Project Director(s) (PD):

PD William M. Coli Institution University of Massachusetts, Amherst

CO-PD John, M. Clark Institution University of Massachusetts, Amherst

Project Title: Measurement of worker/scout exposure to pesticides in “standard” and “reduced risk” IPM systems for New England Apples

Key Words: **Pesticide Risk, Risk Reduction, IPM, Worker Exposure, Apple pest management**

Many commonly used crop protection chemicals, including highly toxic, broad-spectrum, long residual, organophosphate and carbamate insecticides, certain fungicides that are possible human carcinogens, and other pesticides with estrogenic effects, are now thought to represent a significant risk to human health, to beneficial natural enemies and other non-target organisms and to the environment. The passage Food Quality Protection Act (FQPA), raised the prospect that future pest management systems may be far less reliant on these relatively inexpensive, but often riskier materials. To help growers prepare for such an possible outcome, it is critical for the public sector to develop, test and analyze innovative, economically viable pest management programs that use lower risk pesticides in the context of an IPM strategy. Only when such systems are fully characterized and demonstrated to be both affordable and effective, can we anticipate that growers will willingly adopt them.

The proposed project would be in keeping with USDA’s and EPA’s current emphasis on risk measurement and reduction, as described in the USDA “IPM Roadmap”. The project is consistent both with an IPM Working Group (IWG) Priorities grant and with a Critical/Emerging Issues grant.

The team will work collaboratively with private sector partners to describe the current standard integrated management (SIPM) system for New England apples using Crop Profiles and input from growers, along with a reduced risk IPM (RRIPM) system. The SIPM protocol will involve choice of material, rates and frequency of application by cooperating growers based solely on efficacy and cost. RRIPM protocols will involve deliberate choice of materials that either are considered “low risk” by EPA, or are determined to be so using as a model the Benbrook et al. multi-attribute toxicity rating.

Potential dermal and inhalation exposure to various organophosphate, pyrethroid and carbamate pesticides on the part of researchers conducting typical worker and/or IPM scout activities will be determined utilizing dosimetry (i.e., residues on cotton suits, gloves and air samplers). The experimental design will provide a variety of exposure situations in which we can determine “risk". The dosimetry group will wear cotton long-sleeved shirt, long pants, neck hoods, and gloves as passive collectors for dislodgeable pesticide residues. Inhalation exposure will be measured using personal air sampling pumps with pesticides absorbed onto various sorbents, depending on the pesticide. Sample analyses will be conducted at the Massachusetts Pesticide Analysis Laboratory (MPAL), a USEPA/MA Department of Food and Agriculture (MADFA)-supported FIFRA pesticide analytical laboratory.

Literature Review

Many commonly used crop protection chemicals are now thought to represent a significant risk to human health, to beneficial natural enemies and other non-target organisms and to the environment. These include highly toxic, broad-spectrum, long residual, organophosphate and carbamate insecticides, certain fungicides that are possible human carcinogens, and other pesticides thought to have estrogenic effects.

Fenske,(2003) showed that children who live in close proximity to farms using pesticides, have higher exposures than those who live away from farms, and that dust in homes near farms was found to be contaminated with agricultural pesticides. Fenske (2003) also found that 44 pre-school children living in the tree fruit growing regions of Washington state showed increased levels of pesticide metabolites in urine during periods of spraying. Morris and others (1993) found that the majority of the American public believes that it is very important for U.S. farmers to switch to low-chemical production strategies that rely primarily on natural methods. Morris and others (1993) found that the majority of the American public believes that it is very important for U.S. farmers to switch to low-chemical production strategies that rely primarily on natural methods.

The passage in 1996 of the federal Food Quality Protection Act (FQPA), has raised the prospect that future pest management systems will need to be far less reliant on older, relatively inexpensive, but often riskier materials. According to the USEPA, recent use cancellations, label changes, and time-limited registrations resulting from FQPA have reduced to acceptable levels consumer exposure risk from dietary residues. However, continued emphasis is being placed on farm worker exposure as indicated by increases in re-entry intervals (REIs) and pre-harvest intervals (PHIs).

