A perspective on the extension of research-based information to orchard management decision-makers: lessons learned and potential future directions

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Abstract

A central element of the Specialty Crop Research Initiative (SCRI) on ‘enhancing biological control in western orchards’ was to disseminate research-based information generated by the project for adoption and implementation by decision-makers. As the landscape of publicly supported extension and outreach has been changing, our goal was to employ effective and timely strategies that would provide a legacy of project information at relatively low costs. We used various approaches to develop a regional outreach program spanning three states, four institutions, and three crops. Guided by an advisory panel of stakeholders and scientists, our approaches included a simulcast short course, interactive workshops, online media, as well as presentations and print articles. Inevitably, we had to overcome certain challenges and here we share our perspective on the successes, constraints and lessons learned during development and implementation of the project’s outreach program. Finally, we consider future directions and strategies that will aid Cooperative Extension in continuing to meet the needs of western tree fruit and nut industries while optimizing available resources.

Keywords

biological control, outreach, technology adoption, agricultural practices, integrated pest management, tree fruit and nuts

1. Introduction

A major component of the Specialty Crop Research Initiative (SCRI) project “Enhancing biological control in western orchards” was to ensure that research-based knowledge generated by the project was readily available to decision makers in the western US nut and tree fruit industries. This project was conceived and funded during a period when management programs for direct pests, such as codling moth (*Cydia pomonella*), were transitioning from over 50 years of use of organophosphate insecticides (OPs) to “reduced risk” alternatives and mating disruption (MD). This transition coincided with a period characterized as having increased secondary pest outbreaks and created many new challenges for integrated pest management (IPM) programs (Jones et al., 2009, 2010a).

In an overview of the problem, Jones et al. (2009) suggested that there was a knowledge gap for both researchers and IPM practitioners concerning natural enemies and their function in these systems. The research goals of this project were thus focused on broadening our understanding of natural enemy phenology and biology in western orchards, as well as evaluating the effect of newer pesticide chemistries on a select group of natural enemies. The final objective was to synthesize and transfer both existing and new information, with the hope that decision makers would adopt more practices to conserve natural enemies and re-stabilize pest management programs. With over 625,000 acres of apple, pear and walnut planted in the western US and a combined production value of about \$5 billion (ERS USDA Fruit and Tree Nut Yearbook, November 2013, <http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1377>), there was strong justification to increase practices that enhance biological control in commercial orchards on a large scale.

2. Considerations for grant funded outreach

Cooperative Extension, as part of land grant institutions, typically serves as the link between researchers and stakeholders as information is transferred from one to the other. Historically it was assumed that outreach programs originating from research projects would be supported through the traditional Extension system, but today this expectation is seldom realized. SCRI grants are expected to

have a significant outreach portion to transfer information and technology. Yet, one major concern is the loss of information once the grant is completed and there are no longer funds to continue outreach programs. Continued education is necessary as adoption of new information and technology by stakeholders takes time. However, in many cases Cooperative Extension is not able to support and sustain these outreach programs due to reductions in state funding (Jones et al., 2009; Jones et al., 2015a, this issue). Finally, in a multi-state project the development and implementation of the outreach program needs to be cooperative across all participating states, which can be difficult to coordinate. It was important to consider these factors in order to create a robust outreach program for our project.

We also needed to understand how growers make decisions and their perspectives on implementing IPM and biological control. Surveys for pear and walnut growers were devised by a team that included a rural sociologist, researchers, extension personnel, and industry IPM consultants who served on the project's advisory board (Goldberger, 2010, 2011; Goldberger et al., 2015, this issue). Since Washington's apple industry was surveyed extensively during the Pest Management Transition Project (Apple IPM Transition Project, 2007-2010; Goldberger et al., 2011), for this project, we employed less formal follow-up surveys at several industry meetings in 2011-2012. For these inquiries, we used a real-time audience response system (Turning Technologies®, Youngstown Ohio, USA) to gain specific information about biological control from growers and crop consultants. These assessments identified knowledge gaps, evaluated decision-makers' perceptions of biological control practices, and revealed how and where respondents received their information. In turn, survey responses helped to guide the development and methods used in this project's outreach program.

3. Successes in outreach implementation

We utilized both traditional and novel approaches in our information and technology transfer efforts. These included articles published in trade journals, presentations of synthesized project information at industry and professional meetings, interactive educational opportunities, participation in on-farm experiences, a project website (<http://www.enhancedbiocontrol.org>) and production of high

quality guides and information resources. Most of these methods were effective at starting the information transfer process and received positive reviews from our stakeholders. Here we highlight aspects of the program that were most successful in addressing industry needs and influencing the adoption of new practices.

