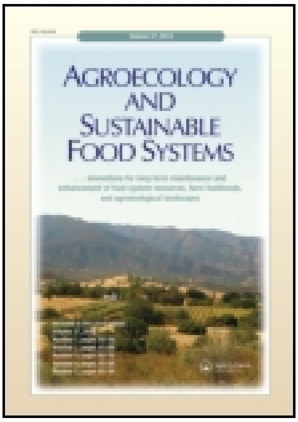
CORE

Metadata, citation and similar papers at core.ac.uk

Provided by Organic Eprints

On: 12 October 2013, At: 18:56
Publisher: Taylor & Francis
Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



Agroecology and Sustainable Food Systems

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/wjsa21

Aligning Insect IPM Programs with a Cropping Systems Perspective: Cover Crops and Cultural Pest Control in Wisconsin Organic Corn and Soybean

Eileen M. Cullen [a] & Katelin M. Holm [b]

[a] Department of Entomology , University of Wisconsin , Madison , Wisconsin , USA

[b] Polk County Wisconsin Land and Water Resources Department , Balsam Lake , Wisconsin , USA

Accepted author version posted online: 03 Jan 2013.Published online: 12 Mar 2013.

To cite this article: Eileen M. Cullen & Katelin M. Holm (2013) Aligning Insect IPM Programs with a Cropping Systems Perspective: Cover Crops and Cultural Pest Control in Wisconsin Organic Corn and Soybean, Agroecology and Sustainable Food Systems, 37:5, 550-577, DOI: 10.1080/21683565.2012.762438

To link to this article: http://dx.doi.org/10.1080/21683565.2012.762438

PLEASE SCROLL DOWN FOR ARTICLE

Taylor & Francis makes every effort to ensure the accuracy of all the information (the "Content") contained in the publications on our platform. However, Taylor & Francis, our agents, and our licensors make no representations or warranties whatsoever as to the accuracy, completeness, or suitability for any purpose of the Content. Any opinions and views expressed in this publication are the opinions and views of the authors, and are not the views of or endorsed by Taylor & Francis. The accuracy of the Content should not be relied upon and should be independently verified with primary sources of information. Taylor and Francis shall not be liable for any losses, actions, claims, proceedings, demands, costs, expenses, damages, and other liabilities whatsoever or howsoever caused arising directly or indirectly in connection with, in relation to or arising out of the use of the Content.

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden. Terms &

Conditions of access and use can be found at http://www.tandfonline.com/page/terms-and-conditions

Downloaded by [68.117.130.162] at 18:56 12 October 2013

Agroecology and Sustainable Food Systems, 37:550–577, 2013
Copyright © Taylor & Francis Group, LLC
ISSN: 2168-3565 print/2168-3573 online
DOI: 10.1080/21683565.2012.762438

Taylor & Francis
Taylor & Francis Group

Aligning Insect IPM Programs with a Cropping Systems Perspective: Cover Crops and Cultural Pest Control in Wisconsin Organic Corn and Soybean

EILEEN M. CULLEN[1] and KATELIN M. HOLM[2]
[1]*Department of Entomology, University of Wisconsin, Madison, Wisconsin, USA*
[2]*Polk County Wisconsin Land and Water Resources Department, Balsam Lake, Wisconsin, USA*

Downloaded by [68.117.130.162] at 18:56 12 October 2013
Archived at http://orgprints.org/24311

This article presents a conversation among researcher, agroecology student, and farmers about the association between cover crops and seedcorn maggot in organic grain crops. Survey data showed that Wisconsin organic farmers would use cover crop management, insect degree day forecasting, and planting date cultural controls, given appropriate knowledge context and extension information provision. We developed electronic and print resources and engaged with farmers and educators nationally through the eOrganic Community of Practice. Project outcomes exemplify student and farmer ability to effect change in land grant university extension recommendations through integrated pest management content and delivery aligned with a cropping systems perspective.

KEYWORDS agroecology, corn, cover crops, integrated pest management, organic, seedcorn maggot, soybean

The authors thank Duncan Hilchey for helpful discussion, and two anonymous reviewers for comments on previous versions of the manuscript. They also thank David Stoltenberg and James Stute for input on the survey questionnaire content and validity, and Wisconsin organic farmers for sharing their experience and perspectives on organic pest management. K. M. Holm conducted the farmer survey as part of her public practice Masters in Agroecology at the University of Wisconsin-Madison. This project was funded in part by a USDA Organic Agriculture Research and Extension Initiative Grant 2010-51300-21282.

Address correspondence to Eileen M. Cullen, Associate Professor, Department of Entomology, University of Wisconsin, 1630 Linden Drive, Madison, WI 53706 USA. E-mail: cullen@entomology.wisc.edu

INTRODUCTION

Integrated pest management (IPM) practitioners have long recognized the pest management benefits of cultural control (El-Zik et al. 1989; Schellhorn et al. 2000; Bajwa and Kogan 2004). Cultural control is the purposeful manipulation of a cropping system's agronomic practices to reduce likelihood of pest infestation and damage. Agronomic practices can serve multiple purposes. For example, legume or small grain cover crops incorporated into corn and soybean grain crop rotations provide soil protection, soil fertility, soil organic matter, and groundwater quality benefits as well as potential pest management advantages (Altieri and Nicholls 2000; Hatfield et al. 2009; David et al. 2010). Adding cover crops to an annual grain cropping system is management intensive, the greatest issue being timing of fall establishment and spring termination. Farmers must strike a balance between maximizing cover crop benefits such as reduced soil erosion and nutrient capture while minimizing the risk of corn and soybean yield reductions (Practical Farmers of Iowa 2011).

Cropping systems evolve in response to a region's agroecological conditions and the sociocultural and economic characteristics of its human population (Bajwa and Kogan 2004). Cover crops in annual grain production systems fit best with no-till, strip-till, or spring tillage systems because they give the cover crop a longer growth period (Practical Farmers of Iowa 2011). Although cover crops have been shown to improve nutrient use efficiency and help reduce phosphorus runoff, cover cropping is rare across the conventional grain crop landscape of the United States Corn Belt (U.S. Environmental Protection Agency (USEPA) 2007; Singer et al. 2007). Jacobson et al. (2011) recognize that this practice would alter the current agricultural system and can therefore be difficult to implement. Conversely, we would expect adoption of cover cropping practices to be common in organic grain crop systems in the same region. USDA National Organic Program standards that growers must adopt, and document with a written organic system plan, to maintain organic certification stipulate use of cover crops under sections 205.203 (soil fertility and crop nutrient management practice), 205.205 (crop rotation practice), and 205.206 (crop pest, weed, and disease management practice), respectively (U.S. Department of Agriculture [USDA] 2012).

