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Educated and Engaged Communicators Are Critical to Successful Integrated Pest Management Adoption

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Abstract

Integrated pest management (IPM) programs combining multiple compatible pest control tactics can result in effective commodity protection, pesticide use reduction, and cost savings – yet establishment of IPM programs is still low in many areas of the United States. While several potential causes of and solutions to low adoption rates exist, our focus is on the often-neglected human aspect of IPM. IPM educators who serve as the conduit of IPM research and advice to IPM practitioners often face challenges in areas that are less scientific and more social, such as communication and teaching. The skills needed in these areas (e.g., conflict management and resolution, needs assessment, negotiation, training, and informal education) are sometimes neglected in the professional development of future IPM educators, to the detriment of their ability to work with practitioners to encourage adoption of IPM programs. We explore these challenges, including a survey of current IPM educators, and propose areas of communication skills that could be included in the professional development of future or early-career IPM educators.

Key words: communication, extension, IPM, relationships, teaching

Modern integrated pest management (IPM) has its genesis in the 'supervised control' and 'integrated control' concepts developed in the mid-20th century by University of California entomologists (Smith and Smith 1949, Stern et al. 1959). While the definition of IPM has changed over time (sometimes obscuring its intent – see Ehler 2006), traditionally, IPM programs are visualized as cycles consisting of scouting, identifying, monitoring, implementing management actions, and evaluating. Management actions in IPM try to combine tactics including chemical, biological, mechanical, cultural, and physical control methods. The goal of an IPM program is to use multiple compatible management methods simultaneously – in an ecologically and economically sound manner – to maintain pest populations at desired levels. IPM strategies are applicable to many fields including agriculture, forestry and natural resources, urban and structural pest control, and human and veterinary pest control. End goals will vary among fields (e.g., desiring nondamaging levels of pests in agriculture versus needing complete elimination of urban pests like cockroaches) and so too will the applicable strategies.

The use of multiple management methods together has resulted in well-documented environmental and economic benefits attributable to IPM. For instance, IPM programs can lead to reductions in the number of pesticide applications and the concentrations used (Williams et al. 2005, Weddle et al. 2009, Shahraki et al. 2011), though direct economic savings may or may not be realized (e.g., Williams et al. 2005, Shahraki et al. 2011). Reduction in pesticide use and increased rotation of pesticide classes also helps delay development of pesticide resistance, which costs U.S. agriculture up to $10 billion annually across all classes of pests (Pimentel 2005, Gould et al. 2018). A decreased health cost burden from worker pesticide exposure could also be expected with less frequent pesticide use (Gilden et al. 2010, Damalas and Eleftherohorinos 2011). IPM can reduce pesticide and allergen exposure to residents in public housing and children in schools (Miller and Meek 2004, Nalyanya et al. 2009). While labor costs may increase on time spent monitoring for pests, there often is a corresponding reduction in time spent applying pesticides, and work time lost due to reentry restrictions after pesticide applications may decrease. Overall, less money is spent on pesticides (which may include chemical, botanical, or microbial formulations) in an IPM program (Williams et al. 2005, Weddle et al. 2009, Shahraki et al. 2011). Further, IPM programs may help preserve beneficial insects, which provide an estimated annual $57 billion in ecological services including pest control and pollination (Losey and Vaughan 2006). The rising demand for environmentally friendly services can also boost the clientele of a business if they offer IPM-based programs.

Despite the benefits of IPM, its realized use is often not as high as expected or hoped (LeBude et al. 2017, Stetkiewicz et al. 2018). Estimates of IPM adoption and implementation rates in the United States vary considerably and are complicated by the many definitions of IPM (i.e., Bajwa and Kogan (2002) list 67 definitions!). Fewer than 10% of the definitions outlined by Bajwa and Kogan (2002) mention human or sociological considerations, and those that do are almost exclusively in reference to human health considerations when using pesticides. In agriculture, rates of true IPM, defined hereafter as a program using standardized monitoring, integration of multiple compatible management tactics, and recordkeeping, are estimated to be as low as 4–8% of total US crop acreage (Ehler and Bottrell 2000). If IPM is instead defined as only insect, weed, or disease scouting, then adoption rates in U.S. agriculture, as a percentage of total acreage, appear to be rather high [i.e., 86% in cotton, 81% in corn (when also considering crop rotation), 75% in vegetables, 72% in fruit and nuts, 56% in soybeans, and 50% in wheat; Agricultural Statistics Board 2001]. However, IPM is more than just scouting, and critical components of true IPM are generally practiced infrequently. For instance, recordkeeping occurs on only 24% of fruit and nut acreage, and the results of scouting are considered when making management decisions on only 34% of soybeans (Agricultural Statistics Board 2001). In a study of IPM in urban landscape management companies focused around Atlanta, GA, IPM (i.e., scouting only) appears in 69% of businesses (Hubbell et al. 2001). This rate dropped to 39% when counting true IPM programs, which contained other components such as recordkeeping and evaluation.