3.1 A focus on interactive education

Educational opportunities during this project included a comprehensive two-day short course, two hands-on field day workshops and eight half-day training workshops. The two-day short course was held at three Pacific Northwest locations that were simultaneously linked via video-conferencing technology (Annual Report, 2012; <http://www.enhancedbiocontrol.org>). There were seventy-five attendees who represented a significant portion of apple and pear decision makers in Washington and Oregon. The course contained several presentations focused on using biological control, a natural enemy identification activity, and several case study and discussion sessions. Throughout the event participants had the opportunity to interact with topic experts at each location. Course evaluations were overwhelmingly positive with 93% of participants stating it was worth their time and registration fee. When asked how the information would change their current or future management practices, the top two responses were the choice of pesticides used and the timing of pesticide applications (Fig. 1). To reach a larger audience, the content of the short-course (including the workbook and narrated slide presentations) was made available on the project website (Jones et al., 2015a, this issue). The short course page has been viewed and/or materials downloaded approximately 500 times since 2012, extending the educational outreach almost seven-fold from the original live event.

To offer additional hands-on experience, the short course was followed up with two field day workshops offered in Wenatchee, Washington (1 hour) and Hood River, Oregon (half-day) during the summer of 2012. A total of twenty-five participants attended these two events where they were able to practice natural enemy identification and monitoring/scouting techniques in an orchard setting.

Due to various limitations (i.e., fiscal and personnel resources, travel, availability of facilitators and participants) we were not able to repeat the two-day course, thus we developed a shorter, hands-on

workshop sourcing components directly related to orchard pest management from the two-day course curriculum. These four-hour workshops were offered at a time and location convenient to the industry groups interested in enhancing their knowledge of biological control. Eight different workshops were delivered to ninety-four attendees in Washington in January to March 2013. Participants completed an online pre-workshop survey that was compared to results from review quizzes taken after workshop attendance, enabling us to assess learning outcomes. The percentage of questions answered correctly after the workshop training nearly doubled for three of the four categories of comparable questions (Fig. 2). These results show a strong knowledge gain about natural enemies and biological control principles from the workshops. Based on this positive feedback we were encouraged to conduct six additional workshops in Washington and Oregon in 2014, involving 83 participants and using leveraged funding for continued outreach on biological control as part of IPM (*see section five discussion*).

3.2 Information availability into the future

As mentioned in section two, one constraint associated with grant-funded outreach is leaving a legacy of knowledge and information transfer that outlasts the project's end date. Web-based information technology (IT) provides a platform for long-term accessibility to resources and the potential to update new information as it becomes available. The use of web-based IT optimizes information flow through efficient access to real-time data, and potentially reduces the lag period for adoption of new agricultural practices (Jones et al., 2009, Jones et al., 2015a, this issue).

This method has been implemented with success by several Extension programs in recent years (Birt et al., 2012; Calixto et al., 2011; Drill, 2012; Fulcher et al., 2012; Kinsey, 2010) and was a logical option for enabling access to the project's information well into the future. Survey results showed that growers like to use the Internet to search for and receive information (Goldberger et al., 2015, this issue). In response, we created a website to house much of the project's content, such as progress reports, research presentations, video and picture galleries, and links to additional online resources (Jones et al. 2015a, this issue). We also engaged the use of social media such as Facebook and Twitter, developed databases for decision support tools, and formatted content so it is accessible on smartphones and tablets.

Decision support tools, such as Washington State University's Decision Aid System (WSU-DAS, <http://das.wsu.edu>) and Oregon State University's MyPest Page (<http://pnwpest.org/risk/models>), are other powerful resources to use for delivery and integration of project research results. Both internet-based decision tools are important information sources for pest management decision-making, especially among pest management consultants, who are a primary source of information for growers in both states (Jones et al., 2010b; Castagnoli, 2006). In Washington, almost all of the tree fruit industry uses or is directly influenced by WSU-DAS, which provides real-time management recommendations based on degree-day models (Jones et al., 2009, 2010b). Already available on WSU-DAS are ten pest insect, four disease, and two horticultural models in addition to WSU pesticide recommendations and known pesticide effects on natural enemies and other non-targets. We have and will continue to add new information derived from this project to WSU-DAS such as natural enemy phenology models and sub-lethal pesticide effects on key natural enemies in orchards (Jones et al., 2015a, this issue; Jones et al., 2015c, this issue). The newly generated information will also be made available for integration into other state and regional decision support platforms.

