

**Northeast Regional IPM Grants Program
Final Report, 21 December, 2006**

A. Grant Data

- Grant #: 2003-41530-01612
- Title: Refinement and Delivery of Bio-based Approaches to Reducing Insecticide Against Two Key Apple Pests.
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- Team members:
 - Arthur Tuttle, Research Associate, University of Massachusetts
 - Jaime Piñero, Post-doctoral Fellow, Institute of Plant Sciences - Applied Entomology, Zürich, Switzerland
 - Suzanne O'Connell, Research Assistant, University of Massachusetts
 - Heather Faubert, Research Assistant, University of Rhode Island
 - Lorraine Los, Fruit Crops IPM Coordinator, University of Connecticut
 - Arthur Agnello, Professor, Extension Tree Fruit Entomologist, Cornell University
 - Glen Koehler, Associate Scientist, University of Maine Cooperative Extension
 - Kathleen Leahy, Independent Consultant, Polaris Orchard Management (sites in NH and VT)
 - Glenn Morin, Independent Consultant, New England Fruit Consultants (sites in NH and VT)
 - Starker Wright, President, IPM Innovation, Inc.
- State(s) involved: MA, CT, RI, NY, NH, VT, ME
- Years funded: 2003-2005
- Funding amount: total of \$150,000.00

B. Nontechnical Summary.

Apple maggot flies and plum curculio beetles are key pests of apples whose control in northeastern USA by current pesticides is threatened under the Food Quality Protection Act (FQPA). Our intent was to optimize a pesticide-treated sphere approach for managing apple maggot and a trap tree approach for managing plum curculio. These methods combine the biological tools of pheromones, host-plant attractants, visual attraction, scouting methods, and the reduced use of relatively safe insecticides. The ultimate goal was to demonstrate efficacy and economic viability of these methods over two years in blocks of apple trees throughout New England and New York.

C. Introduction.

Apples are grown in all Northeastern states. Annual production in the region (also includes NJ, DE, MD, PA, WV) is about 46 million bushels with a value exceeding 225 million dollars.

Apple maggot (AM) and plum curculio (PC) are 2 key insect pests in the region. Unsprayed trees typically have fruit with significant injury by both pests. Orchards using conventional spray programs target 6 out of their 7 annual insecticide sprays against these 2 pests (May-June for PC and July-August for AM). By far the most commonly used sprays are the broadspectrum organophosphates, phosmet and azinphosmethyl. These materials are high-risk for worker exposure, toxicity to non-targets and fruit residues. Azinphosmethyl has a new 14 day re-entry interval and will be restricted further under FQPA. For these reasons and for concerns over pesticide drift beyond orchard boundaries, growers are asking for reduced-pesticide programs and biologically-based alternatives to pesticides. This study represents the culmination of over 20 years of research by Ronald Prokopy and his associated to develop advanced IPM reduced-risk approaches to manage AM and PC. 2005 was the 2nd year of the 2 year demonstration phase of the study in which the odor-baited trap tree approach for monitoring and managing PC damage and odor-baited sphere for directly controlling AM was tested in more than 20 blocks of apple trees in the Northeast.

D. Objectives.

For **plum curculio**, validation and demonstration in 25 commercial orchards of the effectiveness of an optimal trap tree approach to determine need and timing of insecticide use against PC in comparison with existing approaches based on calendar-driven sprays or heat-unit-accumulation models. *The trap tree approach proved effective in the vast majority of the sites over 2 years. In those few cases where fruit injury was above 1 or 2 %, the cause could be attributed to missing an insecticide spray, to having intense PC pressure coming from within the orchard block, or to a planting arrangement of very small apple trees. In both years there was a significant reduction in pesticide use in the advanced IPM treatment. As a result of the reduction in funding (the project was funded at 77% of the original request), the number of sites was reduced to 24 in 2004 and to 21 in 2005.*

For **apple maggot**, validation and demonstration in 25 commercial orchards of the effectiveness of an orchard-architecture-based ranking system for deploying odor-baited pesticide-treated spheres for direct control of AM in comparison with existing approaches to AM control based on calendar-driven sprays or monitoring-trap-capture-driven sprays. *The pesticide-treated sphere approach proved very effective in all but 3 of the 24 sites in 2004 and in all of the 21 sites in 2005. The 3 instances of inadequate control were due to overwintering populations within the orchard block. This would not have occurred if the orchard blocks had been under IPM management in 2003. Pesticide reduction was significant.*

For **apple maggot** and **plum curculio**, delivery of information to all apple growers in these states on advantages of these approaches compared with existing approaches to management. *This objective is being achieved in a bottom-up fashion: direct communication with cooperating growers, influence on neighbors and friends of growers, presentations at twilight meetings and other seasonal gatherings, presentations at state-wide and regional grower meetings, presentations at national and international scientific meetings, and publications in grower and scientific journals.*