What factors, barriers, or misunderstandings are restricting IPM adoption, and how can we improve upon adoption rates? One recent suggestion is to return to the original concepts of ecology and evolution that form important bases of IPM to focus through the lens of a single, standardized definition of IPM (Peterson et al. 2018). This would clarify the confusion around what IPM really is and how to use it. A recent publication in this journal (Dara 2019) suggested a reorganization of IPM to incorporate important aspects that have not been formally stated or previously recognized. Human factors are a critical aspect incorporated into this new framework for IPM. These human factors are the psychosocial descriptors of how and why people think and act in certain ways (e.g., motivation and beliefs) and how people relate to one another (e.g., communication methods, trust, and relationships). These human factors, or the 'human element,' also serve as a social factor in the recently explored Social Ecological Systems approach to IPM (Magarey et al. 2019). The roles of people, communication, and related topics are also addressed as a priority by the USDA Federal Integrated Pest Management Coordinating Committee in their revised National Roadmap for IPM (USDA 2018). We will expand on these human factors, with a focus on communication and education among those who teach and practice IPM, exploring why they are so important to increasing the adoption and success of IPM, where we are currently lacking in this area, and how we can address shortcomings.

Why People Are So Important

All aspects of IPM involve people, from those who teach and advocate IPM, such as Extension professionals and IPM consultants (hereafter referred to as 'IPM educators'), to those who use IPM, such as farmers, nursery owners, pest control company workers, and other stakeholders (hereafter referred to as 'IPM practitioners'). In fact, communication among IPM educators and between IPM educators and IPM practitioners (and the general public) is a key component in the new IPM model proposed by Dara (2019). The relationship between the IPM educator and practitioner is the engine that powers IPM adoption and implementation. The IPM educator must provide authentic participation in the IPM program being suggested by listening to the needs and capacities of the practitioner. These needs and capacities must then be incorporated during development of an IPM program and creation of meaningful training opportunities for the IPM practitioner. Targeting training and education to the specific characteristics of each IPM practitioner may encourage higher adoption rates (McNamara et al. 1991). In-depth working knowledge of the system being managed (e.g., field crops versus forest management, corn versus tomatoes, etc.) is needed by the IPM educator in order to make informed recommendations. This helps make a successful program and also eases communication with the IPM practitioner, who is likely very experienced in their system. Demonstrated knowledge of the system and communication based on mutual respect between the educator and practitioner can help foster initial trust in the educator's abilities and intentions. This trust is critical to gain the buy-in required for an operation to try IPM if it is not already used and to follow recommendations. The importance of trust is not a new concept or issue. For example, lack of trust is commonly cited as a primary reason why underserved minority landowners who own forests in the southern United States do not utilize government assistance or seek help from professional foresters (Dwivedi et al. 2016, Schelhas et al. 2018). While not explicitly dealing with IPM programs, these studies emphasize the importance of trust between teachers and practitioners.

The IPM practitioners ultimately drive the system by deciding if IPM is going to be practiced and, if so, to what extent. Beyond this initial decision, these are the individuals who perform the day-to-day work of scouting for pests, identifying and reporting problems, applying management tactics, and evaluating the efficiency and efficacy of the management program. The commitment of IPM practitioners to using IPM and performing IPM-related duties to the best of their ability decides the success of the IPM program, which ultimately affects the long-term continuity of that program.