3.3 Diffusion of new monitoring tools through on-farm experiences

Participation by key stakeholders in trials or on-farm experiences has long been one stage in the process of adopting new ideas and technology (Rogers, 1963). Early adopters gain experience with the new tools, and spread this information to the industry thereby spurring technology transfer. In 2012, five crop consultants and IPM practitioners agreed to participate in evaluating a novel tool, which utilizes herbivore-induced plant volatiles (HIPVs) and floral volatiles in lures that attract specific species of natural enemies (Jones et al., 2011, 2015b, this issue). Lures, combined with sticky traps, can be used to monitor seasonal activity and relative abundance with more ease and accuracy than traditional methods. Cooperators deployed squalene lure-baited traps in two five-acre apple blocks (1 trap/acre or 5 traps/block) to monitor the green lacewing, *Chrysopa nigricornis* Burmeister. Each cooperator chose a pair of blocks that were managed differently, for example 'low' versus 'high' pesticide input programs.

Cooperators checked, recorded and replaced sticky traps weekly and lures as needed from June to September.

The main objective for this activity was to learn from the cooperators' perspective the utility and value of this new monitoring tool. Each cooperator was interviewed and the edited videos shared on the project website (http://www.youtube.com/watch?v=pmy5_WNSvHs). Overall, cooperators thought the HIPV lure-baited traps were valuable and made natural enemy presence more visible in their orchards (Table 1). New questions also arose from their experiences, such as what the trap counts mean in terms of pest control. For example, does capturing greater than 10 lacewings on average in a one-acre block translate to increased predation and control of pest aphids? Questions such as these will continue to be the focus of new and current research leveraged from this project's results.

In a similar exercise with 10 pear growers and 5 pest management involving consultants in the Hood River Valley in 2012 and 2013, HIPV lure-baited traps were used to monitor natural enemies of pear psylla. Additionally in 2013, biweekly leaf samples were collected to monitor for pear psylla eggs and nymphs. When overlaid with pesticide application information, trends in pest and natural enemy abundance and their pesticide effects were apparent to the participants. Consultants, in particular, recognized the value of this kind of information in supporting pest management recommendations, but were reluctant to invest time or labor in checking and maintaining traps without a clear relationship between monitoring information and potential for providing enhanced biological control of pear psylla.

These monitoring trials provided insight for pest managers regarding the presence of lacewings in their orchards. To better interpret natural enemy observations, data from HIPV lure-baited traps will need to be compared to natural enemy phenology models. In the future, growers will be able to use real time monitoring data in combination with model predictions, as they are incorporated into WSU-DAS, to determine if use of a certain pesticide should be avoided or its application timing shifted. Comparison of real time data with model predictions will also reveal a lack of natural enemy activity when the model indicates it should be present. The value of monitoring with HIPV's and floral volatiles will increase as more natural enemy models and pesticide effect information becomes available.

4. Challenges and lessons learned

While our project experienced many successes with the outreach program and fulfilled a majority of the project goals, our efforts were not devoid of challenges. In general, the issues we faced were directly related to the factors discussed in section two and a reflection of the underlying difficulties within the Cooperative Extension system. In order to address these issues and continue to meet industry needs, it is important to understand what didn't work and how to apply the lessons learned from our experiences.

We found that successful implementation of the outreach program varied for each state involved in the project. For example, we could not produce the same interactive educational events in California that were offered in Washington and Oregon. The UC IPM program and county-based Farm Advisors were provided access to all the information and resources developed for this purpose, but coordination among the various entities, current responsibilities and available resources confounded implementation. In hindsight, it is clear that a larger project with greater funding was needed to enable more active collaboration among extension personnel and provide sufficient resources to guide and implement outreach activities. We also learned that a sound understanding of the extension structure in each state would foster better communication and cooperation among professionals coordinating the project's outreach.

In addition, it became clear that effecting change in IPM programs would require the continued synthesis, integration and delivery of information long after the project's completion. To accomplish this, additional funding would be needed through leveraged grants, state extension programs, or industry/university partnerships (*see section five discussion*). While the overall project website provides access to information in a static form with very little need for continued maintenance, other more dynamic web content, such as the pesticide effect databases (e.g. Orchard pesticide effects natural enemies database (OPENED) (Jones et al., 2015a, this issue)), will require updates as new information becomes available.