E. Approach.

In 2005 we worked in 21 commercial blocks of apple trees adjacent to woods. There were 11 in MA, 2 each in NH, VT, NY, and RI, and 1 each in CT and ME. Each orchard block was divided into 3 plots of about 1 acre each. For **plum curculio**, Plot A (calendar sprays) received 3 whole-plot applications of insecticide (at petal fall + 2 covers). Plot B (heat-unit-accumulation) received a whole-plot spray at petal fall, followed by a whole-plot cover spray which was dependent upon a degree-day model (developed by H. Reissig at Cornell University), in which the last spray has residual activity until 308 degree days (base 50°F) have accumulated since petal fall. In Plot C, a perimeter-row trap tree was baited with 1 dispenser of grandisoic acid (pheromone) plus 4 dispersers of benzaldehyde (host-plant attractant) at the time of petal fall, and a whole-plot spray was applied to kill any PC that had overwintered in the plot or had immigrated early from the woods. A week later, 25 fruit were tagged and numbered and for 6 weeks fruit were examined every 3.5 days for fresh PC egg-laying scars. While immigrating from woods into the orchard, PC were lured into the trap tree and arrested there and in neighboring trees. One new scar indicated the need for a perimeter spray (outer 2 rows). The combined bait resulted in 20 times more damage by PC to fruit on a trap tree than on un-baited trees, thereby greatly reducing the time needed to sample for this key pest. The effectiveness of the trap tree approach was compared with the 2 other approaches. Efficacy of each method was assessed by sampling 10 fruit at random from each of 10 trees in each of 9 rows in each plot. Assessments were made both during early July and also 1 week before harvest.

For **apple maggot** (AM), an improved pesticide treated sphere and a new method for calculating how many spheres to place on the perimeter of a block of trees were successfully tested. The placement method used an index developed from 4 variables: size of orchard trees, quality of pruning, susceptibility of cultivar composition and nature of bordering habitat. In 2003, this approach reduced the number of spheres needed by 40 % from previous methods. The same plots described above for PC were used for AM. All plots received 4 un-baited sticky spheres to estimate penetration of AM adults into the block. These spheres were inspected weekly. Management of AM in Plot A consisted of 3 calendar-driven applications of insecticide to entire plot (mid-July, early-August, mid-August). Insecticide application in plot B (basic IPM) to entire plot was driven by accumulation of AM on the 4 un-baited sticky red monitoring traps (threshold: 8 AM/4 traps). For direct trap-out control of AM in Plot C (advanced-level IPM plot) odor-baited pesticide-treated spheres were deployed on perimeter trees of all 4 sides. The new Pesticide-Treated Sphere (PTS) was composed of a contoured compressed top cap bearing sugar (as feeding stimulant), spinosad (Entrust), and paraffin wax coupled to a hollow plastic sphere. Using the new placement system, an average of 22 PTS, each baited with attractive odor (a 5-component blend), were deployed per plot. There were no insecticide sprays in plot C after the plum curculio season was over (early July). At harvest, 900 fruit per plot were sampled for AM injury.

F. and G. Progress and Results.

In 2004, **plum curculio** injury was not significantly higher in trap tree plots (Plot C) compared to the other 2 management tactics (0.8-1.5 % injury). A 35% reduction in insecticide use was achieved in Plot C for PC compared to Plot A (calendar sprays). In 2005, the average % fruit injured was below 1% for all 3 types of plots in the early July count and in the harvest count. In

2005, we converted the spray events to dosage equivalents (DE) (dividing the actual rate used by the manufacturer's recommended field rate) (MRFR) to adjust for the wide range of field rates in the real world. Among the sites analyzed, the average PC insecticide dosage equivalents for Plot A (calendar spray) were 3.2 DE per orchard site), 2.9 DE per site for Plot B (heat-unit-accumulation), and 2.2 DE per site for Plot C (trap tree approach). The amount of pesticide was reduced 9.4 % from Plot A to Plot B sites and 31 % from Plot A to Plot C sites. The 31 % pesticide reduction provided by the trap tree approach is quite significant and would hopefully offset the cost of performing this advanced-IPM strategy.