Fortunately, concurrent with FQPA-based withdrawal or cancellation of registrations for numerous materials, and significant label changes for others, ongoing industry “R & D” plus “fast track” registration of new lower risk pesticidal chemistries, has resulted in availability of many new pesticides. Some of these represent novel chemistries (e.g., insect growth regulators, strobilurin fungicides, neonicotinoid insecticides, oxadiazine insecticides, etc.) that are effective at rates as low as ounces per acre.

While such materials have many positive aspects, they tend to be dramatically more expensive compared to many of the older materials. Many newer pesticides also fail to provide control of a wide range of pests, and raise concerns about resistance development. For these and other reasons, while growers have begun to incorporate new pesticides into their pest management programs, many continue to rely on the proven materials that have stood the test of time. Growers and pest management specialists participating in the Northeastern IPM Center fruit IPM Working Group understand the current dilemma, and have identified several priorities that will be addressed by the project, including:

- Education regarding use of limited-spectrum insecticides or alternative management strategies as replacements for broad-spectrum materials,
- Development and testing of softer materials and non-pesticide options,
- Replacement of groundwater-risky products, and
- Reduction and replacement of organophosphate pesticides.

In spite of these clear priorities, most farms operate on tight margins. Thus, few if any growers are likely to abandon the older crop protection materials unless re-registration decisions make them unavailable or other considerations (e.g., increasing REIs or PHIs) limit the practicality of their use. What then is to become of growers who have relatively little experience using the newer pesticides, or whose economic bottom line is dependent on materials that cost $8 per acre per application? Will there be sufficient information available for them to transition to organic agriculture or to IPM systems that are based entirely on lower risk materials, or will they simply "throw in the towel" and sell the farm to the highest bidder? In order to help prevent such an undesirable outcome, it is critical for the public sector to develop, test and demonstrate innovative, economically-viable pest management programs that use lower risk pesticides in the context of an IPM strategy. However, only when such systems are fully characterized and demonstrated to be both affordable and effective, can we anticipate that growers will willingly adopt them.

The proposed project is in keeping with USDA's emphasis on risk measurement and reduction, a central aspect to the USDA "IPM Roadmap". Documenting IPM system effect on pesticide-related risk is more important than ever given the recent critical GAO report on IPM. Unless USDA can show that IPM use is reducing risk, the potential exists for reductions in federal support for IPM research and extension activities. As such, the proposed work also addresses a "Critical or Emerging Issue.

In addition to reduced risk to human health and the environment of widespread adoption of RRIPMS, a second potential benefit would be the development or enhancement of market channels catering to health conscious consumers. Recent dramatic growth in the "organic" food sector indicates a huge untapped market for crops grown locally using systems that are protective of the environment, farm workers and consumer health. Experience gained from previous IPM certification efforts (e.g., Core Values Northeast, Wegmans Foods, Partners With Nature, Protected Harvest, Food Alliance Certified, etc.) indicates that consumers respond positively to the use of ecologically sensitive pest and crop management practices. Availability of effective reduced-risk IPM systems plus a well-organized marketing program is anticipated to provide financial incentives adequate to offset potentially higher costs of such systems.

In the six New England states, apples are grown on 21,432 acres (USDA, 1997). In the northeast US, acreage of this crop is even more substantial. As such, apples represent a substantial dollar value to the region's diversified farms. In spite of their proximity to markets, for many growers, profitability has not kept pace with improved yields and quality, and many farmers now operate on thin profit margins if they make any profit at all. In addition, well-publicized examples of environmental contamination from agrochemicals have caused many in the non-farming public to develop negative attitudes toward modern agriculture (Morris *et al*. 1993, Govindasamy and Italia 1998). Morris and others (1993) found that the majority of the American public believes that it is very important for U.S. farmers to switch to low-chemical production strategies that rely primarily on natural methods.

Surveys indicate that consumers have significant concerns about the chemicals used to grow food products, especially effects related to health of themselves and their children. Pesticide use on food crops was identified as the primary food safety concern of consumers in Georgia (Ott *et al.* 1991) and New Jersey (Govindasamy *et al.* 1998). Fifty-nine percent of New England (six northeastern United States) consumers feel that pesticide use is unsafe and unnecessary (Hollingsworth *et al.* 1993). Nearly all the consumers in a survey by Pool (1996) expressed concern over pesticide residues in food; consumers who purchase greater amounts of produce expressed a higher level of concern. Consumers' also express concerns for water quality, environmental degradation, farm worker safety and other secondary issues. (Cuperus *et al.* 1991).