Current Challenges

What are potential current deficits in addressing the human aspect of IPM? Individuals who become IPM educators can have a wide variety of prior experiences in learning, consulting, and managing IPM based on their specific field, their work experience, and/or their education. It is unlikely that one specific area will need improvement at all institutions or for all new IPM educators. To get a better understanding of the variety of possible challenges in teaching IPM, we informally surveyed 12 early- to mid-career IPM educators (and entomological colleagues) about their past and present experiences with communicating about IPM, what they had to learn on the job, and what they wish they knew prior to starting their position in Extension as an IPM educator. The questions in Table 1 were asked to each IPM educator. Questions were asked either by e-mail or on the phone depending on the needs of the interviewee. Interviewees were associated with universities or university Extension services. Interviewees spanned the country, representing 9 states and 10 institutions. Lists containing up to the 20 most common words or phrases used in responses to each question were generated using TagCrowd (www.tagcrowd.com). Common words (e.g., the, an) were excluded. These lists showing the most repeated words were used along with comparing and contrasting responses to identify themes. These represent the 'repetition' and 'similarities and differences' scrutiny techniques for theme identification, respectively (Ryan and Bernard 2003). Selected question responses and identified themes are shown in Table 1. Responses covered a spectrum of individual challenges and experience levels, emphasizing that changes should be individual or institution-specific. However, there were clear commonalities across participants' responses.

Table 1. Results of a survey of IPM educators

Question	Identified Themes	Example Response
What were your experiences with science communication/extension prior to starting your position?	Lack of leadership opportunities during graduate school Large variation in speaking/teaching opportunities during graduate school Unfamiliarity with informal teaching and new modes of communication (online classes, social media)	'NONE. I had done a few presentations for youth and some pesticide applicators, a few scientific presentations while in graduate school, but I would have never thought I'd be a science communicator. … It was pretty minimal.'
Thinking about the communication aspects of your current position: did you feel adequately prepared for the job when you started?	Intensive on the job learning Large variation in preparedness Familiarity with only traditional formal teaching styles	'I was not prepared for extension when I started my position … I was not prepared to establish an extension program, nor was I really aware of what such a program should look like. I think I would have benefited from knowing that outreach and extension were vastly different.'
What aspects of communication or other interpersonal skills did you have to learn on the job in your position? How long did it take for you to feel comfortable in those skills?	Difficulty with hands-on or in person activities Uneasiness with conflict management Adaptability as a key characteristic	'I am still figuring out how best to maneuver situations where there is inherent conflict … As a new(ish) professional, it can be difficult to establish credibility in charged situations and only as you stay in a position longer can you create that credibility over time.'
What were the biggest challenges you faced in terms of communicating, teaching, and developing or maintaining professional relationships (e.g., between you and a grower/client) in your position?	Time management balance between relationships and communication and other professional responsibilities Earning and maintaining trust	'… one challenge was my relative inexperience in more active forms of teaching with an extension audience. I had some exposure to active teaching techniques with undergraduates, but there are challenges unique to extension in implementing these approaches.'
What, if anything, related to the previously discussed areas do you wish you had more training or experience with before starting your position?	Broader background in relevant topics Management of programs and people Evaluating program success and needs Training in Extension-style communication	'Some essential things I wish I had training in are; customer service, extension assessment and analysis (using more social science type stats), and conflict resolution. Other topics I wish I had more knowledge in but are probably not essential would be graphic design and social media analytics.'

A single representative response is given for each question. Themes identified in the responses to each question show the commonalities in the respondents' experiences.

Question 1: 'What were your experiences with science communication/extension prior to starting your position?'

IPM educators generally spoke of a lack of experience or training in nonacademic, face-to-face communication with IPM practitioners and/or the general public. Experience levels with agricultural or more Extension-style communication varied widely. However, even respondents who had some Extension experience giving talks prior to their career noted a lack of opportunities during graduate school to lead and develop Extension programming. More traditional, research-based graduate degrees and postdoctoral experiences (e.g., scientific conference talks) were common among respondents. Experience communicating in informal educational settings was often limited to outreach to school-aged children, as insect outreach programs are fairly common at large universities or science museums (e.g., Iowa State University Insect Zoo: https://www.ent.iastate.edu/insectzoo/, the Bug Bowl at Purdue University: https://extension.entm.purdue.edu/bugbowl/).

Question 2: 'Thinking about the communication aspects of your current position: did you feel adequately prepared for the job when you started?'

Nearly equal numbers of respondents said they felt prepared to work as an IPM educator as those who said they did not (7 vs 5, respectively). Respondents who reported feeling more prepared for their work had prior experiences working with Extension faculty and opportunities to deliver more traditional extension presentations. Respondents overwhelmingly noted that they had to go through intensive on the job learning in Extension-style communication as their prior learning had been only with traditional formal teaching.

Question 3: 'What aspects of communication or other interpersonal skills did you have to learn on the job in your position? How long did it take for you to feel comfortable in those skills?'