We also found that outreach activities and project personnel were helpful in publicizing web-resources. Awareness of these resources helped stakeholders know where to access relevant information and how to use this information. In addition, this interaction created feedback loops where suggested improvements could be made. For example, the project website was visited more often by users in Washington (40%), where there were more frequent recurring promotions of this web resource during outreach events, compared to visits from Oregon (10%) and California (8%). Obtaining and maintaining support for traditional and web-based education for growers, consultants and IPM practitioners is also critical. Implementation of IPM using biological control practices is an information-intensive, complex process that needs both decision support systems and basic stakeholder education programs in order to increase adoption (Jones et al., 2009).

The need for longer-term outreach programs is obvious, but it is unlikely that Cooperative Extension in its current form and funding level can meet this expectation. Across the nation, funding for extension has been decreasing at the local, state and federal levels over the last several years (McDowell, 2004; West et al., 2009). For example, in Washington State over the past 40 years, the number of extension educators working in tree fruits decreased from eight full-time employees in 1970 to just 2.5 at present (T.J. Smith, personal communication, May 8, 2014). Further, state support for Washington State University (WSU) declined 38% between 2008 and 2013, with support for extension declining by \$3 million in the same period (Lester, 2011). While reductions in state funding for higher education has currently ceased, it is unlikely that state or federal funding for Cooperative Extension will increase in the foreseeable future. If current limited extension resources remain the norm, grants and private industry support will be required to fulfill the expectations of stakeholders for a rapid and efficient transfer of critical research information.

5. Future directions and meeting industry needs

The final consideration is to explore new avenues that outreach programs could use in the future while continuing to meet stakeholder needs. One strategy is to leverage additional funding from sources

such as state or federal grant programs, many of which now allow or require inclusion of outreach objectives. In Washington, parts of the outreach program have been continued for an additional two years via funding from a Specialty Crop Block Grant (\$155,743), “Promoting biological control through hands-on and web-based training course, mobile apps, and assisted technology transfer,” provided by the Washington State Department of Agriculture/USDA Specialty Crop Block Grant program. With these funds we are building an interactive online course where participants can receive IPM certification, credits for a pesticide applicators license renewal, and potentially credits toward an advanced degree, such as the WSU MS in Agriculture (Jones et al., 2015a, this issue). Other objectives include additional opportunities for cooperators to participate in the natural enemy monitoring project, creation of a smartphone or tablet accessible field guide for common western orchard natural enemies and associated pests, and finally, translating these resources into Spanish in order to provide them to a large emerging sector of the industry.

Many information transfer systems around the globe have embraced the idea of private extension or “fee for service” models, which have become attractive options here in the US to address the shortfalls in public support of extension activities (Anderson and Feder, 2003; West et al., 2009). These include mechanisms such as private consulting, advisory services provided by agricultural chemical distribution companies, and contracts or direct user charges for public services. This model tends to be most accessible and effective in commercial agriculture where markets for these services are more readily established. Private IPM and agricultural chemical company consultants are key players in the tree fruit and nut industries in the western region. However, when Washington consultants were surveyed about where they received their pest management information, university research/extension (39%) and WSU-DAS (47%) were among the top four selections, indicating these services are important resources for this group of stakeholders (Gadino, 2012). There is also concern that private funding of extension activities could influence the objective quality of information delivered and could slow the adoption of new practices if growers are unable or unwilling to pay for information. Additionally, growers will be less likely to share with others the information for which they have paid.

Another feasible option is to engage in private-public partnerships where there is collective support for extension related activities. Such partnerships are designed to involve the stakeholders who benefit from the services they help fund. An example of a recently established public-private partnership occurred in 2011 when the Washington State tree fruit industry and WSU entered into an agreement to provide long-term support in the form of endowments for research and extension activities that would benefit the industry. Apple, pear, cherry and other stone fruit growers voted and passed a time-limited special project assessment aimed at generating up to \$32 million in endowments over a period not to exceed eight years (Layne, 2014). The funds will be invested in three endowment areas: Endowed Research Chairs, information technology and transfer (ITT), and research orchard and facilities operations. The ITT endowment is targeted for \$12 million, or 42% of the total. The public-private partnership between WSU and the Washington tree fruit industry was initially used to hire an endowed chair as the extension tree fruit leader. Over the next several years, as funds are generated from the ITT endowment, they will be invested in personnel and programs that ensure research information and technology to reach industry stakeholders. The Washington tree fruit industry's investment in the ITT endowment clearly shows they understand and value the Cooperative Extension mission.