Hartman (1996) explored the potential market for environmentally produced goods and found that over half of American consumers have an interest in such products. A survey conducted for the Massachusetts Department of Food and Agriculture (Pan Atlantic 1997) found 91% of consumers support the use of environmentally safe agricultural practices and would purchase products that identify this on the label. These consumers (89%) indicated that food products that claim to have improved environmental performance should be certified or labeled, and 70% reported that they read information on food products and want more detailed information. Programs that encourage and recognize grower use of environmental stewardship and lower risk pesticides can be shown to improve consumer confidence (Bruhn et al, 1992), enhance IPM Adoption (Hollingsworth et al. 1992, 1993; Hollingsworth and Coli, 2001; Petzoldt, 1999), and result in a significant reduction in the use of high risk pesticides (Lynch et al., 2001; Benbrook et al, 2002).

Objectives

The principal objectives of the project are:

1. To bring together a diverse group of apple producers and private IPM consultants to describe the standard IPM (SIPM) system now in use, and to design a reduced risk Integrated Pest Management (RRIPM) system applicable to the New England apple production region
2. To assess these systems using a published toxicity unit index and field testing for efficacy and effects on farm worker and applicator risk,
3. To conduct a comparative economic analysis of SIPM and RRIPM impacts on grower profitability, and work with a regional organization that is actively certifying and marketing "eco-grown" crops in order to investigate market potential and opportunities for increased profitability of crops grown using a Reduced Risk IPM System.

The project is consistent both with an IPM Working Group (IWG) Priorities grant and with a Critical/Emerging Issues grant.

Procedures

Objective 1. The team will work collaboratively to describe in detail the current norm for a pest and crop management system for apples using Crop Profiles and input from growers, along with a reduced risk IPM system (RRIPMS). Specific attention will be paid to pesticide risks to farm workers through exposure, and risk to farm productivity and profitability through increased costs or reduced yield or quality.

The RRIPM system will use only materials that are either classified as low or minimal risk by EPA, or determined to be so using as a measurement tool the Benbrook et al. Multi-Attribute Toxicity Factors model. The system will also incorporate practices (e.g., Prokopy "attract and kill" strategy for apple maggot fly, etc.) that would result in lower risks.

Objective 2. Prior to in-field demonstration and validation, system impacts of reduced risk systems will be modeled in the manner described by Benbrook et al. (2002), and Lynch et al. (2000).

Demonstration field trials of the SIPM and RRIPM systems will be carried out in paired (SIPM and RRIPM) blocks on 5 Massachusetts commercial fruit farms. During this implementation phase, the team will document the actual extent of risk present and/or reduced as staff conduct typical worker or IPM scout/crop consultant activities. Residue sampling will occur on 4-5 occasions during the early part of the season when spraying is usually most intense (for plum curculio, codling moth, and leafminers), and 4-5 occasions during the latter part of the season (for apple maggot flies, leafhoppers/leafminers and spider mites).

Potential dermal and inhalation exposure to various organophosphate, pyrethroid and carbamate pesticides will be determined utilizing dosimetry (i.e., residues on cotton suits, gloves and air samplers). The experimental design will provide a variety of exposure situations in which we can determine "risk". The dosimetry group will wear cotton long-sleeved shirt, long pants, neck hoods, and gloves as passive collectors for dislodgeable pesticide residues (Dow AgroScience 2000a and 2000b).

Inhalation exposure will be measured using personal air sampling pumps (Dow AgroScience 2000c) with pesticides absorbed onto a XAD-2, XAD-4, or PUF sorbent, depending on the pesticide (OSHA, 1986; Clark et al 1999, Egea et al 1997). Total air concentration will be estimated by summing the amount of pesticide collected divided by the amount of air sampled. To estimate the total amount of pesticide inhaled, the air concentration will be multiplied by an inhalation rate of 41 liters/min times the exposure interval. Whole body dosimeters and personal air samplers will be used to estimate the body dose due to dermal and inhalation exposure, respectively, using the protocols described by Nolan et al., (1996) and Byrne et al., (1998) and using published penetration factors available from the USEPA and other sources. All sample analyses will be conducted at the Massachusetts Pesticide Analysis Laboratory (MPAL), a USEPA/MA Department of Food and Agriculture (MADFA)-supported FIFRA pesticide analytical laboratory.

