FINAL PROJECT REPORT

Project Title: Sprayable foam for trapping and killing codling moth larvae

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Cooperators: Lerry Lacey, Gary Judd

Other funding Sources - None

Total Project Funding: $62,300

Budget History:

Item	**Year 1:**	**Year 2:**	**Year 3:**
Salaries	$21,000	0	$21,700
Benefits	6,400	0	6,600
Wages	0	0	0
Benefits	0	0	0
Equipment	0	0	0
Supplies	3,000	0	3,000
Travel	600	0	600
Miscellaneous	0	0	0
Total	$31,000	0	$31,000

ORIGINAL OBJECTIVES:

1. Develop, test, and select a biodegradable replacement, to be applied as a liquid or semi-solid to a tree trunk.

2. Evaluate pesticides and pathogenic nematodes in a candidate foam material to determine both larval recruitment, mortality and duration of effectiveness.

3. Compare cardboard banding and a biodegradable foam in apple orchards for efficacy and cost assessments.

RESULTS & DISCUSSION

SIGNIFICANT FINDINGS:

1. Initially, comparisons of polyurethane foam and cardboard banding showed a superiority of the foam in recruiting greater numbers of larvae that are seeking spin up sites.

However, it was considered that the polyurethane foam would be too expensive, and also is fairly indestructible and would require physical removal from trees and subsequent disposal. An inexpensive and biodegradable alternative was sought.

2. Laboratory evaluations of many alternative materials and formulations showed a clear connection between foam cell (bubble) size and efficacy in recruiting larvae to spin up, and superiority (low cost, ease of use) of several starch based materials over other base materials.

Base materials evaluated included aerated concrete, wheat starch, rice kernel waste material, sawdust and finely ground wood flour. Several adjuvants were included to enhance stickiness and topromote foaming action.

3. An industrial foam (texture sprayer) was modified and used for both mixing experimental materials and application to tree trunks in an orchard.

Field evaluations showed the need to reduce partical size to facilitate the use of the sprayer, the addition of a surfactant, and the need for some water repellency.

4. A set of candidate materials and a specific formulation were selected based on very low cost, biodegradability, and ease of field use.

This formulation was then further evaluated in laboratory assays using artificial trees, in the field on apple trees, and to assess the effectiveness of killing agents. The final material used for further study is a blended combination of 45 parts wood flour, 15 parts hardwood fiber, 28 parts amioca starch, 5 parts Celvol A 125, and 7 parts foamcell A-100, in water.

5. Addition of Permethrin over a range of dosages resulted in the death of larvae contacting the foam, rather than recruitment into the foam. Laboratory assays indicated a high rate of control of wandering larvae.

This suggests a different but effective strategy of using a durable lasting killing strip of material on the trunks of trees, rather than a “trap” such as the banding or foam. A precedent is in use to control climbing cutworms on grape vines.

6. Applications of entomophagous nematodes with foam were developed and tested by Lerry Lacey, with very good results against recruited codling moth larvae as a % kill.

7. The optimized biodegradable foam material yet does not hold up to direct hits from under-tree sprinkler systems.

Additional work is suggested in the following areas.

1. The addition of materials to provide water repellency to the foam may protect the material somewhat from direct hits by sprinklers, which tend to erode the band of foam from the tree.
2. Gary Judd has expressed interest in evaluating the material with the addition of the codling moth larval aggregation pheromone, to determine if recruitment into the foam can be enhanced by the presence of the pheromone. This might be done with microencapsulated pheromone mixed directly into the foam before it is applied.
3. Slower acting pesticides might be evaluated as toxicants to kill larvae entering foam. The advantage of using a slow acting pesticide would in part be to permit direct field evaluation of the effect, as larvae entering foam and dying could be counted. As it stands, larvae that contact the foam and die are not readily found and counted.
4. The use of entomopathogenic nematodes within foam to kill codling moth larvae appears to be effective. Further evaluations are required to determine control effects on a larger scale and to determine the longevity and durability of the nematodes as effective biological control agents.
5. The idea of using the foam material as an agent to apply a pesticide strip on tree trunks, rather than as a trap for larvae, is intriguing. A similar technique was developed by Doug Walsh and is recommended for use on grapes to protect vines from climbing cutworms.