As a pest management cultural control approach, cover crops have both pros and cons, depending on the cropping system. Potential benefits include attraction and sustenance of beneficial insects, spiders and mites, while disadvantages include attraction of insect or rodent pests (Ingels et al. 1994). For example, the seedcorn maggot, *Delia platura* (Meigen), is a soil insect pest of corn and soybean. Seedcorn maggot flies are attracted to lay eggs in fields with decaying green plant material or animal manure organic matter (Hammond and Cooper 1993; Rice and Oleson 2001). Therefore, incorporation of a living green cover crop at spring tillage shortly before corn or

Downloaded by [68.117.130.162] at 18:56 12 October 2013

soybean planting can increase seedcorn maggot populations. Eggs hatch within 2–4 days and develop through three larval instars occurring in the soil where maggots feed on germinating corn and soybean seeds.

Although cover crops play a significant role in multifunctional landscapes of organic cropping systems, this practice can increase attractiveness of fields to adult seed corn maggot flies. Seedcorn maggot damage can be minimized by planting corn and soybean during the fly-free period between generations when the population is entering its non-feeding pupal stage. This approach requires an understanding of the insect's life cycle, behavior, and damage potential in relation to cover crop incorporation timing, tillage intensity, and grain crop planting date (Hammond and Cooper 1993). Cultural control, therefore, represents a fundamental IPM tactic when applied with knowledge of the bionomics, behavior, and ecology of the pest in relation to the cropping system (Bajwa and Kogan 2004).

This article presents an innovative teaching and public engagement approach between a land-grant university researcher and extension specialist, an agroecology graduate student, and Wisconsin organic grain crop farmers. We formed this collaboration through the University of Wisconsin-Madison agroecology program as part of a public practice Masters project (University of Wisconsin 2012a). We used the association between cover crops and seedcorn maggot risk in organic grain cropping systems to initiate a dialogue among university, student, and farmers about knowledge-intensive agronomic practices as the basis of cultural control in organic pest management programs.

Wisconsin organic grain crop farmers participated in a mail survey to provide data on crop rotation practices, their awareness of seedcorn maggot risk to corn and soybean following spring cover crop incorporation, and their perceptions of implementing cultural control using insect degree days, cover crop management, and grain crop planting date tactics. We also explored how organic farmers prefer to receive information on seedcorn maggot management, in particular, and organic IPM programs, in general. This article begins by focusing on farmer-participant survey response data. We then discuss the extension entomology IPM programming approach we took to incorporate knowledge and information shared by organic farmer survey participants, and project outcomes that increase farmer access to cultural control IPM information appropriate to organic grain cropping systems.

Downloaded by [68.117.130.162] at 18:56 12 October 2013

METHODOLOGY

Agroecology Public Practice Masters Project

The goal of our agroecology Masters' public practice project was to begin a dialogue with Wisconsin organic farmers about a domestic agricultural land use question. Based on ecological linkage between cover cropping and seedcorn maggot in annual grain crop systems, and our hypothesis that organic farmers have adopted this agronomic practice without knowledge of cultural control consequences for insect pest management, this project had four objectives:

1) Determine current crop rotation practices used by organic corn and soybean farmers in Wisconsin.
2) Assess farmer awareness of seedcorn maggot pest potential to corn and soybean following spring incorporation of a cover crop.
3) Understand farmer perceptions of the feasibility of implementing cultural pest control for seedcorn maggot on their own farms using insect degree day forecasting, cover crop management, and grain crop planting date tactics.
4) Exemplify innovative methods of public engagement and information provision concerning organic IPM programs to Wisconsin farmers.

Downloaded by [68.117.130.162] at 18:56 12 October 2013

Survey Instrument

A descriptive survey research design was used to collect data from farmer participants (Ary et al. 1990; Lozier et al. 2004; Boone et al. 2007). A self-administered written questionnaire was developed from a review of the literature on seedcorn maggot bionomics, behavior, and ecology in Midwestern United States annual grain cropping systems with spring tillage incorporation of green cover crops prior to planting. Questionnaire content and face validity were established by a panel of experts consisting of a Wisconsin organic grain crop farmer, a University of Wisconsin-Madison agronomist, and a University of Wisconsin-Extension county agent that works with organic grain crop farmers (Litwin 1995). Modifications were made to the questionnaire in response to validity testers' interpretation of the survey instrument to incorporate their suggested improvements.

The questionnaire, entitled, "Organic Growers' Perspective of Seedcorn Maggot: A Survey of Wisconsin Organic Growers About Seedcorn Maggot Management," was comprised of four sections (Table 1). Most questions were multiple choice and required participants to check only one answer. Where appropriate, respondents were asked to check all choices that applied. Some questions included open-ended response format and an extra page was included for additional comments.

In the first section, questions 1–3 asked participants about their current cropping system practices and insect related stand losses in general.

The second section, questions 4–7, asked participants if they had received information about seedcorn maggot specifically, where they received such information, observation of seedcorn maggot damage on their farms, and their preferred organic pest management techniques (if any) for seedcorn maggot.

Downloaded by [68.117.130.162] at 18:56 12 October 2013

TABLE 1 Questionnaire content for the survey instrument: Organic Growers' Perspective of Seedcorn Maggot—A survey of Wisconsin organic growers about seedcorn maggot management

Questions 1–3 asked farmers about their cropping systems and insect-related stand loss	
Q 1	Do you plant corn as part of your crop rotation?
Q 2	Do you plant soybean as part of your crop rotation?
Q 3	Do you plant vegetables as part of your crop rotation?
	If Yes (Questions 1–3, respectively) . . .
	Do you incorporate a living green legume (e.g. alfalfa, clover, etc.) into the soil in spring prior to planting?
	Do you experience insect-related stand loss in fields planted following spring legume incorporation?
	Do you incorporate a living green grass (e.g., winter rye) into the soil in spring prior to planting corn?
	Do you experience insect related stand loss in fields planted following spring grass incorporation?
Questions 4–7 asked farmers where they have received information about seedcorn maggot, occurrence of seedcorn maggot in their cropping systems, and preferred management approach for this pest	
Q 4	Have you received information about seedcorn maggot? : *If Yes* . . . Please identify source(s)
Q 5	Is seedcorn maggot a problem in your fields?
Q 6	How did you confirm presence of seedcorn maggot in your fields?
Q 7	What is your preferred method of management for seedcorn maggot?
Questions 8–13 asked farmers to provide their opinion about using knowledge of the seedcorn maggot lifecycle as a cultural control approach to manage this insect pest	
Q 8	Are you interested in using degree days to predict seedcorn maggot peak adult emergence and adjust planting date to minimize crop damage?
Q 9	What factors might prevent you from using seedcorn maggot degree days?
Q 10	Would you be willing to wait 2.5 to 3 weeks after spring cover crop tillage to plant?
Q 11	What factors might prevent you from waiting 2.5 to 3 weeks after spring cover crop incorporation to plant?
Q 12	Are you interested in implementing a seedcorn maggot trapping system in your fields to identify seedcorn maggot peak adult emergence and adjust planting date to minimize crop damage?
Q 13	What factors might prevent you from adopting a seedcorn maggot trapping system?
Question 14 asked farmers to provide information about their preference for receiving information about insect pest management for organic agriculture	
Q 14	How would you like University of Wisconsin-Extension Entomology to provide information about insect pest management options for organic agriculture?

