Northeast Regional IPM Grants Program
Final Project Report

A. Grant Data

- Grant #: 58-1275-3-183
- Title: Integrating behavioral control with reduced area treatment approach for managing Colorado potato beetle and other insect pests of potato
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- State(s) involved: Maine and Maryland
- Years funded: 2003-06
- Funding amount: $140,000

B. Nontechnical Summary.

Insecticide applications are harmful to the environment, cost considerable amount of money to potato growers, and usually fail in the long run because pests evolve an ability to tolerate them. Normally, potato growers apply insecticides to their entire fields. However, this might not be necessary if we have a good understanding of pest biology and distribution within the crop. We investigated possibility of reducing treated areas by taking advantage of natural pest habit to spend winters outside of potato fields, and then move back in each spring. We also attempted to lure pests into treated areas of the field by making plants smelling more attractive to them. Perimeter spray that leaves a block of untreated rows in the middle of an imidacloprid-treated field proved to be an efficient approach to managing Colorado potato beetle populations even without enhanced smell. This would allow growers to cut insecticide use by at least 20%. Applying the formulation of attractively smelling chemicals resulted in substantially lower densities of all Colorado potato beetle life stages except egg masses compared to similar treatments without such chemicals (although not necessarily due to the smell itself). Unfortunately, the smell lasted only for a fairly short time after application.

C. Introduction.

With over 100,000 acres harvested anually, potato remains one of the most important crops in the Northeastern United States. It is attacked by a number of insect pests that can completely destroy the crop in the absence of appropriate control measures. Just as in most other crops, potato growers rely mostly on synthetic chemicals to alleviate insect problems. However, over-reliance on insecticides is a dangerous and unsustainable approach. Not surprisingly, there is a substantial public pressure towards reduction of insecticide use. This is especially true in the Northeastern region, where increasing urbanization has led to the development of a mosaic residential/agricultural landscape in formerly agricultural areas, thus commonly creating a conflict between the residential population and farmers over perceived dangers of insecticide use.

Despite much talk about its benefits, integrated pest management (IPM) is still far from being universally adopted by commercial potato growers. Currently, insect pest control in potato in the Northeastern region is largely based on using the chloronicotinyl insecticide imidacloprid. Reliance on a single group of closely related compounds is a dangerous case of "putting all eggs in one basket," with the fallacy of such an approach being repeatedly and expensively demonstrated throughout the history of pest control. In our situation, first cases of field Colorado potato beetle resistance to imidacloprid have already been reported, and there is no reason to believe that it will not spread throughout presently susceptible beetle populations. Although resistance development can be delayed by using appropriate management practices, diversification of a pest management "portfolio" is still an important task facing commercial potato growers. Simple replacement of imidacloprid by some other chemical (or even a non-chemical control method) will never provide a lasting solution to pest control in potato fields. It is essential that not only do we have a variety of techniques available for suppressing pest populations, but also that these techniques are unified in a single economically optimized approach.

Perimeter spray that leaves a block of untreated rows in the middle of an imidacloprid-treated field is an efficient approach to managing Colorado potato beetle populations. Colonization of potato crops by insect pests starts at field edges, and then progresses towards field center. Therefore, treated rows serve as barriers to the pests colonizing potato fields. As a bonus, untreated rows also serve as a refugium for insecticide-susceptible insects. Imidacloprid resistance in the Colorado potato beetle is incompletely recessive. Therefore, the progeny of resistant × susceptible crosses can be effectively killed by imidacloprid applied at the recommended rate. Manipulation of chemically mediated behaviors provides a potentially valuable tool for suppressing populations of pest insects that can be easily integrated with perimeter sprays. Several synthetic kairomone blends, based on the volatiles produced by potato plants, have been recently demonstrated to be attractive to both adult and larval stages of the Colorado potato beetle. We investigated if these kairomones could be used used for attracting beetles to insecticide-treated areas within reduced area treatment systems, thus increasing their exposure to toxins and reducing the amount of insecticides necessary for successful beetle control.

D. Objectives.

1. *Develop economically feasible "attracticide" blends combining Colorado potato beetle plant attractants with low-risk insecticides.* We successfully completed screening of a variety of insecticides in combination with kairomone blend. Combining kairomone with in-furrow neonicotinoids resulted in the lowest Colorado potato beetle densities. Spinosad-kairomone combination showed the best potential as a foliar application because of its low mammalian toxicity and high efficiency against the target pest. However, residual activity of kairomone in the currently available formulation turned out to be rather low, and its inert carrier compound needs further improvement.
2. *Determine possible effects of these attracticides on non-target arthropods, such as other potato pests and beneficial natural enemies.* We did not detect any effects of kairomone odor on non-target insects, while inert kairomone carrier elicited strong avoidance response in potato aphids.

