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Adoption of Integrated Pest Management Practices Among Oklahoma Greenhouse Producers: A Case Study for Experiential Learning

Abstract

An instruction- and experience-based workshop was conducted for Oklahoma greenhouse producers to teach principles of integrated pest management (IPM) for common arthropod pests of greenhouse crops. Workshop effectiveness was evaluated using a pre- and post-test instrument to measure changes in knowledge and attitudes about IPM and current use and intention to adopt IPM practices. Findings indicate the objectives were accomplished as participants reported significant increases in IPM knowledge, a marked acceptance of IPM practices, and a willingness to adopt IPM. Extension workshops that combine classroom instruction and hands-on demonstration can be used effectively to teach relevant concepts to stakeholders.

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Introduction

The nursery and greenhouse industries are a vital component of the U.S. agricultural sector, producing a wide variety of ornamental and edible crops. While the national market share for Oklahoma is small (1% annually) (USDA Economic Research Service, 2010), the nursery and greenhouse industries are key contributors to the financial health of the state, generating over $107.3 million in revenue in 2007 (USDA National Agricultural Statistics Service, 2009). In a 2010 survey, nursery and greenhouse crops ranked sixth (2.5% of total receipts) among all Oklahoma agricultural commodities and second in total revenue ($165.7 million) (USDA Economic Research Service, 2010). Given their importance to the Oklahoma economy, nursery and greenhouse crops must be protected from insects, mites, and diseases to ensure continued economic vitality of the state's agricultural sector.

Insect and mite pests of greenhouse crops present unique production challenges. Plants are frequently moved in and out of the greenhouse, creating opportunities for repeated exposure to arthropod pests. Pest proliferation is favored in greenhouses because a continuous supply of host plants is grown in a protected, enclosed environment. Also, arthropod pests often exist in the absence of natural enemies, unless predators and parasitoids are intentionally introduced as biological control agents. These challenges, common among all nursery and greenhouse operations, contribute to increased pesticide use and impede the adoption of integrated pest management (IPM) strategies for managing greenhouse pests. Conversely, greenhouses are ideal systems for implementing IPM strategies because they are closed systems, thereby containing biological control agents, excluding arthropod pests, and allowing producers optimal control over the crop environment (Grant, 1997).

Many arthropod pests and plant pathogens are managed successfully in greenhouses using IPM strategies (Pottorff & Panter, 2009). Integrated pest management programs are designed to combine two or more pest management strategies that effectively reduce pest populations below damaging levels (or aesthetic thresholds) while minimizing pesticide use (Sadof & Raupp, 1996; Wyckhuys & O'Neil, 2007; Boissard, Martin, & Moisan, 2008; Wilen, Lazaneo, & Parker, 2011). Additionally, IPM approaches should be environmentally sustainable and profitable and account for arthropod and vertebrate pests, plant pathogens, and weeds simultaneously (Ehler, 2006). Pesticides are not abandoned entirely but are used judiciously when alternative strategies fail. Alternative pest management strategies include biological control, cultural control, and mechanical/physical control options (Rebek, Frank, Royer, & Bográn, 2012).

To address the pest management needs of greenhouse producers, the authors designed a workshop that combined traditional classroom instruction with hands-on demonstration to educate industry clientele about IPM for arthropod pests of greenhouse crops (ornamental and vegetable plants). Extension workshops, demonstrations, and on-site training are proven tools in teaching stakeholders important concepts and principles for a wide variety of applications (e.g., Sikora et al., 2001; Stier, Delahaut, Pellitterri, Williamson, & Becker, 2002; Fishel, 2008). The research goal of the case study reported here was to demonstrate retention of concepts taught in the classroom via experiential learning, which is broadly applicable to various Extension programs. Specifically, we measured the educational impact of the workshop as well as producers' willingness to adopt IPM as an effective strategy for managing pests in the greenhouse.

Methods

Extension programs play a vital role in keeping the greenhouse industry informed of continuous industry and legislative changes as well as updates on the status of key arthropod pests. As such, the authors conducted a Greenhouse IPM Workshop on November 5, 2008 at Oklahoma State University in Stillwater. The workshop attracted 29 participants who represent a broad cross-section of the industry, most of whom work primarily in greenhouse operations. Also present were Extension educators from several counties who facilitate knowledge transfer to industry members. Workshop objectives were to: 1) educate workshop participants about current IPM practices for common arthropod pests of greenhouse crops and reinforce these concepts through hands-on, experiential activities, and 2) evaluate changes in their knowledge, attitude, and willingness to adopt IPM practices following the workshop.