Next, the survey instrument presented participants with a brief description of seedcorn maggot behavior and life cycle, followed by an explanation of three monitoring techniques that have been published in the entomological research literature to minimize seedcorn maggot damage to corn and soybean using a cultural control approach.

The cultural control strategy is to plant corn and soybean during the "fly-free" window between seedcorn maggot generations, when the population is nearing its non-feeding pupal stage. Determining the fly-free period requires an understanding of seedcorn maggot degree days. Degree days measure heat unit accumulation required for insect development and are calculated on a daily basis, using weather station data nearest the farm or field where IPM decisions are made (Sanborn et al. 1982; Funderburk et al. 1984; University of California Integrated Pest Management Program [UC IPM] 2003a). For farmers to plant corn and soybean crops during the fly-free period, it is first necessary to determine peak fly emergence when 50% of the spring population has emerged as flies. The majority of eggs will be laid in freshly plowed fields during this period of peak fly activity, thus farmers can avoid planting during this time when crop damage risk is highest. The three monitoring techniques presented for participant consideration in the survey were:

1) Calculate seedcorn maggot degree days beginning January 1. Peak adult emergence of the spring generation occurs at 360 Fahrenheit degree days (base 39°F) or 200 Celsius degree days (base 3.9°C) (Funderburk et al. 1984).
2) Assume peak adult emergence occurs at the date of spring tillage cover crop incorporation since adult seedcorn maggot flies are most attracted to freshly plowed fields with decomposing green plant material (Hammond 1995).
3) Set out yellow pan traps filled with soapy water around field edges. Check weekly during spring to identify, count, and record seedcorn maggot flies and determine peak emergence (Broatch and Vernon 1997; Delahaut 2007).

Following this description of seedcorn maggot cultural control, questions 8–13 asked participants to indicate their relative interest in using each of the three monitoring techniques as part of a seedcorn maggot cultural control strategy on their farm, and to identify barriers that would prevent them from using one or more of the IPM monitoring techniques.

Finally, question 14 asked participants how they would like University of Wisconsin to offer information about insect pest management for organic grain cropping systems.

The mail questionnaire and farmer participant consent process were reviewed by the University of Wisconsin-Madison Education Research Institutional Review Board (protocol SE-2008-0529).

Data Collection and Analysis

The survey population consisted of 561 organic farmers from Wisconsin in the Midwestern United States. This population was obtained by combining up-to-date mailing lists of organic grain and vegetable crop farmers

Downloaded by [68.117.130.162] at 18:56 12 October 2013

Downloaded by [68.117.130.162] at 18:56 12 October 2013

provided by the University of Wisconsin-Madison Center for Integrated Agricultural Systems and the Midwest Organic Services Association, Inc., Viroqua, Wisconsin. Duplicate names that appeared on both lists were removed so that individuals were not counted twice. Individuals of the population were divided into homogeneous subgroups, or strata, by county before sampling. A stratified random sample was then drawn from 57 of Wisconsin's 72 counties in a number proportional to each stratum's size when compared to the population. The survey sample was comprised of 252 organic corn and soybean farmers, and each farmer in this sample was mailed a questionnaire.

Data were collected using Dillman's (1978) total design method. A cover letter, questionnaire, and self-addressed stamped return envelope were mailed to farmers on December 1, 2008. The cover letter explained the purpose of the project, assured respondent confidentiality, and provided brief instructions for completing the questionnaire. Approximately one week later, December 10, a reminder postcard was mailed to non-respondents. On January 23, 2009, a replacement survey, cover letter, and self-addressed stamped return envelope were mailed to remaining non-respondents.

Survey data were analyzed using SPSS Statistics 20.0 (IBM SPSS, Chicago, IL, USA). Appropriate descriptive statistical procedures were employed (frequencies, percentages, means, and standard deviations). Qualitative responses to open-ended questions were grouped to correspond with each question, and coded to identify overarching themes (Knutson et al. 2011).

Public Engagement to Increase Organic IPM Information Provision through Extension

Survey response data from Wisconsin organic farmers about their cover cropping practices, awareness of seedcorn maggot, perceptions of cultural pest control tactics, and preferred sources for accessing insect IPM information contributed to the next phase of this project. We used this farmer input as a springboard to increase organic IPM program information access and relevance to farmers who have already adopted cover crops in an annual grain cropping system but were not previously aware of the association between cover crops and seedcorn maggot.

Online degree day calculator IPM decision support tool

Because seedcorn maggot damage can be minimized by planting corn and soybean during the fly-free period between generations, we developed an online IPM decision support tool to help farmers quickly and easily track seedcorn maggot growth and development using insect degree days as part of a cultural control IPM program. The UW-Extension Ag Weather website maintained by the University of Wisconsin-Madison Department of Soil Science provides grid-interpolated daily air temperature data from automated weather stations across Wisconsin and Minnesota (University of Wisconsin 2010). This weather station network and an internet delivery service were used to create a seedcorn maggot thermal model to help farmers monitor seedcorn maggot growth and development near the farm or field where IPM decisions are being made.

The literature on seedcorn maggot biology and phenology was reviewed and applied to thermal model computer programming requirements. Required model components include a lower developmental threshold, or base temperature, of 3.9°C (39°F) below which seedcorn maggot development stops, an upper developmental threshold temperature of 28.9°C (84°F) above which seedcorn maggot growth rate begins to decrease, and a biofix date of January 1, the date from which to begin seedcorn maggot degree day accumulation. A single sine calculation with horizontal cutoff at the upper developmental threshold temperature was used in the seedcorn maggot thermal model (Sanborn et al. 1982; Funderburk et al. 1984; UC IPM 2003b).

Downloaded by [68.117.130.162] at 18:56 12 October 2013

Extension publication series on organic field crop IPM

Although survey respondents could benefit from knowledge about seedcorn maggot and insect IPM within the context of organic grain cropping systems, no such extension entomology resources were available to farmers at the time of this study. Based on farmer survey response (Table 2), we launched a new publication series through University of Wisconsin-Extension Cooperative Extension Publishing titled “Insect IPM in Organic Field Crops.”

eOrganic community of practice

We partnered with eOrganic, the eXtension Community of Practice for organic agriculture, to expand the scope of public engagement about insect

TABLE 2 Farmers’ preferred information sources on organic agriculture insect pest management

How would you like UW-Extension to provide information about insect pest management for organic cropping systems? (Check all that apply)	Response (n = 134)	
	No. of respondents	Percentage
Field days on organic farms	85	63
Field days at University of Wisconsin research farms	44	33
UW-Extension fact sheets written for organic cropping systems	99	74
Internet	50	37
E-mail	28	21
Grower and Extension agent discussion networks	29	22
Other[a]	16	12

[a]Comments in Other category (representative comment):
–By regular mail.