When lacking prior experience, IPM educators reported that on the job development of these skills took 1–2 yr before they began feeling comfortable in their own interpersonal communication with IPM practitioners or other stakeholders. Hands-on, interactive activities were noted as particularly challenging forms of communication to learn. Management of emotions and conflict in IPM educator-practitioner relationships was singled out as difficult skill to learn and one that had to be developed entirely on the job. Many who obtain extension jobs do so in fields which may be outside their formal training and must do intense independent learning about their new field or system on their own time. Based on anecdotal evidence from our own and our peers' experiences, some nonextension professionals believe 'extension is extension' and 'you just have to learn a new system' – two phrases which, while technically correct, do not remotely convey the effort and time required to do these things effectively. After training deeply in a highly specific area during their education, IPM educators often start their career from scratch in an entirely different field, having to cover a wide variety of topics.

Question 4: 'What were the biggest challenges you faced in terms of communicating, teaching, and developing or maintaining professional relationships in your position?'

The biggest challenges respondents identified included time management in balancing practitioner/client relationships and other professional duties, gaining trust of stakeholders, budget constraints, and the huge breadth of expected knowledge. Nearly, all respondents touched on the effort and time required to earn the trust of their new clientele. It can take years for someone new – particularly when not from the geographical area in which they obtained their job – to gain the trust of local farmers, ranchers, or natural resource managers. In many regards, this cannot be taught in an organized setting and is part of growing each relationship over time.

When discussing challenges, we cannot ignore the fact that some respondents reported incidents of communication issues with IPM practitioners stemming from sex, gender, or age bias. One respondent said, 'Even after 2 yr of being in this position, I still have a grower that refuses to let me set foot on his farm because I'm not from [that state], [am] a relatively 'young' female, and wasn't raised growing [commodity]'. While communication issues rising from discrimination based on age, sex, gender identity, race, or sexuality cannot be properly explored in this manuscript, these issues do need to be addressed within both IPM and science in general.

Question 5: 'What, if anything, related to the previously discussed areas do you wish you had more training or experience with before starting your position?'

Respondents all noted some activity related to a career in Extension that they wish they had been trained on or even been informed about prior to starting their position. Evaluating program impact and training in informal Extension-style communication were highlighted. One respondent wanted to know 'How to build an extension program! What are the expectations of a specialist (vs. county agents), especially one with split research responsibilities? What are the guidelines for designing program content and evaluating it? What are the recommendations for tracking inputs and outputs?' General skills in management of programs, budgets, and people were also desired.

Improving IPM Communication

Skills related to enhancing the relationship between the IPM educator and the practitioner deserve attention, as that relationship influences the adoption and success of an IPM program. Like the challenges discussed here, any needed improvements in developing IPM educators will vary by individual and institution. Natural science knowledge (e.g., statistics, biology, chemistry, etc.) is what many future IPM educators get plenty of during their education. But social science and liberal arts skills (e.g., communication, sociology, psychology, etc.) are often largely neglected at science-heavy research institutions, despite future IPM educators needing a broad background in these skills in addition to the scientific knowledge. Identifying and addressing these gaps can help future IPM educators form effective relationships with IPM practitioners from the beginning. Two major initial areas on which focus could be placed are communication and teaching.

Communication plays heavily into the applied skills of persuasion and conflict management and is instrumental in the ability of the IPM educator to gain the trust and respect of the IPM practitioner (Breetz et al. 2005, Ahmadvand and Karami 2007). Those with effective communication skills – which should be based in two-way communication, or listening and asking questions, not just talking – almost always make more effective and influential IPM educators (Leeuwis 2004). Based on experience, those lacking these essential communication skills rarely excel in this area. Unfortunately, formal instruction on how to communicate is rarely a requirement during traditional graduate education in agriculture, natural resources, and life sciences. Interested individuals often have to seek out this training on their own time. Based on the anecdotal evidence presented here, extension professionals have a high likelihood of needing to learn most of these communication lessons on the job. Based on the authors' experience and interviewee stories, communicating to the general public, or any nonscientifically trained audience, is never as easy or straightforward as it may seem, even for the most prolific and polished scientific speakers and writers. Collaborations with humanities programs and professional science communicators could provide fruitful continuing education opportunities for IPM educators and other scientists to ease these challenges.