In 2004, **apple maggot** injury was low in all 3 types of plots (0.2 to 0.9 % fruit injured). The injury in Plot C was higher (0.9 %) than in Plot A (0.23), but being below 1 %, this was not a concern. In 2005, the maggot injury was even lower (0.09-0.23 % fruit injured) and again Plot C had "more" injury than Plot A, but the level was economically insignificant. Among the sites analyzed for insecticidal inputs, the average dosage equivalents were: 1.5 for Plot A (calendar sprays), 0.8 per site for Plot B (sprays based on interior sticky trap captures), and 0.1 for Plot C (pesticide-treated spheres). The amount of pesticide was reduced 47 % from Plot A to Plot B and 93 % from Plot A to Plot C. The combination of a very effective pesticide-treated sphere (treated with the safe material, spinosad) and a 93% reduction in pesticide use should place this method in a very favorable light for future use.

H. Impacts.

The trap tree approach for managing plum curculio and the pesticide-treated sphere (PTS) approach for managing apple maggot are both new IPM practices that have been developed by this project and the work which preceded it. These practices could be implemented on 14,900 acres in New England and at least twice as many acres in New York other apple growing regions where these pests are a problem. The trap tree approach resulted in a 30 % reduction in insecticide use for plum curculio. The technique is best used in concert with insecticides that are low risk for worker exposure, as frequent field scouting is involved. The PTS approach for apple maggot uses a tiny amount of spinosad, an insecticide which is low risk with respect to all criteria. There is a 90-100 % reduction in insecticide sprayed on the fruit and leaves as compared with conventional approaches, which greatly lowers the risk for natural enemies, worker exposure, air & water resources, and fruit residues.

The trap tree and the PTS approaches have the benefit of lowering the pesticide costs of the grower dramatically. They may also help qualify the grower for certification programs like EcoApple or Europgap which aim for good prices for fruit grown according to sustainable practices. These benefits are offset somewhat by costs of the pheromones, plant attractants, spheres, and the labor involved in set-up and field scouting. Revenues from implementing these techniques could help support an independent consultant or scout in each New England state and a few in New York, New Jersey, and Pennsylvania. The 25 growers involved in the study are satisfied with the efficacy of the techniques and are excited by the benefits to environmental stewardship.

This study has validated 2 IPM systems (trap tree approach for plum curculio and PTS approach for apple maggot). Within the trap tree approach, 6 strategies were validated: use of PC

pheromone and host plant attractant within the trap tree, twice weekly monitoring of fresh PC scars, action threshold, timing of perimeter sprays, and use of low risk spray. Within the PTS approach, 5 strategies were validated: the attractiveness of the spheres, the attractiveness of the 5-component blend of host plant attractants, the placement of spheres in canopies, the density of spheres per acre, and the efficacy of the spinosad. The project was presented to many groups of growers and research scientists (see Presentations). Approximately 400 of these attendees received summaries and updates of the experiments. Twenty-five growers worked closely with the project scientists over 2 growing seasons. Another 50 personnel were then trained by those primary collaborators. We believe that approximately 20 growers in each New England state and more in New York, New Jersey, and Pennsylvania will adopt practices validated by this project. The PTS approach is less labor-intensive than the trap tree approach and is closer to commercialization. A new product, the CurveBall, being developed for apple maggot control by IPM Innovations, Inc., is the direct descendent of the PTS used in this project. If CurveBalls make it to market, the number of adopters may be far greater than the numbers predicted here.

I. Appendices.

Outreach.

Presentations (a partial list).

Arthur Agnello. November 11, 2004. Refinement of bio-based approaches to reducing insecticide use against plum curculio and apple maggot. Great Lakes Fruit Workers Meeting, Guelph, Ontario, Canada, November. 70 attended, and December 2, 2004. Cumberland Shenandoah Fruit Workers Conference, Winchester, VA. 50 attended.

Arthur Agnello, December 15, 2004. Moderator, Panel Discussion: Importance of Integrated Pest Management (Dedicated to Ron Prokopy). Grower Panelists: Chuck Souther, Ezekiel Goodband, David Kollas, and William Broderick. New England Fruit Meeting, Manchester, NH. 175 attended.

Arthur Agnello. December 15, 2004. Orchard monitoring and sampling as a basis for decision making in control of apple maggot and plum curculio. New England Fruit Meeting, Manchester, NH. 125 attended.

Arthur Agnello. February 15, 2005. Bio-based management of plum curculio and apple maggot. Empire State Fruit & Vegetable Expo, Syracuse, NY. 100 attended.

Arthur Agnello. March 21, 2005. Refinement of bio-based approaches to reducing insecticide use against plum curculio and apple maggot. Entomological Society of America Eastern Branch Meeting, Harrisburg, PA. 25 attended.

Arthur Agnello. September 4, 2006. Field assessment of behaviorally-based management tactics for *Conotrachelus nenuphar* (Herbst) and *Rhagoletis pomonella* (Walsh) in the northeastern US. IOBC Workshop on Arthropod Pest Problems in Pome Fruit Production, Lleida, Spain. September. 50 attended.