Downloaded by [68.117.130.162] at 18:56 12 October 2013

IPM programs for organic grain cropping systems (eXtension 2012). The mission of eOrganic is to a) engage farmers, agricultural professionals, and other members of the organic agriculture community with timely and relevant science-, experience-, and regulation-based information in a variety of media and educational formats, and b) foster a national organic research and outreach community (eOrganic 2012a). We presented a free web-based workshop, or webinar, facilitated by eOrganic. A webinar reaches a national and international audience via live presentation and audience members can participate by typing in questions, which speakers respond to, during a live chat portion of the program moderated by eOrganic staff (eOrganic 2012b).

The 75-minute webinar and discussion forum, "Integrated Pest Management in Organic Field Crops," was presented on March 29, 2011. The webinar was co-taught by a university researcher, graduate student, and organic farmer. First, the farmer shared her cultural control IPM approaches to minimizing insect pest damage in an organic cropping system. Next, the researcher and graduate student presented information and results from research relevant to organic grain cropping systems. The webinar highlighted seedcorn maggot as a case study of cultural insect control in organic corn and soybean. Objectives of the webinar were to increase participant understanding of how agronomic practices affect cultural pest control outcomes, how to access insect degree day information, and how to apply knowledge of insect pest life cycles to corn and soybean planting date decisions.

After the webinar, e-mails were sent to each of the participants inviting them to complete a brief online evaluation of the webinar. Several follow up reminders were sent over a two-week period. Evaluation survey questions asked participants about their professional role, the geographic region where they work, extent to which their understanding of the topic was improved by participation in the webinar, extent to which they intend to apply the information in their work, whether the technical level of the presentation was appropriate, and whether they would recommend this webinar to others. Webinar participant feedback results are reported in the format used by Coe (2011).

RESULTS

Survey of Wisconsin Organic Farmers About Seedcorn Maggot Cultural Pest Control

We obtained a 60% response rate for the mail survey with 152 completed questionnaires returned from the total sample of 252. Farmer respondents are located in 55 of the 57 counties surveyed, with a mean concentration of 3 respondents per county and a range of 1 to 22 respondents per county across the 55 counties represented in the survey.

Downloaded by [68.117.130.162] at 18:56 12 October 2013

Cropping system practices

A majority of respondents grow corn (91%) as part of their organic crop rotation, and 78% of those incorporate a living green legume cover crop into the soil in spring prior to planting corn. Organic corn is less likely to be preceded by a grass cover crop (38%).

Approximately half of all respondents (40%) include soybean in their organic crop rotation. Among this group, it is more common to incorporate a grass (38%) than a legume (26%) cover crop in spring before soybean planting.

Additionally, 16% of all respondents plant vegetable crops, including green bean, pea, onion, potato and sweet corn, as part of their organic grain crop rotation. Half of these respondents incorporate a legume (52%) or grass (52%) cover crop in spring prior to seeding vegetable crops.

Two thirds of the respondents who practice cover cropping plant corn or soybean into cover crop residue within 14 days of tillage incorporation (Figures 1 and 2). Results for time between cover crop incorporation and vegetable crop planting indicate a longer waiting period with response frequencies at time intervals greater than 14 days (Figure 3).

Tillage tools and intensity of soil disturbance and cover crop residue incorporation are presented in Table 3 for all cover crop-cash crop categories in the survey.

Insect-related stand loss following cover crop incorporation

Most farmers in the survey are confident they have not sustained insect-related stand losses in corn following spring incorporated legume (n = 103; 63%) or grass (n = 53; 62%) cover crops. Approximately one third of respondents have observed stand loss in corn planted after spring incorporation of a living green cover crop, however, they have not diagnosed the cause and are unsure if stand losses are insect-related in corn following a legume (n = 103; 32%) or grass (n = 53; 25%) cover crop. A small percentage of farmers responded with certainty that stand losses are insect-related in corn following legume (n = 103; 5%) or grass (n = 53; 13%) cover crops.

Perception of insect-related stand loss in soybean following spring cover crop incorporation also revealed that most respondents have not experienced soybean stand loss following a legume (n = 16; 69%) or grass (n = 23; 57%) cover crop. One quarter of respondents have observed soybean stand loss when planting into freshly tilled cover crop residue. However this group had not diagnosed the problem and was unsure if losses are insect-related when soybean follows a legume (n = 16; 25%) or grass (n = 23; 30%) cover crop. Only 6.3% (n = 16) and 13.0% (n = 23) of farmers responded with certainty that soybean stand losses are insect-related when soybean follows a spring incorporated grass or legume cover crop, respectively.