Objective 3. The team will complete an economic assessment of the proposed systems to understand their relative effect on grower productivity and profitability. Economic assessment will compare "Reduced Risk IPM" protocols to "Standard IPM" protocols to document the extent of financial risk to grower adopters. This aspect of the work is important since many of the newer pesticidal chemistries are more costly than older, broad spectrum, higher risk ones, and/or require tank mixes with other materials to deal with pests that formerly were controlled by the inexpensive broad spectrum material.

Another element of economic evaluation will involve determining whether crops grown with such protocols can gain a price premium (to offset potential higher costs) via certification and marketing by a third party group. In collaboration with Red Tomato, we will create a preliminary marketing plan for fruit crops grown under the reduced-risk systems. After developing, evaluating, and field-testing the RRIPM system, the team will develop and publish production standards similar to IPM Guidelines previously developed (Hollingsworth and Coli, 1999).

Results of the project will be described to regional apple growers through periodic newsletters and at Extension-sponsored field days at collaborating farms and through articles published in the regional Extension journal *Fruit Notes of New England*.

Given the similarity of the apple pest complex throughout New England (and into the Hudson River Valley), it is anticipated that the project dosimetry findings and RRIPMS standards developed will be readily applicable beyond the borders of Massachusetts. Thus the proposed work will serve as a model for similar projects regionally in apples, and may also be readily applied to crop production systems for other crops in the region and beyond.

Literature Cited

Benbrook, C.M., Sexon, D.L., Wyman, J.A., Stevenson, W.R., Lynch, S., Wallendal, J., Diereks, S., VanHaren, R., And Granadino, C.A. 2002. Amer. J. of Potato Res. 79: 183-199.

Bruhn, C., Peterson, S. Phillips, P. and Sakovidh, K. (1992) Consumer response to information on integrated pest management. *Journal of Food Safety* 12, 315-326.

Cuperus, G. W., Kendall, P., Rehe, S., Sachs, S., Frisbie, R., Hall, K., Bruhn, C., Deer, H., Woods, F., Branthaver, B., Weber, G., Poli, P., Buege, D., Linker, M., Andress, E., Wintersteen, W., Dost, F., Damicone, J., Herzfeld, D., Collins, J., Cartwright, B., and McNeal, C.D. (1991) Integration of food safety and water quality concepts throughout the food production, processing, and distribution educational programs: using Hazard Analysis Critical Control Point (HACCP) philosophies. *Okla. Coop. Ext. Serv. Circ. E-903*.

Fenske, R. 2003. Pesticides and Farming: Are children in harm’s way? AgConnections. NIOSH Ag. Research Update for Spring 2003. Vol1(2): 1.

Govindasamy, R. and Italia, J. (1998) Consumer concerns about pesticide residues. *New Jersey Agricultural Experiment Station Publication FS896*.

Govindasamy, R., Italia, J. and Rabin, J. (1998) Consumer response and perceptions to integrated pest management produce. *New Jersey Agricultural Experiment Station Publication P-02137-5-98*.

Hartman, H. (1996) *The Hartman Report Food and the Environment: A Consumer’s Perspective* Phase I. The Hartman Group, 10422 SE 14th St, Bellevue, WA 98004.

Hollingsworth, C.S., Coli, W.M. and Van Zee, V. (1992) Massachusetts grower attitudes toward a certification program for integrated pest management. *Fruit Notes* University of Massachusetts Extension 57(4): 7-11.

Hollingsworth, C.S., Paschall, M.J., Cohen, N.L, and Coli, W.M. (1993) Support in New England for certification and labeling of produce grown using integrated pest management. *American Journal of Alternative Agriculture* 8:78-84.

Hollingsworth, C.S. and Coli, W.M. 2001. IPM Adoption in Northeastern U.S.: An examination of the IPM continuum. American Journal of Alternative Agriculture. 16(4): 177-183.

Lynch, S., Sexon, D., Benbrook, C., Carter, M., Wyman, J., Nowak, P., Barzen, J., Diercks, S., and Wallendal, J. 2000. Accelerating Industry-wide Transition to Reduced-Risk Pest

Management Systems: A Case Study of the Wisconsin Potato Industry. http://ipcmwisc.edu/bioipm/reports/choicesfinal/pdf.

