAFC)

Figure 1: Cabbage maggot feeding on rutabaga

Pest Behaviour and the Exclusion Fence Concept

To understand why a fence might protect a crop from CM, it is important to know the behaviour of the pest. Adult flies of CM emerge in the spring from pupae that overwinter in the soil. After mating, the females search for host plants and lay eggs in the soil, near the base of the Brassica plants. The maggots cause damage by feeding on the roots. When fully mature, the maggots pupate and may emerge as adults of the second generation or overwinter and emerge the following spring. From 1 to 3 generations per season are possible, depending on the region.

In seeking out host plants, however, most female flies tend to fly low above the soil. It is for this reason that a vertical screen fencing or "exclusion fence" surrounding the field might protect the crop by intercepting the flies before they make their way into the crop to lay eggs. This hypothesis was tested in the early 1990s when studies showed that, under controlled conditions, fences 90 or 120 cm in height stopped 80% or 90% of flies, respectively from entering small enclosures in fields.

As part of the Reduced Risk Strategy for Cabbage Maggot, a three-year project was initiated in 2009 to further validate and demonstrate the use of exclusion fences as a tool in combination with other available methods for CM management in commercial fields. The work encompassed the development and on-farm demonstration of a prototype fence and a commercial fence model. An illustrated manual to facilitate transfer of the technology to growers was also prepared as part of the project.

Description of the Exclusion Fence

The prototype fence developed in 2009 consisted of black, 1 mm mesh nylon window screen attached to upright aluminum rails at 2.5 m intervals. The height of the fence was 1.3 m. In line with each rail was an additional 0.3 m length of rail as a brace to support a mesh overhang, bent downward at a 45° angle and facing outside the field. A nylon rope running between the rails served to keep the fence material taut along the top of the rails. Approximately 0.2 m of excess screen was laid flat on the ground inside the field and covered with soil. The fence assembly was rolled up for storage at end of season and reinstalled before the following planting season. It is estimated that under optimal conditions this fence could be re-used for about ten years.

Photo credits: Bob Vernon (AAFC)

Figure 2: Prototype exclusion fence erected around a 2.7 ha field of commercial rutabagas in Delta, BC, in 2009. The set up included planting of 7 rows of rutabagas parallel to and 1 m inside the fence perimeter, and an opening at the far corner of the field to allow grower and equipment access into the field.

In 2010, a commercial fence design developed by Agriculture and Agri-Food Canada researchers: the Telstar Eco Fence, became available in Canada. Its performance was evaluated during 2010 and 2011 in commercial rutabaga plots across BC, and in research plots in Saskatchewan and Newfoundland. The new design follows the same principles and is similar to the earlier prototype, but is much easier to install and dismantle.

Results from the Exclusion Fence Trials

In 2009, the prototype fence was assessed in commercial rutabaga fields for its impact on the movement of CM flies, subsequent egg deposition and damage to rutabaga plants. Treatments were either fenced or unfenced fields. In both cases insecticides were applied in order to periodically and uniformly reduce CM populations throughout the fields. These applications would not have altered the distribution patterns of new CM flies entering the fields being assessed in the trials.

Results of 2009 field trials represent ideal fence exclusion conditions as demonstrated by the number of CM adults in the field, egg deposition, and damage to rutabaga plants. When comparing within-field distribution of CM flies in both fenced and unfenced fields, the highest numbers were recorded in the corners and along the edge of the field (Figure 3). Further from the edge and into the field, the population sharply declined inside the fenced field (e.g. 66% fewer flies at 6 m from the fence than at 1 m) whereas the pattern was gradual in the unfenced field (only 20% fewer flies at 6 m from the edge than at 1 m). These data indicate that the movement of female flies into a fenced field was significantly reduced by the fence, and their distribution inside the fence was more closely aggregated near the fence perimeter.

A similar trend was observed with the number of times that fresh *D. radicum* eggs were found present (oviposition events) at individual plants (Figure 4). In the fenced field, counts dropped rapidly between 6.5 and 13 m from the fence, with 93% fewer events at 13 m than at 6.5 m. In the unfenced field, the decline was more gradual, with only 57% fewer oviposition events at 13 m than at 1 m from the edge.