Future IPM educators need instruction on teaching in informal settings away from lecture-style academic courses and research talks. IPM educators must be able to communicate with industry professionals, landowners, and children and families through writing, speaking, and media outlets such as radio, television, and online platforms like blogs and social media (Allen et al. 2010, Brownell et al. 2013). Training on how to interact with the media is also needed (Ruth et al. 2005). Infographics and other visual communication products can be critical in communicating information, making design and artistic skills desirable and collaborations with professional scientific artists even better. How to conduct and evaluate effective IPM education should also receive time during the professional development of IPM educators (Engel and van den Bor 1995, Strong et al. 2010). Individual or institution-level needs assessment in the form of surveys or other tools should help explore what specific training and education can be created or improved. Strengths and weaknesses will vary, so there cannot and should not be a one-size-fits-all solution.

Here we have addressed part of the human aspect involved in IPM from the view of IPM educators. Similar assessment of IPM practitioners would likely reveal a separate, but overlapping, set of challenges and needs. Keeping records of scouting and management efficacy and providing training on pest recognition and scouting techniques for employees are just two areas where IPM practitioners may encounter human-related roadblocks to successful adoption of IPM. These are areas in which IPM educators may also potentially assist the practitioner.

Some may say that we're advocating for too much extra work and training, that the time in graduate school is finite, and that no one can possibly learn everything they'll need to know during this period in their life. We agree – one cannot possibly get 100% prepared for their future job during graduate school. But many of the communication concerns brought up here could be addressed. Perhaps IPM internships, where students shadow or work with an experienced IPM educator (e.g., an Extension professional), would help future IPM educators be effective more quickly in their careers. New training programs for recently-hired Extension professionals focused on communication and other interpersonal considerations could also help educators settle into their role faster.

Here, we explored the communication aspect of the human factors involved in IPM. Going forward, IPM educators, practitioners, and other professionals should consider all the human factors that affect IPM and create strong collaborations with our colleagues in applicable fields, such as psychology and sociology, when conducting research or training. Recognizing and showing appreciation for the important roles that all people play in the implementation and success of IPM will encourage engagement in and retention of IPM programs. Seeing people as an integral part of IPM, not something outside of it, will push IPM adoption and success to new heights.

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References Cited

Agricultural Statistics Board. 2001. Pest management practices 2000 summary. Natl. Agric. Statist. Serv. Publ. Sp Cr 1 (01): 10–28.

Ahmadvand, M. and E. Karami. 2007. Sustainable agriculture: towards a conflict management based agricultural extension. J. Appl. Sci. 7: 3880–3890.

Allen, K., K. Abrams, C. Meyers, and A. Shultz. 2010. A little birdie told me about agriculture: best practices and future use of Twitter in agricultural communications. J. Appl. Commun. 94(3). doi:10.4148/1051-0834.1189.

Bajwa, W. I. and M. Kogan. 2002. Compendium of IPM Definitions (CID) - What is IPM and how is it defined in the Worldwide Literature? IPPC Publication No. 998, Integrated Plant Protection Center (IPPC), Oregon State University, Corvallis, OR.

Breetz, H. L., K. Fisher-Vanden, H. Jacobs, and C. Schary. 2005. Trust and communication: mechanisms for increasing farmers' participation in water quality trading. Land Econ. 81: 170–190.

Brownell, S. E., J. V. Price, and L. Steinman. 2013. Science communication to the general public: why we need to teach undergraduate and graduate students this skill as part of their formal scientific training. J. Undergrad. Neurosci. Educ. 12: E6–E10.

Damalas, C. A., and I. G. Eleftherohorinos. 2011. Pesticide exposure, safety issues, and risk assessment indicators. Int. J. Environ. Res. Public Health. 8: 1402–1419.

Dara, S. 2019. The new integrated pest management paradigm for the modern age. J. Integr. Pest Manage. 10(1): 12; 1–9.

Dwivedi, P., A. Jagadish, and J. Schelhas. 2016. Perceptions of stakeholder groups abouts the participation of African American family forest landowners in federal landowner assistance programs. J. For. 114: 89–96.

Ehler, L. E. 2006. Integrated pest management (IPM): definition, historical development and implementation, and the other IPM. Pest Manag. Sci. 62: 787–789.

Ehler, L. E. and D. G. Bottrell. 2000. The illusion of integrated pest management. Issues Sci. Technol. 16: 61–64.

Engel, P. G. H. and W. van den Bor. 1995. Agricultural education from a knowledge systems perspective: from teaching to facilitating joint inquiry and learning. Eur. J. Agric. Educ. Ext. 1: 1–23.

Gilden, R. C., K. Huffling, and B. Sattler. 2010. Pesticides and health risks. J. Obstet. Gynecol. Neonatal Nurs. 39: 103–110.