Downloaded by [68.117.130.162] at 18:56 12 October 2013

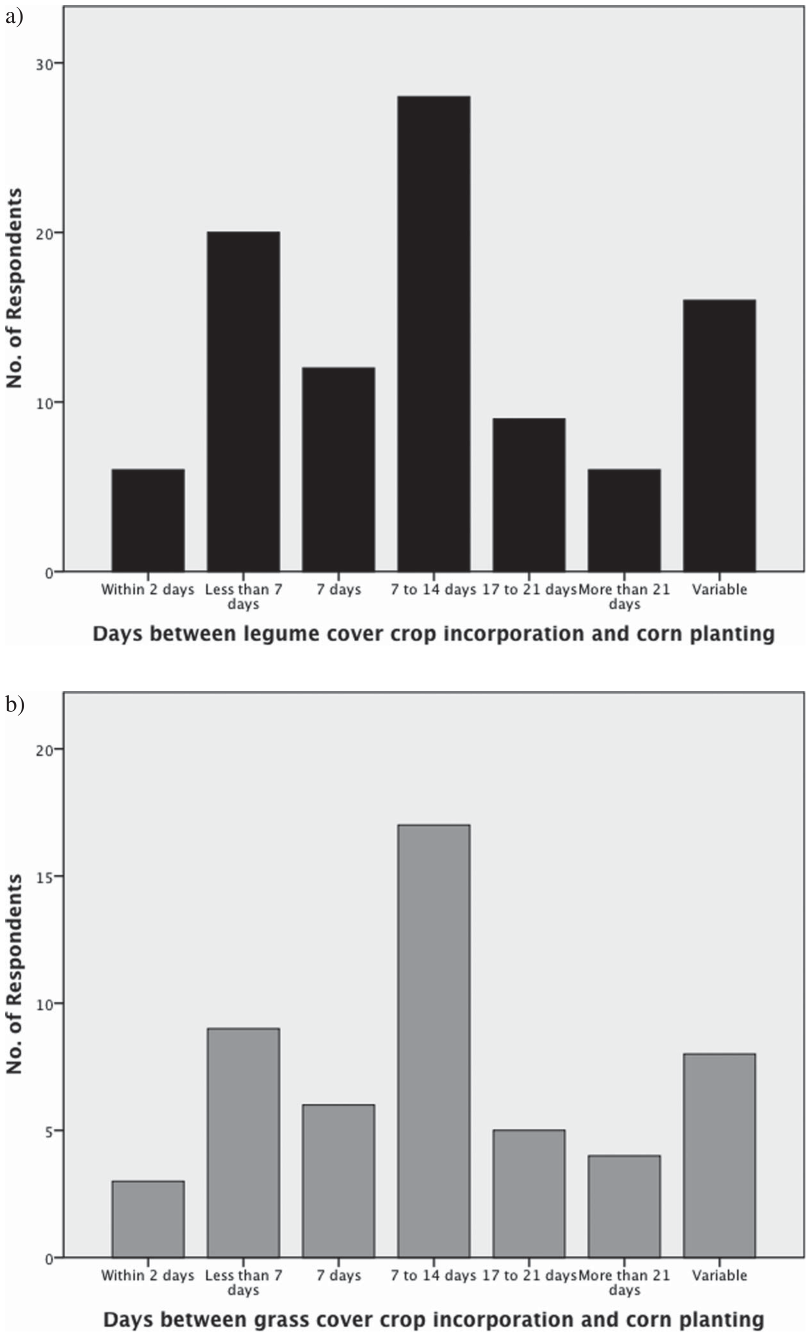
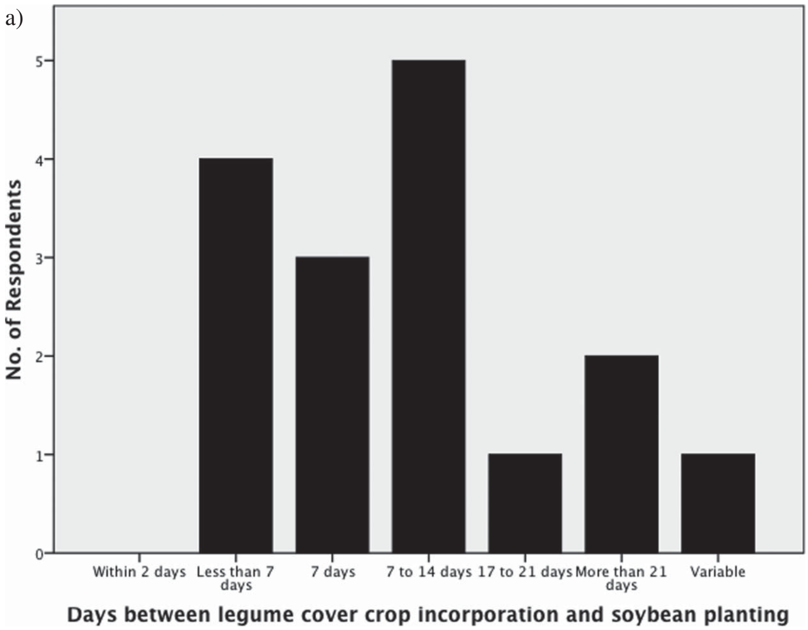


FIGURE 1 a) Response frequency for interval between spring tillage incorporation of a legume cover crop and corn planting date in days (n = 107 respondents); b) response frequency for interval between spring tillage incorporation of a grass cover crop and corn planting date in days (n = 52 respondents).

Downloaded by [68.117.130.162] at 18:56 12 October 2013

a)



b)

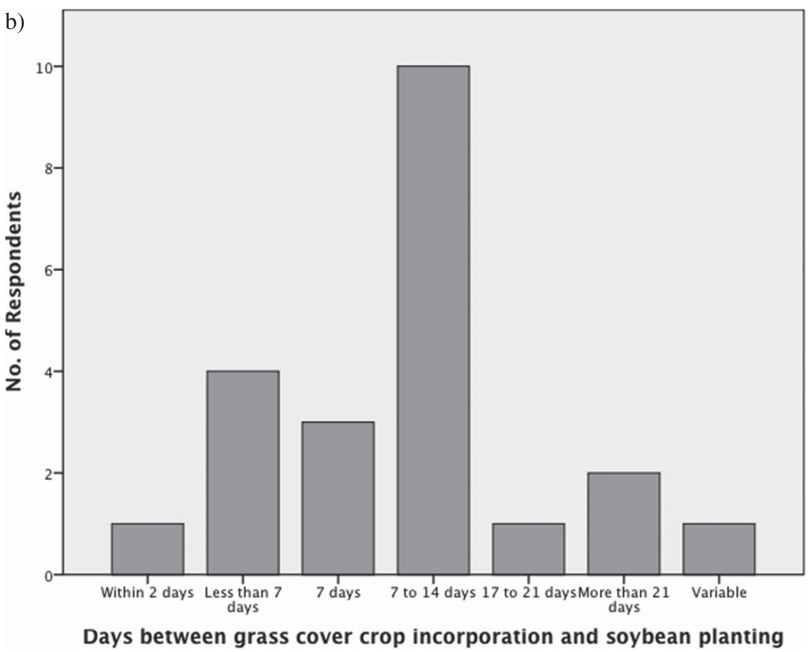


FIGURE 2 a) Response frequency for interval between spring tillage incorporation of a legume cover crop and soybean planting date in days (n = 16 respondents); b) response frequency for interval between spring tillage incorporation of a grass cover crop and soybean planting date in days (n = 23 respondents).