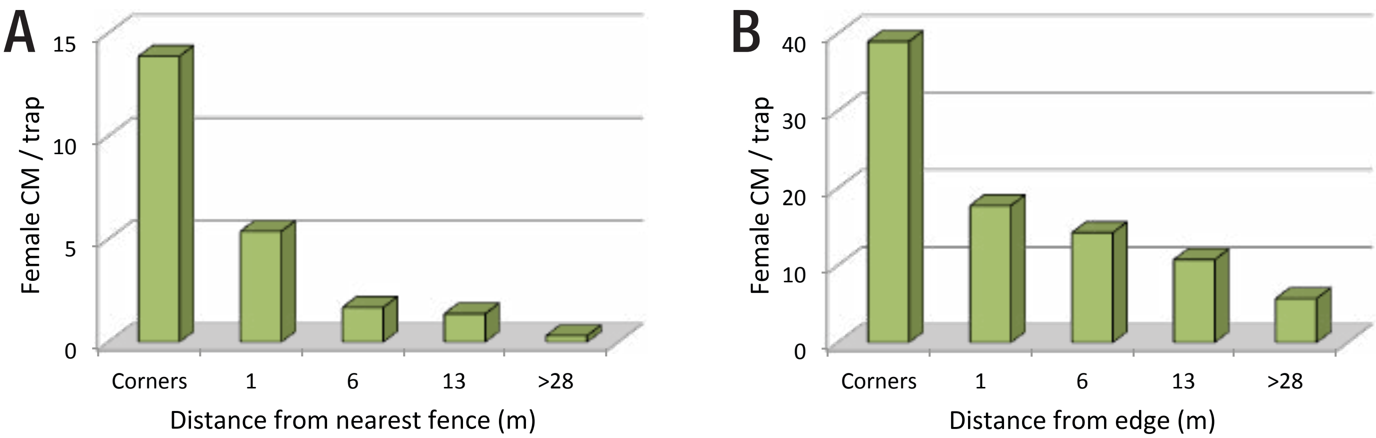

Figure 3: Mean CM female flies captured on yellow sticky traps at various distances from the field edge within fenced (A) and unfenced (B) fields of rutabaga in 2009, in Westham Island, BC. Bars represent means of 15 and 8 weekly observations in the fenced and unfenced fields, respectively.