Experiential learning activities allowed workshop participants to observe cultural control strategies designed to prevent pest problems from occurring, including proper greenhouse sanitation, weed control, pest exclusion methods, plant health maintenance, and inspection of incoming plant shipments for signs and symptoms of insects and plant pathogens. Topics included monitoring techniques such as frequent scouting for pest problems and use of pest monitoring devices (e.g., sticky traps). Also, participants gained practical experience by releasing biological control agents (e.g., arthropod predators and parasitoids) in a greenhouse. Participants learned how and when to release natural enemies for target pests and which greenhouse conditions fostered maximum effectiveness of selected biological control agents.

The authors evaluated workshop success using a pre- and post-test instrument to measure changes in knowledge and attitudes about IPM and gauge current use and future adoption of IPM practices in Oklahoma greenhouse production (i.e., measure changes in behavior). Pre- and post-test questions were identical, and the survey structure was predicated on previous work with evaluating Extension workshops (Kelsey, Schnelle, & Bolin, 2005). All responses for the pre- and post-tests were anonymous.

Data were collected to describe the sample, including demographic and industry data such as gender, age, years of industry experience, primary area of work, primary nature of operation, size of operation, and whether participants were the primary decision makers for pest management in their operations (Table 1).

Table 1.
Demographic and Industry Data for Workshop Participants

Question	***n***				
Gender	27	Male 52%	Female 48%		
Age Range	26	26-35 15%	36-45 27%	46-55 39%	56-65 19%
Years of experience in industry	25	1-9 52%	10-19 16%	20-29 16%	30-39 16%

Primary area of work	28	Greenhouse 61%	Nursery 11%	Landscape 4%	Other 24%
Primary nature of greenhouse operation	21	Retail 29%	Wholesale 14%	Education/Research 48%	Other 9%
Size of operation (thousands of sq. ft.)	18	< 10 44%	10-20 6%	> 20 50%	
Primary decision maker for pest management	25	Yes 60%	No 40%		

Another group of questions measured participants' familiarity with IPM before and after the workshop (i.e., knowledge gained) and their historical and future use of IPM (i.e., behavior change) (Figure 1). Questions about specific pest management tactics were asked on a Likert-type scale of always, sometimes, rarely, and never (Table 2). The pre- and post-test design allowed for measurement of changes in future pest management decision making. The final section of the instrument measured changes in attitude about IPM following the workshop. A Likert-type scale of strongly agree, agree, neutral, disagree, and strongly disagree were used (Table 3).

Data were analyzed using SAS version 9.2. Non-parametric Wilcoxon rank sum tests (PROC NPAR1WAY, SAS 9.2) followed by Kruskal-Wallis chi-square tests were used to compare pre- and post-test responses. Non-parametric statistics are most appropriate for analyzing Likert-type response data (Jamieson, 2004; Allen & Seaman, 2007; Boone & Boone, 2012). All response data were analyzed at a significance level of $P \leq 0.05$.

Results and Discussion

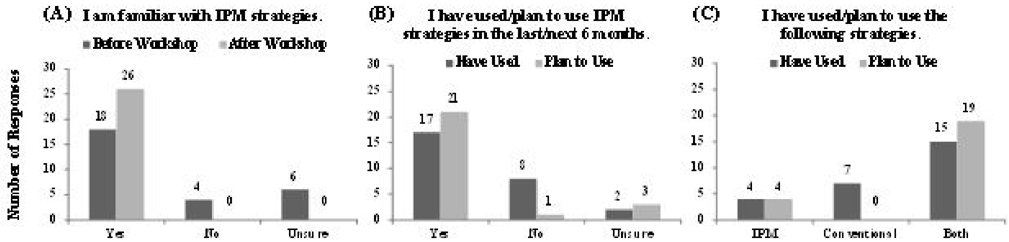
Twenty-eight participants completed the surveys, and the number of respondents to each question varied between 18 and 28.

