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MANAGEMENT PRACTICES FOR CONTROL OF EUROPEAN WIREWORMS IN CANADA

Interim Research Report E2010-37

BACKGROUND

Significant losses in crop yield, quality and marketability have been attributed to wireworms, a pest of growing concern and widening distribution in Nova Scotia and across Canada. While the Maritime Provinces harbour indigenous wireworm species, three species introduced to North America from European ship ballast cause the lion's share of damage.

The destructive larvae of these three species, *Agriotes lineatus*, *A. obscurus*, and *A. sputator*, persist in the soil for several years, feeding on the roots of host plants and causing significant reductions in the yield and quality of economically important crops. Root crops such as potatoes and carrots are particularly susceptible because damage (holes produced by feeding larvae) to the new tubers and carrots can appreciably reduce quality, yield and storability.

To control this pest, the adult must be deterred from entering and depositing eggs in the field, the larvae must be deterred from attacking the cash crop and/or the larvae themselves must be controlled. This is a difficult challenge due to the lifecycle, feeding preferences and movement habits of the wireworm.

Larval wireworm feeding on barley seedling (J. Nelson)

Wireworm trapping in the rotation trial (J.MacKenzie)

WHAT WAS DONE

In 2007, the Organic Agriculture Centre of Canada (OACC) began developing cultural management strategies targeted at the larval wireworm and adult click beetle. Damage to crops as a result of wireworm feeding may be mitigated by deterring egg laying in crop fields or reducing viability of eggs and young wireworms, developing methods to deter feeding on cash crops, and using unattractive or ill-suited plants in a crop rotation.

Crop Rotation for Wireworm Control:

Rotational crops may be used to create an inhospitable soil environment for wireworms. A 3-year crop rotation trial was established at the Brookside research site in 2007, with the second year of cover crops planted in 2008. The trial includes crops which may have a detrimental effect on wireworm populations, such as glucosinolate-releasing brown mustard, quick growing buckwheat which may be incorporated when wireworms are most vulnerable to mechanical damage, flax with possibly poor nutritional quality for the wireworm, deep rooted and soil-drying alfalfa, and a control of barley underseeded to clover. In 2009, these plots were planted with carrots for evaluation of crop damage.

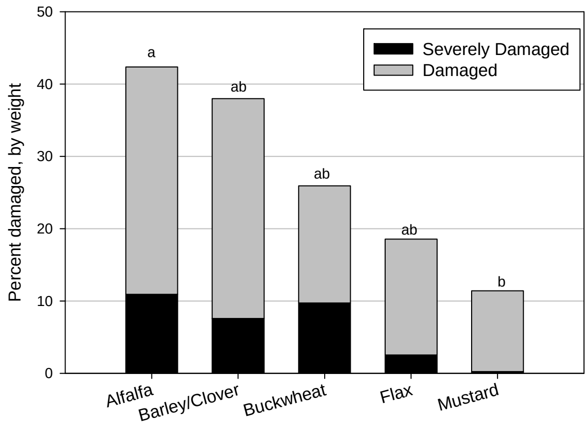

Figure 1. Effect of previous crop history on the level of wireworm damage to harvested carrots.

Wireworm populations in the plots seeded with the various crops were monitored throughout the 2007 and 2008 growing seasons. No significant differences in wireworm abundance due to the crop planted were detected. There was, however, an emerging trend towards high wireworm populations in the barley underseeded to clover plots and fewer wireworms in the flax and brown mustard plots.

The ability of these cover crops to reduce the extent of wireworm damage to a subsequent root crop was then examined. In 2009, the plots were sown with carrots to evaluate how the rotations affected wireworm damage to the carrot. Crop yield and the incidence and severity of damage were measured.

Trends toward lower levels of wireworms in the mustard plots in the 2007 and 2008 season held in 2009, with a significant reduction in wireworm damage to carrots planted after the brown mustard cover crops (Figure 1). This suggests that the glucosinolates present in the brown mustard plants may have an overall effect on the levels and/or feeding activity of wireworms that carried over into the next crop year. Unfortunately, this reduction in wireworm damage came at the expense of carrot yield.

Development of a Push-Pull-Immobilize Strategy:

This control strategy is based on pushing wireworms away from a cash crop using feeding deterrents, pulling wireworms from the cash crop using attractive bait crops, and immobilizing wireworms through the use of amendments that may kill the larvae.

Push Strategy: The push strategy aims to create a crop condition that is not attractive to wireworms. Plant-derived feeding deterrents, which may be applied as seed treatments or to growing plants, are currently being evaluated. Neem oil, marigold extract and brown mustard extract were evaluated in the lab for their ability to limit wireworm feeding in choice tests where the deterrent was applied or not applied to carrot. While the marigold and brown mustard extracts did not limit wireworm feeding, the application of neem oil to carrot baits significantly reduced wireworm feeding (Figure 2). These positive results led to further testing of neem oil in the field (see below).