Morris, P.M., Rosenfield, A. and Bellinger, M. (1993) What Americans think about agrichemicals. A nationwide survey on health, the environment and public policy. Public Voice for Food and Health Policy. Washington, DC.

Ott, S.L., Huang, C.L. and Misra, S.K. (1991) Consumers' perceptions of risk from pesticide residue and demand for certification of residue-free produce. In J.A. Caswell (ed), *Economics of Food Safety*, Elsevier, New York. pp. 176-188.

Pan Atlantic Consultants (1997) Report to the Massachusetts Department of Food and Agriculture on consumer preferences and attitudes regarding Massachusetts grown agricultural products. Massachusetts Department of Food and Agriculture. Boston.

Petzoldt, C.P. 1999. Challenges for land grant university personnel resulting from participation in eco-labeling efforts. In Proceedings: Adding Value Through Environmental Marketing: Opportunities for Food Producers, Processors and Retailers. Institute for Agriculture and Trade Policy, Minneapolis, MN.

Pool, W.M. (1996) The influence of consumer attitudes and perceptions about pesticides and produce quality on technology transfer. M.S. thesis. Rochester Institute of Technology. 160 pp.

USDA. 1997. Census of Agriculture, United States, Summary and State Data. Vol.1, part 51, Tables 29, 31.

Probable Duration

All components of the project will be completed with 18 months from a presumed starting date on April 1, 2004

Evaluation Plans

The project will be considered to have succeeded if reduced risk systems show lower toxicity unit ratings, lower dislodgeable residues and reasonable cost compared to conventional IPM systems where pesticides are chosen based primarily on cost and efficacy.

Cooperation and Institutional Units Involved

A multi-disciplinary team (Entomology, Plant Pathology, Plant Science, Pesticide Toxicology, and Resource Economics) based at the University of Massachusetts, Amherst, will conduct the project. The UMass team will continue a previously established collaboration with 5 private sector growers, local IPM crop consultants (New England Fruit Consultants), representatives of Red Tomato, a Massachusetts-based produce marketing firm, and Dr. Charles Benbrook, a nationally recognized leader in the evaluation of pest management programs.

Key Personnel

Participant Name	Affiliation/Occupation	Role
William M. Coli, Ph.D.	UMass, Amherst IPM Program Coordinator Dept. of Entomology	Project P.I./Facilitator, Coli will provide overall coordination and facilitation for the project, participate in development of RRIPMS for apples, and submit interim and final reports.
J. Marshall Clark, Ph.D.	UMass, Amherst Director, Mass. Pesticide Analytical Lab. (MPAL) Dept. of Vet. and An. Sci.	Project Co-Investigator. Clark will oversee residue analysis and data summarization
Raymond Putnam	UMass, Amherst Chief Chemist, MPAL Dept. of Vet.and An. Sci.	Project Participant, Putnam will collaborate with residue data collection, and lead analysis and summarization
L. Joe Moffitt, Ph.D.	UMass, Amherst Professor, Dept. of Resource Economics	Project Economist, Moffitt will lead development of economic assessments of RRIPM and SIPM systems
Charles Benbrook, Ph.D.	Benbrook Consulting	Project Participant, Benbrook will lead development of toxicity indices for SIPM and RRIPM systems
Roberta Spitko, Ph.D.	Independent Crop Consultant, Adjunct Faculty, Plant and Soil Sci.	Project Participant, Spitko will participate in developing and field-testing RRIPM for apples, and in developing marketing plans.
Arthur Tuttle, M.S.	UMass, Amherst Dept. of Microbiology	Tuttle will lead development and field testing of SIPM and RRIPM systems, and participate in developing marketing plans
Daniel R. Cooley, Ph.D.	UMass, Amherst Associate Professor Dept. of Microbiology	Project Participant, Cooley will participate in developing RRIPMS for apples, and in developing marketing plans.
Lynne Colangione	Red Tomato Produce Marketing	Project Participant, Colangione will lead development of marketing plans
5 Massachusetts farmers	Various Massachusetts farms	Project Participants, Farmers will participate in developing RRIPM for all crops, field test SIPM and RRIPM systems, and participate in developing marketing plans

Collaborative Arrangements

Letters of intent from Dr. Clark and Dr. Benbrook are attached.