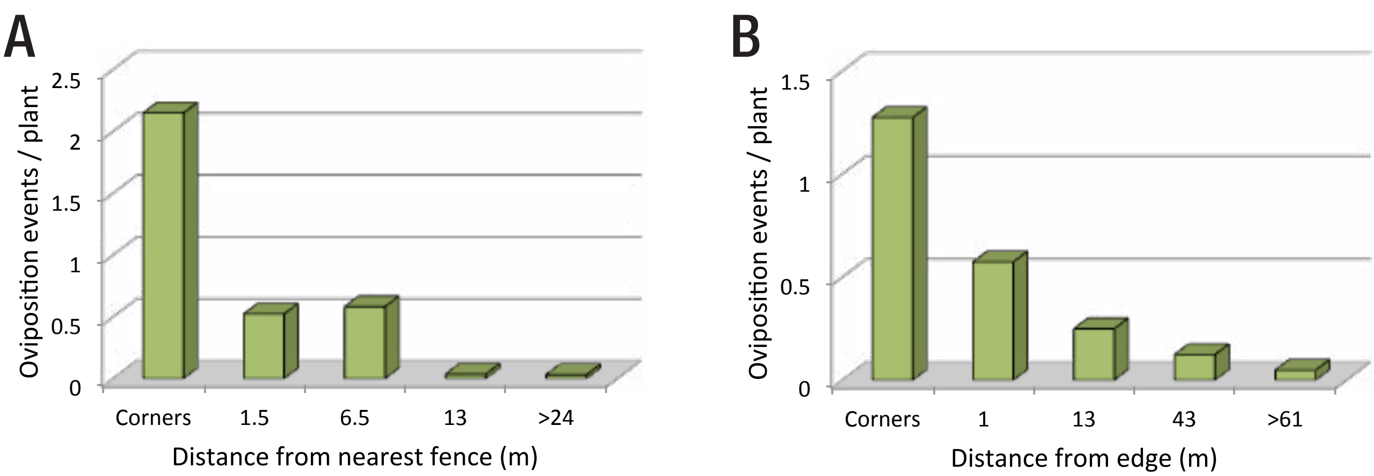

Figure 4: Mean number of oviposition events per plant at 62 sampling locations (10 plants per location) in fenced (A) and 38 sampling locations in unfenced (B) rutabaga fields in 2009, in Westham Island, BC. The same ten plants were examined during weekly visual sampling between 8 May and 3 July in the fenced field, and between 29 May and 31 July in the unfenced field, respectively. Bars represent the mean number of times eggs were observed per plant at various locations in the field over the entire sampling period.

Results of damage to rutabaga within the fenced field (Figure 5) show that sample sites at 1.5 and 6.5 m into the field had the highest percentage of culls (22 and 23%, respectively), but it dropped rapidly by 97% between 6.5 and 13 m. This trend closely followed the distribution of oviposition events in that field. The situation was different in the unfenced field, where the percentage of rutabaga culls was much higher and it declined linearly between 1, 13, 43, and 61 m from the edge.

As the grower's tolerance for root maggot damage in rutabagas was 10% culls, the difference between the fenced and the unfenced field had clear economic significance. At that level of tolerance, damage in the fenced field was higher than the threshold (up to 23% culls) in a limited area only, less than 13 m into the field. At 13 m and further, damage to harvested rutabagas was negligible (1% culls). In contrast, damage in the unfenced field was much higher than the tolerance threshold from near the edge (85% culls at 1 m) until somewhere between 43 and 61 m into the field (25% and 7% culls, respectively). That level of damage had forced the grower to abandon harvest in the unfenced field, despite six prophylactic insecticide applications during the season.

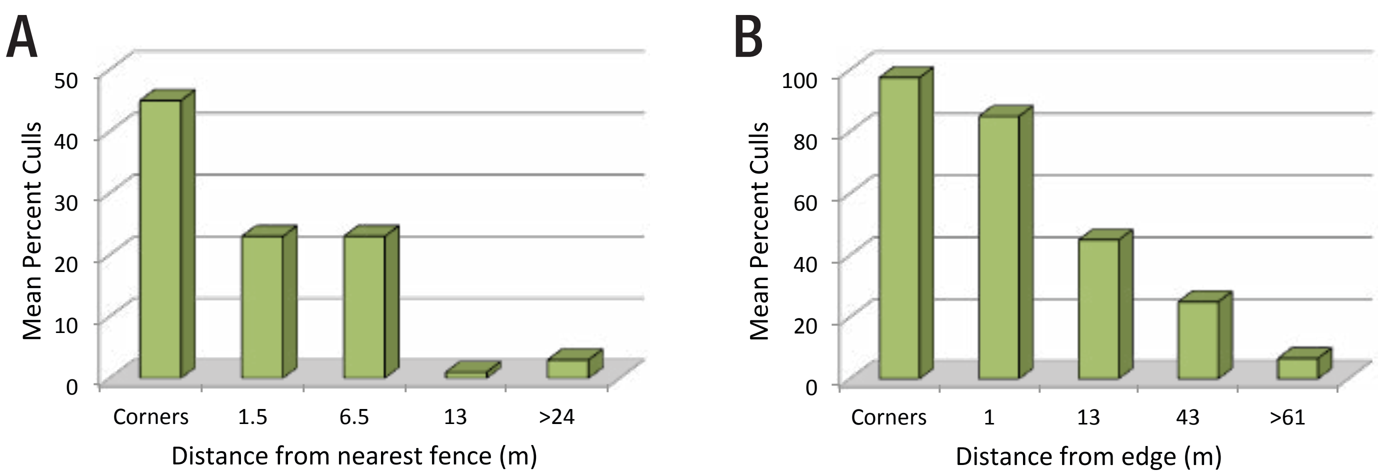

Figure 5: Mean percent of rutabaga culls at harvest at 38 sample locations in a fenced field (A), and 36 sample locations in an unfenced field (B) in 2009. Ten plants were examined in each sampling location.