Alternatively, less attractive varieties or cultivars of a given cash crop could be employed. However, an evaluation of four carrot varieties, including Chantenay, Scarlet Nantes, and Yaya, revealed no significant differences in the relative attractiveness of these varieties. At this time, variety selection may not be a useful tool for carrot producers aiming to reduce wireworm damage.

Pull Strategy*:* The pull strategy aims to reduce wireworm damage to a cash crop by introducing a more attractive bait crop to lure wireworms out of crop rows. Potential bait crops, including wheat, red-skinned potato, corn and dandelion were evaluated in the lab, with results suggesting that germinating wheat is more attractive to wireworms than carrot, and may thus serve as an effective trap crop (Figure 3). Red-skinned potato, dandelion, and corn did not prove to be sufficiently attractive to wireworms to merit use as trap crops in carrot production. These positive results for wheat led to further testing of wheat as a pull agent in the field (see below).

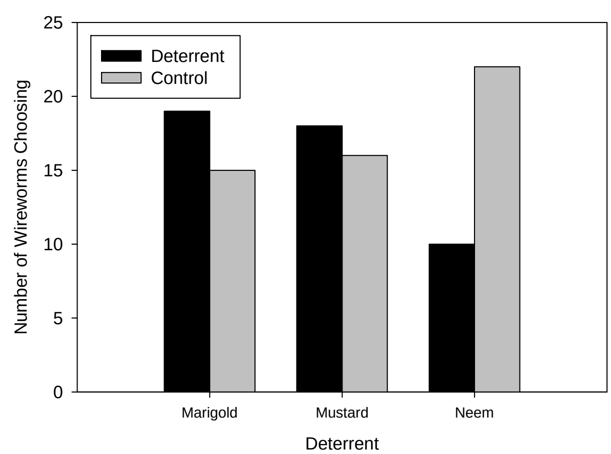

Figure 2. Number of wireworms choosing carrots treated with feeding deterrents.

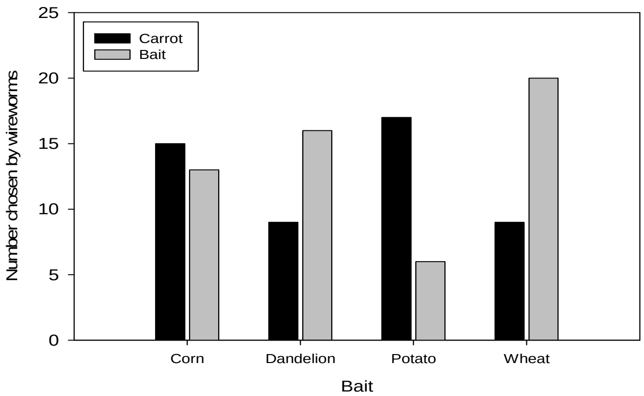

Figure 3. Number of wireworms choosing carrots or various baits in a laboratory trial of the 'pull' strategy.

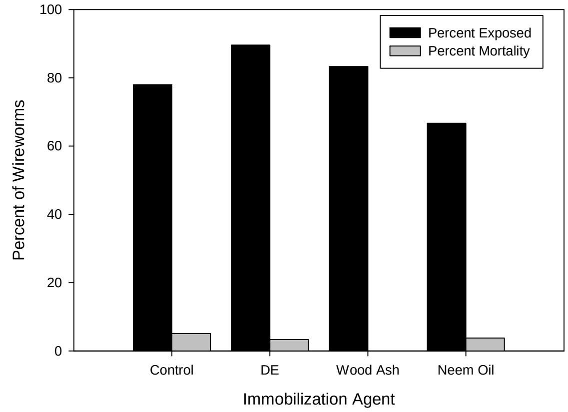

Figure 4. Percentage of wireworms passing through soil treated with immobilization agents to reach a food bait, and the percent mortality of the exposed wireworms.

Immobilize Strategy: The potential for organic soil amendments, such as diatomaceous earth, neem oil and wood ash, to immobilize or control wireworms was evaluated in laboratory conditions. Wireworms were placed at one end of an experimental chamber opposite a food bait, separated by soil treated with a potential immobilization agent. The wireworms' movement through the chamber, feeding activity and subsequent mortality were then examined. None of the immobilization agents tested interfered with wireworm movement toward the bait, nor was mortality over a two month period significantly increased by any of the amendments (Figure 4). It was, however, observed that wireworm feeding frequency was reduced in the presence of neem-amended soil.