Regardless of how Cooperative Extension chooses to adapt to the current and future needs of its stakeholders in different states, it is clear that the use of technology should be an integral part of the process (Jones et al., 2015a, this issue). Tools such as websites and decision support systems will help optimize available resources and can lead to new interactive modalities for teaching and learning experiences. For example, converting educational short courses, workshops or even aspects of field day experiences into interactive online education modules will provide users access to these resources at their convenience. Once such resources are produced they will require limited support and maintenance. There is also the opportunity to engage growers and consultants in self-assessment activities through web-based programs. Growers could enter their pest management practices into an on-line system along with the results from those decisions, and make comparisons between orchards, different years or even anonymously with other growers. Additionally, grower data collected during the normal course of

producing a crop can provide important contributions to traditional experimental research approaches and is the basis of “eco-informatics” approaches being developed in several cropping systems (Rosenheim and Meisner, 2013; Rosenheim et al., 2011; Michener and Jones, 2012). In the very near future as the use of eco-informatics and decision support tools expand, the Internet will likely evolve into the best forum for the diffusion of new IPM practices among growers.

In summary, we employed a combination of approaches in the outreach program for this biological control project. Several of these activities and events were highly successful and aided in fulfilling the goals set forth in the grant. There were also a number of challenges experienced, some of which were a reflection of the problems confronting the current system. It is clear that Cooperative Extension programs will increasingly be expected to become more efficient with fewer resources, and the need to deliver state-of-the-art information on sustainable management programs. While our project provides information on possible directions, it is critical that Cooperative Extension makes bold changes to meet the future needs of agriculture.

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Table 1. Summary of cooperator's perspectives on using the HIPV traps to monitor green lacewings (*Chrysopa nigricornis*).

Fig. 1. Responses from interactive two-day short course evaluations when asked how participants' current or future management practices will change based on what they learned.

Fig. 2. Comparison of participant learning outcomes before and after their attendance at hands-on workshops that focused on enhancing biological control and orchard IPM.

Table 1. Summary of cooperator’s perspectives on using the HIPV traps to monitor green lacewings (*Chrysopa nigricornis*).

Question	Summary of responses
Was monitoring for natural enemies (NE’s) different compared to other sampling methods?	<ul style="list-style-type: none">• Liked that using sticky traps for lacewings was similar to sampling for codling moth and leafrollers• Sampling method was unique and easy
What were the benefits of using HIPV traps to monitor NE’s?	<ul style="list-style-type: none">• Good indicator of natural enemy presence or absence in the orchard• Data can help guide management practices• HIPV traps give direction on looking for natural enemies (where to look, what to look for and what is already accounted)• HIPV traps reduce sampling time compared to other methods such as visual counts
Were there drawbacks to using the HIPV traps to monitor NE’s?	<ul style="list-style-type: none">• Cost of monitoring needs to be balanced with benefit• Takes extra time to check lacewing traps• No correlation between trap numbers and level of control you are trying to achieve• Helpful tool, but should not rely solely on the traps (at least until we have a better understanding of what the trap counts mean)• HIPV traps should not replace physical presence in the orchard

Figure 1

Figure 2

Biological Control Basics and Natural Enemy ID
An engaging training opportunity by WSU-TREC

The WSU Enhancing Biological Control project team of first-time trainings where you can learn about natural enemies in your orchard and how you can enhance their contribution to controlling orchard pests. The training consists of two modules that can be taken as one unit or separately. The modules cover the following content:

Module 1: Understanding the basics of biological control and learning to recognize natural enemies in the orchard

- Discuss general principles and examples of biological control in orchards.
- Review key natural enemy groups in western orchards and describe features used for their identification at all life stages.
- Practice insect identification skills using magnification equipment and insect guides produced by our team.

Module 2: Applying new biocontrol information: monitoring, models, and pesticide effects on natural enemies

- Learn about new and old ways to monitor for natural enemies in your orchard.
- Explore how knowledge about natural enemy phenology helps in making better pest management decisions.
- Understand how pesticides affect natural enemies and how to mitigate negative impacts.
- Apply new information in a practical exercise and discover how biological control can benefit your operation.

To schedule a training in your area or for more information about biological control please contact us via our website www.enhancedbiocontrol.org or call Dr. Angela Gadino (509-663-8181 x.286).

Enhancing Western Orchard Biological Control

www.enhancedbiocontrol.org

Bar chart showing the percentage of correct answers before and after a workshop for four categories. The Y-axis represents the Percent (%) answered correctly, ranging from 0 to 100. The X-axis lists the categories. The legend indicates that grey bars represent 'Before workshop' and black bars represent 'After workshop'.

Category	Before workshop (%)	After workshop (%)
Correctly identify natural enemies	44	64
Knowledge of habitat needs for natural enemies	41	89
Identify pesticides that are most harmful	25	63
Identify pesticides that are least harmful	28	61