Gould, F., Z. S. Brown, and J. Kuzma. 2018. Wicked evolution: can we address the sociobiological dilemma of pesticide resistance? Science. 360: 728–732.

Hubbell, B. J., W. J. Florkowski, R. Oetting, S. K. Braman, and C. D. Robacker. 2001. Implications of lawn care and landscape maintenance firm profiles for adoption of pest-management practices. J. Agric. Appl. Econ. 33: 147–159.

LeBude, A., A. Fulcher, J.-J. Dubois, S. Kris Braman, M. Chappell, J.-H. Chong, J. Derr, N. Gauthier, F. Hale, W. Klingeman *et al.* 2017. Experiential nursery integrated pest management workshop series to enhance grower practice adoption. HortTechnology 27: 772–781.

Leeuwis, C. 2004. Communication for rural innovation: rethinking agricultural extension. Blackwell Publishing, Oxford, United Kingdom. 428 p.

Losey J. E. and M. Vaughan. 2006. The economic values of ecological services provided by insects. BioScience 56: 311–323.

Magarey, R. D., T. M. Chappell, C. M. Trexler, G. R. Pallipparambil, and E. F. Hain. 2019. Social ecological system tools for improving crop pest management. J. Integr. Pest Manage. 10(1): 1–6.

McNamara, K. T., M. E. Wetzstein, and G. K. Douce. 1991. Factors affecting peanut producer adoption of integrated pest management. Appl. Econ. Perspect. Policy 13: 129–139.

Miller, C. M. and F. Meek. 2004. Cost and efficacy comparison of integrated pest management strategies with monthly spray insecticide applications for German cockroach (Dictyoptera: Blattellidae) control in public housing. J. Econ. Entomol. 97: 559–569.

Nalyanya, G., J. C. Gore, H. M. Linker, and C. Schal. 2009. German cockroach allergen levels in North Carolina schools: comparison of integrated pest management and conventional cockroach control. J. Med. Entomol. 46: 420–427.

Peterson, R. K. D., L. G. Higley, and L. P. Pedigo. 2018. Whatever happened to IPM? Am. Entomol. 64: 146–150.

Pimentel D. 2005. Environmental and economic costs of the application of pesticides primarily in the United States. Environ. Develop. Sustain. 7: 229–252.

Ruth, A., L. Lundy, R. Telg, and T. Irani. 2005. Trying to relate: media relations training needs of agricultural scientists. Sci. Commun. 27: 127–145.

Ryan, G. W. and H. R. Bernard. 2003. Techniques to identify themes. Field Methods 15: 85–109.

Schelhas, J., S. Hitchner, and P. Dwivedi. 2018. Strategies for successful engagement of African American landowners in forestry. J. For. 116: 581–588.

Shahraki, G. H., M. N. Hafidzi, M. S. Khadri, J. Rafinejad, and Y. B. Ibrahim. 2011. Cost-effectiveness of integrated pest management compared with insecticidal spraying against the German cockroach in apartment buildings. Neotrop. Entomol. 40: 607–612.

Smith, R. F. and G. L. Smith. 1949. Supervised control of insects utilizes parasites and predators and makes chemical control more efficient. California Agric. 3: 12.

Stern, V. M., R. F. Smith, R. van den Bosch, and K. S. Hagen. 1959. The integration of chemical and biological control of the spotted alfalfa aphid: the integrated control concept. Hilgardia 29: 81–101.

Stetkiewicz, S., A. Bruce, F. J. Burnett, R. A. Ennos, and C. F. E. Topp. 2018. Perception vs practice: farmer attitudes towards and uptake of IPM in Scottish spring barley. Crop Protect. 112: 96–102.

Strong, R., A. Harder, and H. Carter. 2010. Agricultural Extension agents' perceptions of effective teaching strategies for adult learners in the Master Beef Producer program. J. Ext. 48: 1–7.

USDA. 2018. A national roadmap for integrated pest management. <https://www.ars.usda.gov/ARSUserFiles/OPMP/IPM%20Road%20Map%20FINAL.pdf>. Accessed 14 April 2019.

Weddle, P. W., S. C. Welter, and D. Thomson. 2009. History of IPM in California pears–50 years of pesticide use and the transition to biologically intensive IPM. Pest Manag. Sci. 65: 1287–1292.

Williams, G. M., H. M. Linker, M. G. Waldvogel, R. B. Leidy, and C. Schal. 2005. Comparison of conventional and integrated pest management programs in public schools. J. Econ. Entomol. 98: 1275–1283.