Field Testing of the Push-Pull Immobilize Strategy: The effectiveness of the wheat pull strategy was tested in a field trial in 2008, while a field trial in 2009 explored the use of wheat as a pull agent and neem as a push agent. As there was no strong lab evidence in support of an immobilization agent, no field tests of this strategy were performed.

Wheat planted between carrot rows before harvest as an in-field test of the "pull" strategy (J. MacKenzie)

In 2008, wheat was densely seeded between carrot rows in August and September in an effort to lure the wireworms away from the maturing carrots until harvest. These timings were chosen in an effort to have strong wheat growth at the time of the return of wireworms to the warm and moist surface soils in the fall, when feeding results in quality reductions in root crops. While there were strong trends suggesting that wheat was effectively attracting wireworms and reducing feeding damage to the carrot cash crop, this reduction was not statistically significant (Figure 5a). Furthermore, this late season wheat planting did not compete strongly with the carrots and thus did not result in reduced carrot yield (Figure 5b).

In the 2009 trials, wheat was planted between carrot rows as a pull agent one month before carrot harvest, as in the "Late" planting in the 2008 trials. Neem oil was tested at concentrations of 5% and 10% in solution, lower than the full strength and 50% rates tested in laboratory trials. If effective, the lower rates could reduce costs for producers. In addition, a combined push-pull employing both wheat and neem oil together was examined.

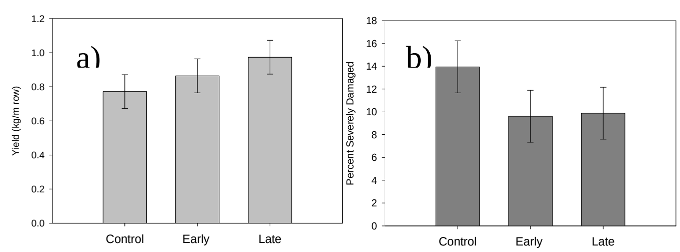

Figure 5. Carrot yield (a) and percent by weight with severe wireworm damage (b) when wheat was planted adjacent to carrots either in August (Early) or in September (Late).

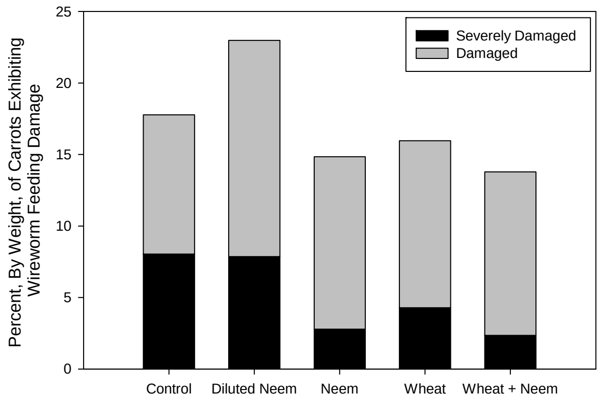

Figure 6. Effect of push and pull agents on the level of wireworm damage to harvested carrots.

Neither neem nor wheat on their own or in combination significantly reduced levels of wireworm damage to carrots, although trends suggest they may have some potential (Figure 6). The lower strength neem solution (5%) seems to have elevated wireworm damage significantly over the control, for reasons unknown (Figure 6). Despite variable levels of wireworm damage, there were no differences in overall or marketable carrot yield from the plots. Future research will concentrate on further testing and validation of the 'Pull' strategy using wheat and the 'Push' strategy using neem oil.

Click Beetle Crop Preference:

The crop preferences of adult click beetles were examined in 2007 at the Brookside research site. Plots were arranged as a Latin-square and seeded with barley, buckwheat, brown mustard or flax. Beetles of the three *Agriotes* species commonly found in NS were captured prior to the trial, sorted by species, and marked. The marked beetles were then released into the plots at points lending each crop an equal opportunity of visitation. Pitfall traps in each plot allowed the recapture of the marked beetles and provided insights into crop preference.

No consistent trends in crop preference of the adult click beetles were seen in the field trial. This may be attributed to changes in click beetle behaviour over time, climatic conditions, or changes in the habitat types offered by the various cover crops as they developed. Click beetles tended to migrate toward areas where ground cover was greatest.

Click beetles awaiting marking and release (J. Nelson)

The Bottom Line...

Wireworms are a damaging crop pest for which there are few organic management techniques currently available. Research is currently underway to evaluate the use of crop rotation and a push-pull-immobilize strategy for wireworm management. Initial results suggest that some control may be provided by using brown mustard in a crop rotation or through the use of a push-pull strategy.

Credits

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