Downloaded by [68.117.130.162] at 18:56 12 October 2013

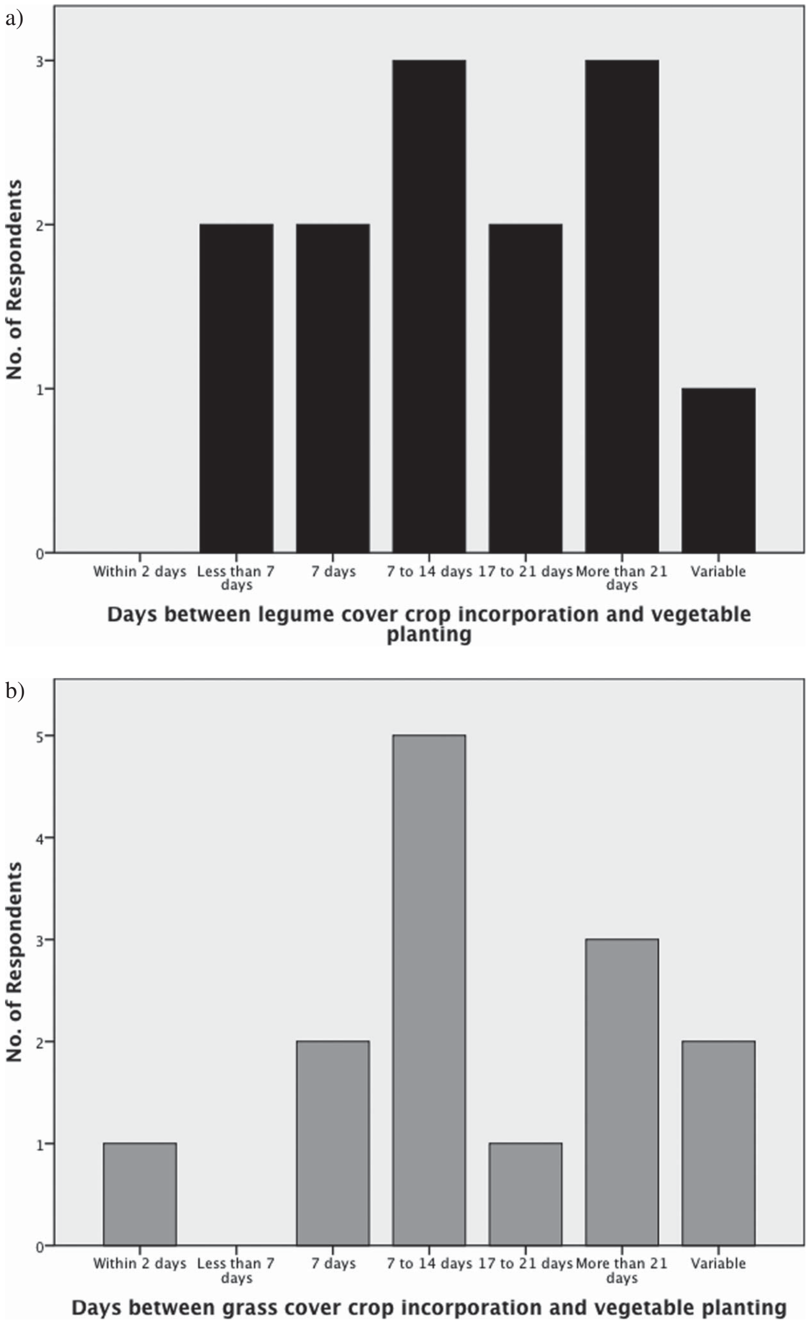


FIGURE 3 a) Response frequency for interval between spring tillage incorporation of a legume cover crop and vegetable crop planting date in days (n = 13 respondents); b) response frequency for interval between spring tillage incorporation of a grass cover crop and vegetable crop planting date in days (n = 13 respondents).

Downloaded by [68.117.130.162] at 18:56 12 October 2013

TABLE 3 Categories (n = number of respondents in each cover crop-cash crop category) and percentages for spring cover crop incorporation methods

	Tillage intensity scale (lowest to highest) →						
	Secondary[a]					*Primary*[b]	
Cover crop-cash crop category	Rototiller/ finisher	Cultivator	Rotovator	Chisel plow	Disk plow	Moldboard Plow	Combination *primary/ secondary*
Legume-corn ($n = 104$)	1	2	14	6	4	48	25
Grass-corn ($n = 51$)	2	4	16	6	10	28	34
Legume-soybean ($n = 16$)	0	0	25	6	6	31	32
Grass-soybean ($n = 23$)	4	0	26	18	13	13	26
Legume-vegetable ($n = 13$)	8	0	23	0	31	23	15
Grass-vegetable ($n = 14$)	7	0	22	0	14	36	21

[a]Secondary tillage is shallower, and sometimes more selective, producing a smoother surface for seedbed preparation.
[b]Primary tillage involves more soil disturbance with deeper tillage and more residue incorporation.
Note. Tillage intensity scale adapted from Hammond 1997.

Compared to corn and soybean cover cropping systems, more farmers attributed vegetable crop stand loss to insect-related causes when vegetables are planted into legume (n = 13; 23%) or grass (n = 13; 15%) cover crop residue. One third of this respondent group has observed vegetable crop stand losses following spring cover crop incorporation, but they do not know the cause of stand losses in vegetables following legume (n = 13; 31%) or grass (n = 13; 31%) cover crops. The remaining half of farmers in the survey with a cover crop-vegetable system have not experienced insect-related vegetable crop stand losses following spring incorporation of a legume (n = 13; 46%) or grass (n = 13; 54%) cover crop.

Farmer awareness of seedcorn maggot in organic grain cropping systems

Of the 152 survey respondents, 129 (85%) have not received any information, and only 23 (15%) have received information, on seedcorn maggot as a potential seedling pest in organic production systems where cover crop green manures are utilized. Table 4 shows the primary information sources identified by these respondents from which they became aware of seedcorn maggot.

When asked directly "Is seedcorn maggot a problem in your fields?" half of all survey respondents perceived no problem (51%), while 43% are unsure if seedcorn maggot is impacting crop stand establishment. The remainder

TABLE 4 Source of information about seedcorn maggot as a potential pest of organic grain cropping systems

Where have you received information about seedcorn maggot? (Check all that apply)	Response (n = 23)	
	No. respondents	Percentage
Agricultural business or farm input supply company	7	30
Other farmers	7	30
Internet	3	13
E-mail	2	9
Midwest Organic & Sustainable Education Service (MOSES)	6	26
UW-Extension publications for conventional cropping systems	8	35
UW-Extension county agents	3	13
Extension publications from state(s) other than Wisconsin	1	4
Organic certifier/inspector	2	9
Organic farming conferences	1	4
Other[a]	8	35

[a]Comments in Other category:
–My experience growing conventional corn prior to becoming organic;
–Crop consultant;
–Faculty, University of Wisconsin – Madison Entomology Department;
–Mostly from my education at agricultural college;
–By planting corn for 35 years. I could see if you planted corn in the wrong conditions (wet or lumpy soil) and corn did not germinate in 3 to 4 days, the maggots would eat the germ of the seed;
–University of Wisconsin classes;
–Farm magazines;
–Organic crop consultant.

Downloaded by [68.117.130.162] at 18:56 12 October 2013

of farmers perceived seedcorn maggot as either a minor (4%) or major (1%) problem. Farmers were then asked the open-ended question "what is your preferred method of management for seedcorn maggot?" and Table 5 lists response frequencies and percentages of cropping system practices that respondents perceive as effective seedcorn maggot management tactics such as crop rotation, planting date, green manure cover crop management, and soil mineral amendments.

Feasibility of implementing cultural pest control

Three pest monitoring techniques were briefly explained in the questionnaire as ways to estimate peak emergence of overwintered seedcorn maggot flies in spring. This knowledge is essential to implement a cultural pest control program for seedcorn maggot. Once peak emergence timing is known, farmers can avoid planting crops during peak flight when egg laying and risk of seedling damage is highest.