3. *Evaluate efficiency and economic feasibility of reduced area treatment approach combined with attracticide blends.* Reduced area treatment approach (perimeter spray) was demonstrated to be an efficient and economically feasible way to control insect pests of potato. Kairomone blend may further improve its performance, but a better inert carrier is needed to deliver it in the field.

E. Approach.

First, we conducted a series of small-plots experiments following standard insecticide testing methods. We screened different commercially available insecticides in combination with newly synthesized Colorado potato beetle kairomone in order to develop attracticide blend to be used in potato fields. Kairomone formulation was applied twice during the season: first, during the peak colonization by overwintered beetles, second, during the peak emergence of summer-generation adults. Foliar insecticides were applied when insect populations reached economic threshold densities. After that, we conducted a series of experiments to (1) determine if attracticide applications should be targeted against overwintering adults or against small larvae; (2) to determine the best attracticide application mode (large droplets as opposed to fine mist); and (3) to determine possible effect of inert kairomone carrier on insect populations. Residual activity of kairomone applied by both methods was tested by collecting volatiles from field-treated plants and analyzing their content. We also conducted laboratory toxicity assays to follow-up on our field experiments.

For each treatment, five 17.7 m long and 4 row wide experimental plots were planted to certified seed potatoes. Plots were arranged in a randomized complete block design. The number of Colorado potato beetles in all life stages, the number of potato-colonizing aphids, and defoliation index were determined weekly at each plot. European corn borer infestation was evaluated by counting number of entrance holes and diapausing larvae at the end of the season. During the harvest, tubers along a 3 m long strip at each of the two middle rows were excavated and weighed. We also measured the level of virus infection in potato tubers harvested at kairomone-treated and untreated plots using ELISA.

Once small-plot testing was completed, we conducted larger-scale experiments on one-acre rectangular plots. We tested effects of incorporating kairomone applications into perimeter spray technology. Sampling was conducted along transects parallel to the longer side of each plot and going across the entire plot. Four transects was set up at each plot. Transect location was selected at random each week. The number of Colorado potato beetles in all life stages, aphids, European corn borer egg masses, and natural enemies on each selected plant will be recorded.

F. Progress.

We have successfully completed three field seasons collecting data to address all three of the original project objectives. One manuscript has been accepted by the Journal of Economic Entomology, one manuscript has been accepted by the Journal of Insect Behavior, and one more is currently in preparation. Three presentations were delivered at professional meetings. We also used some of the data generated as a result of this project to prepare six extension presentations and publish one extension article.

G. Results.

Applying the kairomone formulation resulted in substantially lower densities of all Colorado potato beetle life stages except egg masses compared to similar treatments without the kairomone formulation. There was a significant interaction between time and kairomone, with the differences starting to manifest themselves one to two weeks after the first kairomone application. Similarly, lower defoliation recorded for kairomone-treated plots starting one to two weeks after the first kairomone application.

Both small larvae and adults were affected. However, inert carrier also appeared to have a negative effect on beetle populations by itself. Defoliation indices generally trailed beetle densities, but the differences, for most part, were not statistically significant. Drop applications had a much longer residual activity and a more pronounced effect on both beetle densities and defoliation indices than spray applications. Attracticide (spinosad plus kairomone formulation) performance was comparable with that of commercial spinosad formulation, but much inferior to that of in-furrow imidacloprid.

We did not detect any difference among the treatments in aphid or European corn borer populations. The level of virus infection in tubers was also not affected by kairomone applications. Potato aphids did not respond to the kairomone odor in a Y-shaped olfactometer. However, they avoided potato leaflets containing droplets of either kairomone formulation or inert carrier in a Petri dish behavioral assay.

Perimeter spray provided an excellent protection of the potato crop. Pest densities on perimeter-treated plots were 6-11 times lower than on the untreated control plots, but comparable to those on completely treated plots. Kairomone formulation did not enhance efficiency of the treated perimeter. However, beetle pressure on our plots was relatively low, so that perimeter sprays provided almost complete control even in the absence of the kairomone odor. Effects of applying kairomone formulations are likely to be more pronounced when beetle densities are higher.

H. Impacts.

Reduced area treatment approach will significantly (at least by 20%) reduce the amount of insecticides applied to potato crops while reducing the probability of insecticide resistance development in Colorado potato beetle populations. Implementation of this technology is very simple and does not require any special skills or major modifications in the existing crop management practices. All that is required is to place flags in certain areas of the field and to shut down the sprayer each time the tractor enters the flagged area. Therefore, we expect it to be readily accepted by commercial growers. The lead investigator has been recently awarded an EPA Pesticide Environmental Stewardship Grant to promote, among other things, the use of this technology.

I. Appendices.

A. Page proofs of the manuscript accepted by the Journal of Economic Entomology.
B. A presentation made during the Annual ESA meeting in Fort Lauderdale, Florida.