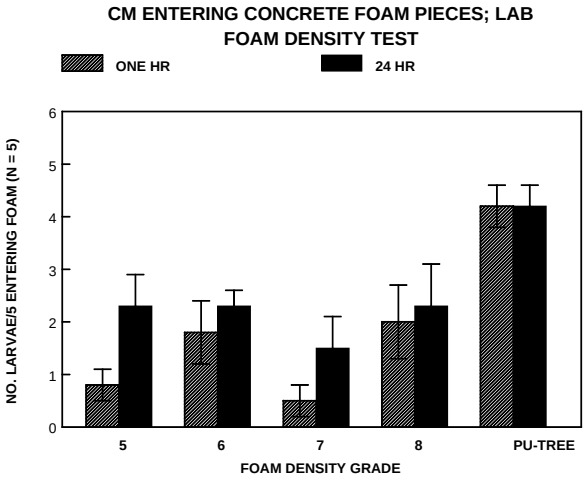
Best results in laboratory assays were with polyurethane foams, a fiber reinforced foam, a fiber roll, a straw/starch formulation, and cardboard. These results supported the hypotheses that efficacious materials facilitated codling moth entry by chewing through the material and by the presence and size of air pockets or cells. All materials that strongly recruited larvae were “chewable” and open in consistency.

Table 1. Percent of mature codling moth larvae entering piece of test material held in 16 oz plastic cup in laboratory. N = 10 to 20.

Material	% Larvae Entering Test Material	
	30 min	24 hours
Rice Straw/Starch Foam	20	100
Concrete Foam	0	60
Fiber Reinforced Concrete Foam		20
90		
Mearl 10 Cement Foam	0	20
Mearl 5 Cement Foam	0	0
Pressed Cork	0	25
Starch Fiber Foam	0	15
Pressed Board	0	10
Fiber Foam	20	70
Foam Freeze Starch	0	0
Polyethylene foam	0	50
Polyurethane Foam	10	90
Polystyrene Foam	10	65
Large Pore Starch Foam	90	90
Fiber Roll	100	100
Great Stuff®	50	100
Card Board	85	85

Comparisons of densities of ultra-light concrete did not show an improvement in efficacy with

decreasing density and all densities were inferior to cardboard banding. The lack of acceptance by some larvae may have been due to the toughness of the concrete, despite the presence of numerous small air pockets. It was surprising nonetheless to see codling moth larvae bore into soft forms of concrete and spin up cocoons within the concrete.



Assessments of formulations of milled wheat straw were efficacious in laboratory assays, and the series of alterations made in the formulation were intended to improve water repellency, stickiness and maintenance of depth, and ease of application to the tree trunk.

A milled wheat straw sprayable foam applied to apple tree trunks in autumn of 2007 was successfully applied through a texture applicator air gun, to a depth of about ½ inch. This material remained intact on the trees through December, but was readily knocked off at that time.

Plans and Time Line for 2008.
January to April. Additional foams will be laboratory-tested for acceptability to codling moth larvae, in Wapato. These assays will further evaluate the milled wheat straw mixtures, altered to provide greater foaming action after application to the tree.

May/June. One or more candidate materials will be evaluated in the field, using the commercial foamer applicator, to determine the acceptability of such applications to codling moth larvae when applied to tree trunks. These treatments will be directly compared to cardboard banding. Applications to apple tree trunks will be made in early June, and counts made of cocoons in early July.

May to August. Formulation alterations will be made in Albany to provide better foaming action and larger cell sizes within the material applied to trunks. A second generation milled wheat starch foam will then be tested in the laboratory in Wapato to determine if changes in the formulation impacted acceptability to larvae. In addition, preliminary attempts will be made in the laboratory to test a pesticide and nematodes in the foam formulation. These materials will be evaluated in the laboratory, using the arena bioassay, in comparison to foam without pesticide or nematodes. Data will be obtained on recruitment of larvae into the foam (to test the hypothesis of no repellency of the treatments) and on mortality and survival of larvae within the foam.