These results suggest that, under certain conditions, an exclusion fence may be used as a first line of defense against the CM. With fewer flies entering the fenced field than the unfenced one, fewer eggs were deposited on the crop and consequently, damage to the roots was reduced. In both fields, infestation declined with distance from the edge. The drop, however, was more rapid in the fenced field: pest populations and crop damage were primarily aggregated within a 13 m perimeter inside the fence, whereas in the open field the pattern was more linear, with significant adult populations, oviposition events, and unmarketable crop recorded further into the field.

Results from trials conducted in subsequent years (not presented here) helped in identifying the factors that may limit the efficacy of the fence. Consequently, the following criteria have been developed to guide selection of fields where exclusion fence technology may be successfully implemented as part of an integrated system for CM management.

Conditions Affecting Exclusion Fence Efficacy

The efficacy of fencing will vary between locations and years according to a number of variables, which have to be considered before choosing this technology as a control option. The importance of these variables was demonstrated in 2010 and 2011, where more flies were able to defeat the fences, resulting in higher levels of damage than in 2009. From these 3 years of research, scientists were able to identify the factors that either reduce or favour the efficacy of fencing as a pest management tool for CM.

Below are some key criteria recommended to be considered to ensure optimal CM control using fencing as part of an integrated management approach:

- Low surrounding topography – trees, bushes, or upward slopes or high ground around the field enable incoming flies to more easily fly over the fence and into the crop
- Minimum vegetation growth external to the fence – weeds and other plants outside the fenced field should be removed or maintained at low height so these do not affect the flight pattern of the flies (they tend to fly above high vegetation and into the crop)
- In-field cruciferous weed control is essential as a means of eliminating alternative hosts and potential sources of re-infestation
- Pest pressure has to be low to moderate for best results – under high pest pressure the fence is less effective as the number of flies that defeat the fence is proportionally higher, causing an increase in crop damage
- Previous-year crops should be non-host plants – if cruciferous crops (or weeds) were in the field the previous year, overwintering CM pupae will already be in the soil, giving rise to fly populations inside the fenced area
- Timing of fence erection must be before the planting of the Brassica crop or shortly thereafter
- Square field shape – plots that are long and narrow are more costly to fence on a per hectare basis, and prone to have higher levels of damage because of a relatively larger field area exposed to highly infested corridor occurring up to 13 m inside the fence

- Field size – fenced fields less than 1 ha in size would benefit less than larger fields, since most of the area in a smaller field would be within 13 m of a fence which would require pesticide applications to maintain flies below threshold

When location is properly selected, the exclusion fence technology can help reduce the number of flies entering the field, and, consequently, reduce damage to the crop caused by the pest. As part of an integrated management program, insecticide sprays may only be required to control the pest population along the 13 m corridor inside the fence, therefore reducing the amount of pesticide required compared to unfenced fields where the entire field must be treated.

Acknowledgment

These results were made possible thanks to the following individuals and groups: Markus Clodius, Wim van Herk, and Chantelle Harding (AAFC) for assistance in preparing and setting up the fence, and data analysis; ES Cropconsult Ltd. personnel for their assistance in field trials and data entry; grower Kevin Husband (Emma Lea Farms, Delta, BC) for his cooperation and donation of fence material, time, and rutabaga fields; and Susan Smith (BCMAF) for assistance in the field and in establishing a network of organizations to fund part of the project. Funding for this project was provided in part by: the BC Vegetable Marketing Commission (Brassica Levy Fund); the Lower Mainland Horticultural Improvement Association; and the Processing Vegetable Industry Development Fund.

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About the Pesticide Risk Reduction Program at Agriculture and Agri-Food Canada

The Pesticide Risk Reduction Program delivers viable solutions for Canadian growers to reduce pesticide risks in the agricultural and agri-food industry. In partnership with the Pest Management Regulatory Agency of Health Canada, the Program achieves this goal by coordinating and funding integrated pest management strategies developed through consultation with stakeholders and pest management experts.

The Pesticide Risk Reduction Program is actively pursuing the development and implementation of strategies which are key to reducing pesticide risks in the agricultural environment. To view the Program's current priorities and the issues being addressed, visit: www.agr.gc.ca/pmc. To consult other factsheets in this series, visit: www.agr.gc.ca/sustainable-crop-protection.

AAFC No.12356E ISSN 2368-8262
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