Knowledge and Use of IPM

One major objective was to determine changes in participants' general knowledge of IPM and intent to use IPM strategies following the workshop. Although 64% (18/28) of participants came to the workshop with prior knowledge of IPM, all respondents indicated improved familiarity with these strategies after the workshop (Figure 1A). These results confirm that Oklahoma greenhouse producers are in need of continuing education with respect to pest management. Additionally, an increased proportion of participants intended to use IPM within 6 months of the workshop's conclusion, and none planned to rely solely on conventional control strategies (Figure 1B, C). These results indicate the workshop was successful in educating participants about greenhouse IPM and encouraging participants to adopt IPM strategies in the future. Yet 83% (19/23) of participants were unwilling to abandon conventional control strategies altogether, opting instead for a combination of conventional control and IPM following the workshop (Figure 1C). These results may reflect reluctance to rely entirely on IPM due to: 1) a lack of long-term experience with these methods (e.g., 52% of workshop participants had less than 10 years of experience in the greenhouse industry [Table 1]), and 2) previous failures with IPM methods among more experienced growers.

Figure 1.

Number of Responses to Pre- and Post-Test Questions Regarding General Knowledge and Use of IPM



Use of Specific IPM Strategies

Post-test results note important gains in knowledge about the biology and life cycles of arthropod pests, a key component of successful IPM programs (Table 2). Specifically, more growers were informed about pest prevention and identification of adult and immature stages of major pests. Important gains in knowledge also included soil fertility and pH, sources for information about alternative pest control strategies, and importance of record keeping for all pest management decisions.

In addition, many participants reported their intent to use specific IPM strategies following the workshop, including cultural, physical/mechanical, biological, and chemical control methods (Table 2). Significant changes ($P \leq 0.05$) in knowledge and/or behavior were observed for the following categories.

Cultural and physical/mechanical control

- Inspecting plants for pests and diseases before incorporation into the greenhouse
- Keeping the greenhouse production area sanitized
- Use of exclusion devices that keep arthropod pests from invading the greenhouse

Biological control

- Use of natural enemies for key arthropod pests
- Use of insecticides that are compatible with biological control

Chemical control

- Use of biorational, reduced-risk products

Table 2.
Responses to Pre- and Post-Test Instrument Regarding Knowledge Gained and Use of Specific IPM Strategies

	Pre-test					Post-test					Statistics	
Question Prompt	*n*	**A**	**S**	**R**	**N**	*n*	**A**	**S**	**R**	**N**	**χ2**	**p-value**
I inspect incoming plants for pests before integrating them into current stock.	26	14	9	2	1	25	20	5	0	0	4.45	**0.0350**
I reject or return infested shipments.	21	6	4	4	7	22	11	5	2	4	2.66	0.1031
I destroy heavily infested plants.	25	10	7	5	3	26	18	2	4	2	2.97	0.0847
I plan for pest problems before they occur by learning each species' potential for pests and diseases.	25	7	10	6	2	25	20	5	0	0	15.4	<0.0001
I can identify major arthropod groups in the immature stage.	26	6	11	6	3	26	11	13	2	0	5.18	**0.0229**

I can identify major arthropod groups in the adult stage.	25	13	8	2	2	26	20	5	1	0	3.86	**0.0495**
I monitor and scout for pests before applying pesticides.	26	21	5	0	0	26	25	1	0	0	2.96	0.0855
I use established treatment thresholds for common arthropod pests.	23	12	5	4	2	26	15	9	2	0	0.81	0.3667
I use biorational, reduced risk pesticides over conventional products.	23	1	17	2	3	26	8	16	1	1	6.13	**0.0133**
I rotate among pesticides with different modes of action to manage resistance.	25	15	8	0	2	26	20	6	0	0	2.01	0.1560
I use natural enemies to manage pests.	25	1	11	5	8	26	8	12	2	4	7.42	**0.0064**
I plan for pest problems before they occur.	23	3	14	2	4	25	13	12	0	0	13.5	**0.0002**
I use sanitation to effectively reduce pest populations.	26	11	12	2	1	26	19	6	1	0	5.34	**0.0208**
I do not allow weeds to grow beneath the benches.	26	13	8	1	4	26	19	2	1	4	2.59	0.1074
I maintain or mow vegetation outside the greenhouse range.	23	19	3	1	0	24	22	1	1	0	0.78	0.3780
I employ spot treatments whenever possible.	26	12	13	1	0	26	18	8	0	0	3.03	0.0816
I disinfect growing areas.	25	8	10	4	3	26	18	6	1	1	6.79	**0.0092**
When choosing pesticides I also factor in the product's toxicity to beneficial insects.	25	8	8	7	2	25	17	5	2	1	7.52	**0.0061**
I know pH and soluble salt levels for each of my crops.	25	5	11	6	3	26	15	9	1	1	8.10	**0.0044**
I maintain records of pest control decisions to reflect upon for making future decisions.	26	12	6	6	2	26	19	4	3	0	4.40	**0.0359**
I use pest exclusion tactics to effectively reduce pest populations.	23	2	12	3	6	26	9	13	2	2	6.24	**0.0125**
I can identify major arthropod pests and plant damage caused by these pests.	26	9	11	4	2	26	12	13	1	0	2.17	0.1411
I can identify signs and symptoms of major disease-causing plant pathogens.	25	4	15	4	2	26	9	16	1	0	4.87	**0.0273**
I can identify beneficial arthropods.	26	7	11	6	2	26	10	13	3	0	2.33	0.1266
I know where to find alternative pest control information and products.	26	9	12	4	1	26	17	9	0	0	6.63	**0.0101**
A = Always, S = Sometimes, R = Rarely, N = Never												