August /September. Field trials will evaluate the second generation foam, in comparison to cardboard banding , to evaluate efficacy in recruiting larvae in the field, but also to durability when exposed to irrigation sprinklers.

September 2007 into January 2008. It is anticipated that a series of laboratory assays will need to be done to evaluate and compare several pesticides at different dosages, and different dosages of nematodes, to select dosages that provide optimum results in anticipation for field testing in 2008. In addition, information obtained from the two field trials may indicate the need for additional fine tuning of the foam formulation to provide durability and rain fastness. Any changes to the formulation would necessitate additional laboratory testing before the next field season.

EXECUTIVE SUMMARY

The original vision of the project was to develop a material to mechanically apply to apple and pear tree trunks that might replace cardboard banding as a trap for codling moth larvae seeking spin up sites. This material needs to be biodegradable and incorporate a toxicant or biocontrol agent to eliminate the need for removal, as banding is presently removed and destroyed. Additionally, a formulation that can be mechanically applied might be suitable as a carrier for the larval aggregation pheromone under development by Simon Fraser University personnel. Replacement of cardboard banding by a sprayable, biodegradable foam with toxicant and pheromone incorporated might reduce costs of application and subsequent removal and destruction of banding. Specific objectives then were to:

1. Develop, test, and select a biodegradable replacement, to be applied as a liquid or semi-solid to a tree trunk.
2. Evaluate pesticides and pathogenic nematodes in a candidate foam material to determine both larval recruitment, mortality and duration of effectiveness.
3. Compare cardboard banding and a biodegradable foam in apple orchards for efficacy and cost assessments.

Objective 1 was largely accomplished with the evaluation in laboratory assays of a number of base materials and formulations. A formulation based on finely ground wood flour was then developed for testing with pesticide, with nematodes, in the laboratory and on apple trees. Several trials were conducted on apple trees to evaluate mechanical application and durability. Durability was considered to be suitable, but with problems encountered when irrigation sprinklers directly hit foam on trees.

Objective 2 was largely met. Pesticide (Permethrin) was evaluated as an adjuvant to the foam, as well as pathogenic nematodes. These evaluations were made both in the lab and in the field. Both were highly effective in killing codling moth larvae. However, in the laboratory assays it was clear that larvae were killed by contact with the foam, even at very low pesticide concentrations, and without the opportunity to tunnel into the foam. Hence, we were not able to evaluate larval recruitment into foam in the field test. Good results were obtained in the lab and in the field with nematodes because larvae were attacked by nematodes following entry into the foam.

Objective 3 was not well met. Direct comparisons of foam and cardboard were successful without pesticide, but did not provide meaningful results when Permethrin was used, presumably because larvae were toxified upon contact and without tunneling into foam. Counts of larvae in foam with pesticide were then very low.

The final results of the project provide both intriguing developments and constraints that yet need to be overcome for commercial application and availability. We do feel that this approach provides a cheap alternative to the current practice of banding trees, with considerable flexibility for added treatments to enhance efficacy. Cost savings would be with 1) the replacement of labor with a mechanical application, 2) no need to physically remove material from trees, 3) no need to destroy larvae in the material, and 4) possible reduction in most of materials. Treatment options that are possible include 1) use of pathogens such as entomopathogenic nematodes for an organic option, 2) use of a larval aggregation pheromone (not tested here), and 3) other pesticide treatments to kill larvae. Constraints or further improvements suggested include 1) additional water-proofing to resist erosion from direct contact by sprinklers, 2) possibly a slower acting pesticide to permit larvae to enter foam, and 3) stronger foaming action which may further promote larval entry. It is acknowledged that the use of this material with pesticide added and sprayed as a band onto tree trunks provides a possible different treatment as a potentially equally effective treatment. That is, it seems possible that a pesticide-treated foam sprayed in a band onto an apple trunk may kill all larvae moving along the trunk without requiring larval burrowing or entry into the material. It is our intention to investigate this possibility further.