Daniel Cooley and William Coli. December 17, 2005. The New England Tree Fruit IPM Story. Entomological Society of America national Meeting, Ft. Lauderdale, FL. Symposium talk: 200 attended.

Glen W. Koehler. July 18, 2006. Plum curculio and Apple maggot Low Input Management Project Update. Maine State Pomological Society Annual Meeting and Field Tour. Monmouth, ME. 75 attended.

Glen W. Koehler. March 28, 2006. Apple Pest Management Basics. Maine Vegetable & Fruit School. Waterville, ME. 65 attended.

Glen W. Koehler. January 12, 2006. Apple Pest Management Updates. Maine Agricultural Trade Show. Augusta, ME. 110 attended.

Glen W. Koehler. July 28, 2004. New tools for plum curculio and apple maggot management. Maine State Pomological Society Annual Meeting and Field Tour. Monmouth, ME. 75 attended.

Tracy Leskey. January 17, 2007. Bomb Trap Trees as a Plum Curculio Management Tool. Massachusetts Fruit Growers Association Winter Meeting. Belchertown, MA. 120 attendees anticipated.

Lorraine Los. December 7, 2004. A comparison of three management systems for plum curculio and apple maggot. Annual Meeting of the Connecticut Pomological Society. Glastonbury, CT. 110 growers attended.

Lorraine Los. June 14, 2005. Annual meeting of the Quinebaug Valley Fruitgrowers Association. Woodstock Orchards, Woodstock, CT. The NE IPM PC/AM experiment was part of the farm tour. Demonstration/talk. 35 growers attended.

Lorraine Los. August 19, 2005. Farm tour for the UConn College of Agriculture and Natural Resources Executive Council. Woodstock Orchards, Woodstock, Ct. The NE IPM PC/AM experiment presented and discussed. Approx. 15 administrators attended.

Lorraine Los. December 6, 2005. A comparison of three management systems for plum curculio and apple maggot- 2 year results. Annual Meeting of the Connecticut Pomological Society. Glastonbury, CT. 90 growers attended.

Jaime Piñero. December 17, 2005. Semiochemically-based monitoring of plum curculio immigration and egg laying in the Northeast. Entomological Society of America National Meeting. Ft. Lauderdale, FL. Symposium talk: 200 attended.

Arthur Tuttle. October 26, 2005. Bio-based trap tree approach for managing plum curculio in orchards: 2004-2005 results. and Bio-based approach to managing apple maggot in orchards: 2004-2005 results. Annual New England, New York, and Canadian Fruit Pest Management Workshop. Burlington, VT. 45 attended.

Arthur Tuttle. July 18, 2005. Advanced IPM approaches to managing plum curculio and apple

maggot: Ron Prokopy's legacy. Massachusetts Fruit Grower's Association Summer Meeting. Bolton, MA. Demonstration/talk: 90 attended.

Starker Wright. December 17, 2005. Commercial application of behavioral control for apple maggot fly. Entomological Society of America National Meeting. Ft. Lauderdale, FL. Symposium talk: 200 attended.

Starker Wright. January 17, 2007. Recent Developments in 'Curve Ball' Apple Maggot Fly Management. Massachusetts Fruit Growers Assoc. Winter Meeting. Belchertown, MA. 120 attendees anticipated.

Publications (a partial list).

Piñero, J.C., and Prokopy, R.J. 2005. Spatial and temporal within-canopy distribution of egg-laying by plum curculio (Coleoptera: Curculionidae) on apples in relation to tree size. *J. Entomol. Sci.* 40(1): 1-9.

Prokopy, R.J., Jácome, I., and Bigurra, E. 2005. An index for assigning distances between odor-baited spheres on perimeter trees of orchards for control of apple maggot flies. *Entomol. Exp. et Appl.* 115(3): 371-377.

Prokopy, R.J., Jácome, I., Bigurra, E., and Blanco, M. 2004. Evaluation of pesticide-treated spheres for control of apple maggot flies in 2003. *Fruit Notes.* 69(2): 21-25.

Prokopy, R.J., Jácome, I., Gray, E., Trujillo, G., Ricci, M., and Piñero, J.C. 2004. Using odor-baited trap trees as sentinels to monitor plum curculio (Coleoptera: Curculionidae) in apple orchards. *J. Econ. Entomol.* 97: 511-517.

Prokopy, R.J., Chandler, B.W., Dynok, S.A., and Piñero, J.C. 2003. Odor-baited trap trees: a new approach to monitoring plum curculio (Coleoptera: Curculionidae). *J. Econ. Entomol.* 96: 826-834.