Attitude About IPM

Another objective was to determine if there were any changes in attitude regarding IPM among participants following the workshop. There were significant increases ($P \leq 0.05$) in the number of growers who reported IPM was important and were willing to use IPM strategies, especially when it proved more effective than conventional control, regardless of cost (Table 3). There was little change in the number of participants who were concerned about adverse environmental effects of pesticide use, worker safety, development of pesticide resistance in populations of key pests, and loss of effective pesticide products due to legislation (Table 3). Likely, these results reflect the fact that most participants were aware of these issues and concerned about them prior to attending the workshop. After the workshop, a greater number of growers disagreed with the statement that they would use IPM only when it was cheaper than conventional control, although this change was not significant (P > 0.05) (Table 3). This result emphasizes the importance of balancing effective pest management with profitability because growers may be unwilling to adopt IPM if it is too costly.

Table 3.

Responses to Pre- and Post-test Instrument Regarding Attitude Toward IPM

	Pre						Post						Statistics	
	n	SA	A	N	D	SD	*n*	SA	A	N	D	SD	χ2	p-value
IPM is important to my operation.	25	10	10	5	0	0	27	20	7	0	0	0	7.62	**0.0058**
I routinely use IPM in my operation.	25	6	10	7	2	0	26	11	14	1	0	0	5.83	**0.0158**
I use IPM if it is more effective than conventional control, regardless of cost.	25	3	11	9	2	0	26	9	12	4	1	0	5.02	**0.0250**
I use IPM only when it is cheaper than conventional control.	25	1	2	14	7	1	26	4	4	5	12	1	0.01	0.9127
I am concerned with adverse environmental effects of pesticide use.	26	9	13	3	1	0	27	14	10	2	1	0	1.39	0.2391
I am concerned with pesticide safety issues and worker protection.	26	14	11	0	1	0	27	19	7	1	0	0	1.40	0.2360
I am concerned about the development of pesticide resistance in key pests.	26	11	13	2	0	0	27	17	9	1	0	0	2.28	0.1311
I am concerned about the loss of effective pesticides due to federal regulation.	26	14	9	2	1	0	27	18	6	2	1	0	0.69	0.4076
I inform clientele that I use IPM in my growing practices as part of my environmental stewardship.	24	4	5	13	1	1	25	5	12	7	0	1	2.89	0.0889
* SA = Strongly Agree, A = Agree, N = Neutral, D = Disagree, SD = Strongly Disagree														

Conclusions

Results of the survey indicate measurable gains in knowledge of IPM principles among workshop participants. Pre- and post-test responses indicate a general acceptance of IPM practices and, in general, a willingness to adopt IPM in participants' respective businesses. Thus, the objectives for the Extension workshop were realized. The combined format of classroom instruction and hands-on demonstration contributed to the workshop's success because participants were able to apply knowledge gained in the classroom through greenhouse activities demonstrating IPM principles. The practice of pairing conceptual and experiential learning has long been recognized as a powerful tool to enhance retention of key concepts and their subsequent application in the real world (Marshak, 1983). This strategy is universally applicable and, thus, transcends state borders and disciplines.

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