First, farmers were asked if they are interested in using insect degree days to forecast seedcorn maggot peak emergence in spring and adjust planting date accordingly to avoid the peak flight period (Sanborn et al. 1982; Funderburk et al. 1984). Table 6 shows that approximately half of respondents are interested in using insect degree days to predict seedcorn maggot

TABLE 5 Cultural practices perceived by farmers to have seedcorn maggot management benefits in organic cropping systems

What is your preferred method of management for seedcorn maggot?	Response (n = 62)	
	No. of respondents	Percentage
Crop rotation	11	18
Planting date	5	8
Green manure management	2	3
Soil health/mineralization	6	10
Granular sulfate in furrow at corn planting	2	3
No management methods used for seedcorn maggot	27	44
I am not familiar with seedcorn maggot	6	10
Other[a]	3	4

[a]Comments in Other category:
–Fall plowdown of legumes and dairy manure instead of spring plowdown;
–Planter box seed treatment;
–Bird predation (crows).

Downloaded by [68.117.130.162] at 18:56 12 October 2013

developmental events in the field. Table 7 shows farmer response to factors that may prevent them from using insect degree days as part of a seedcorn maggot cultural control program, notably a lack of knowledge about how to use insect degree days and/or the perception that it would be too time consuming to do so.

Second, farmers were asked if they would be willing to wait 2.5–3 weeks after spring incorporation of a living green cover crop to plant corn, soybean or vegetable crops. This cultural control approach is based on the assumption that the seedcorn maggot emergence peak occurs for a particular farm at the date of spring tillage since adult flies are most attracted to freshly plowed fields with decomposing plant organic matter (Hammond 1995). Table 6 shows respondents' level of willingness to wait 2.5–3 weeks between spring cover crop incorporation and planting date. Table 8 shows some of the constraints that would prevent farmers from delaying planting date

TABLE 6 Response frequencies (n = number of respondents) indicating farmer interest in using three different IPM approaches to predict seedcorn maggot peak adult emergence and adjust corn and soybean planting date to minimize crop damage

Seedcorn maggot IPM cultural control tactic	No	Yes	Unsure	Already use this tactic
Interest in using insect degree days to forecast seedcorn maggot emergence peak? (n = 139 respondents)	22	66	51	0
Willingness to wait 2.5 to 3 weeks to plant after spring cover crop incorporation (n = 138 respondents)	27	57	38	16
Interest in using soapy water pan traps to forecast seedcorn maggot emergence peak? (n = 138 respondents)	37	52	49	0

Downloaded by [68.117.130.162] at 18:56 12 October 2013

TABLE 7 Factors that constrain organic farmer respondents from using insect degree days

What could prevent you from using insect degree days to predict seedcorn maggot peak flight? (Check all that apply)	Response (n = 138)	
	No. of respondents	Percentage
I do not know how to use insect degree days	56	41
I do not know where to access daily temperature data	31	22
Too time consuming	56	41
Do not trust weather station data for on-farm decisions	8	6
Other[a]	11	8
None of the above, I want to use insect degree days	31	22

[a]Comments in Other category:
–I am in Northern part of state and am not sure if degree day model would work here;
–We live too far North, narrow planting window;
–Have never had a problem;
–Unsure;
–Results for degree day timing may not match up with optimal weather conditions for planting;
–I would need to learn how to use insect degree days.

TABLE 8 Farmer constraints to waiting 2.5–3 weeks after spring cover crop incorporation to plant corn, soybean, or vegetables

What could prevent you from waiting 2.5–3 weeks after cover crop incorporation to plant? (Check all that apply)	Response (n = 138)	
	No. of respondents	Percentage
Weather constraints	96	70
Schedule constraints	43	31
Yield loss in corn and soybean if I wait too long to plant	50	36
Other[a]	50	36
None of the above, I am willing to wait 2.5 to 3 weeks to plant	23	17

[a]Comments in Other category (representative comments):
–Canning company schedules;
–Corn hybrid maturity dates determine how late I can plant, cannot wait too long;
–I would loose weed control in my soybeans by waiting to plant;
–Silage corn I can wait to plant, grain corn I cannot;
–Once planting is in motion, we keep going until done. It is too hard to wait;
–Waiting 2.5–3 weeks to plant soybean after winter rye cover crop would reduce effectiveness of this practice.

by 2.5–3 weeks after cover crop incorporation including weather, schedule, and/or yield loss constraints.

Third, farmers were asked about the feasibility of using yellow pan traps filled with soapy water to collect seedcorn maggot flies and determine the peak emergence flight based on trap capture records (Broatch and Vernon

Downloaded by [68.117.130.162] at 18:56 12 October 2013

TABLE 9 Farmer constraints to deploying and checking soapy water pan traps for seedcorn maggot flies

What factors would prevent you from using pan traps to determine seedcorn maggot peak emergence? (Check all that apply)	Response ($n = 134$)	
	No. of respondents	Percentage
Too expensive to trap	40	29
Too time consuming to trap	64	48
Too labor intensive to trap	45	34
I am too busy to manage insect traps	62	46
I do not know how to identify seedcorn maggot flies in trap	58	43
I do not trust trap reliability for field-specific insect activity	7	5
Other[a]	11	8
None of the above, I am interested in seedcorn maggot trapping	22	16

[a]Comments in Other category (representative comments):
–Unsure of treatment options once the traps reveal peak seedcorn maggot fly emergence;
–As a rule, we already wait at least two weeks between plowing and planting;
–Weather is the determining factor for when we plant.

1997; Delahaut 2007). Compared to seedcorn maggot degree days and planting date delay after cover crop incorporation, survey respondents were less interested in using yellow soapy water pan traps to determine seedcorn maggot peak emergence flights (Table 6). Farmers felt trapping would be too time consuming given their busy schedules, and they do not know how to identify seedcorn maggot flies in trap captures (Table 9).

Farmers' preferred sources of information on organic pest management

Farmers were provided a choice of extension programming methods and asked to select their most preferred sources of information delivery from University of Wisconsin-Extension entomology on insect pest management for organic cropping systems. Table 2 shows the highest response frequency was obtained for UW-Extension fact sheets written from an organic cropping systems perspective (74% of respondents), followed by field days on organic farms (63%) and/or online resources (37%).

Public Engagement to Increase Organic IPM Information Provision through Extension

Online degree-day calculator IPM decision support tool

Farmer participants in the survey are interested in using insect degree days to determine seedcorn maggot spring emergence peak, and plan cover crop incorporation and corn and soybean planting dates around this significant pest life cycle event (Table 6). Before farmers can feel more comfortable using insect degree days to make pest management decisions on their farms, they require information on how to access and use insect degree days (Table 7).

In response to these survey results, we developed a seedcorn maggot degree day webpage that features a map displaying accumulated seedcorn maggot degree days from the January 1 biofix to the current date across Wisconsin and Minnesota (University of Wisconsin 2012b). The webpage explains how to interpret seedcorn maggot degree days to avoid planting crops during peak seedcorn maggot fly emergence when egg laying and risk from seedcorn maggot to untreated seeds is highest. Additionally, seedcorn maggot was added to the UW-Extension Ag Weather degree day calculator webpage (University of Wisconsin 2012c). This interactive tool allows farmers to enter the location of their farm to the nearest latitude and longitude coordinates, select seedcorn maggot thermal model parameters, and enter the January 1 biofix and end dates. The degree day calculator returns total seedcorn maggot degree days accumulated for the specific location where IPM decisions are being made.

Downloaded by [68.117.130.162] at 18:56 12 October 2013

Extension publication series on organic field crop IPM

To overcome information constraints identified by survey respondents (Table 2), the first publication in this series addresses seedcorn maggot cultural control in organic cropping systems. UW-Extension publication A3972-01, "Insect IPM in Organic Field Crops: Seedcorn Maggot," provides information on seedcorn maggot identification, life cycle, crop damage symptoms, and the use of insect degree days and cover crop management to help farmers plant corn and soybean during the fly-free period between seedcorn maggot generations when risk of crop damage is lowest (Holm and Cullen 2012).

eOrganic community of practice

There were a total of 127 participants in the eOrganic webinar "Integrated Pest Management for Organic Field Crops." Eighty-six participants (68%) completed feedback surveys within 2 weeks of the webinar. Participants work in all regions of the United States, including the Northeast (26% of respondents), the Central states (23%), the South (10%), and the West (27%). Some respondents (14%) selected the "other" option to indicate they worked in more than one region of the United States, or in other countries including Canada, Greece, and Chile. The audience for the webinar consisted of farmers (22% of respondents), extension personnel (13%), university researchers or educators (8%), nonprofit organization staff (3%), agricultural professionals (23%), and others (master gardeners, organic certification

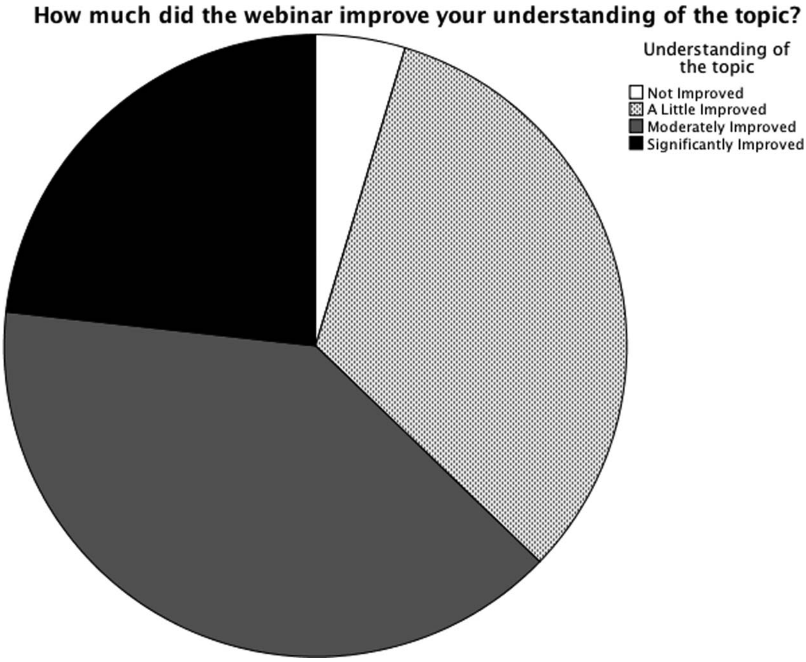


FIGURE 4 Knowledge gain reported by participants in the eOrganic webinar "Integrated Pest Management in Organic Field Crops" ($n = 86$ respondents).

Downloaded by [68.117.130.162] at 18:56 12 October 2013

inspectors, home gardeners, USDA Natural Resources Conservation Service technical service providers, and graduate students).

Figure 4 displays a summary of knowledge gained by webinar participants. Sixty-three percent of respondents answered that the webinar moderately or significantly improved their understanding of the topic. Additionally, participants reported the extent to which they intend to apply knowledge gained during the webinar to their work (Figure 5). Sixty-nine percent of respondents answered that they intend to apply the knowledge gained somewhat or a lot. The technical level of the material presented was judged to be just right by 84% of respondents. The material was judged to be too basic by 7% of respondents; and too technical by 9% of respondents.

When asked whether they would recommend the webinar to others, 72% said yes and 27% said maybe. Participants reported that the webinar was easy to access; with 86% finding it very easy to access and 10% somewhat easy to access.

DISCUSSION

Consistent with our expectation that cover cropping is common in organic grain crop production systems, a high proportion of respondents in our

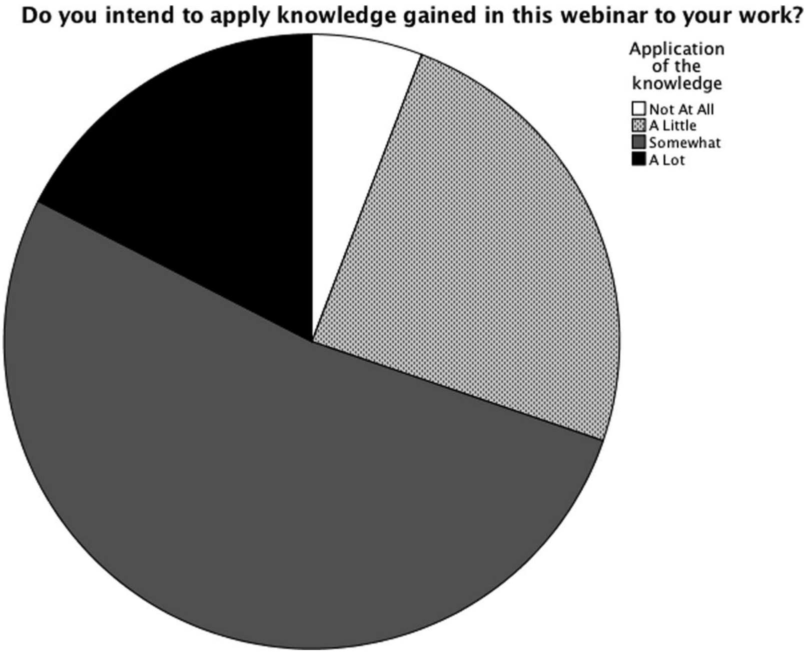


FIGURE 5 Extent to which participants in the eOrganic webinar "Integrated Pest Management in Organic Field Crops" intend to apply knowledge gained during webinar to their work (n = 86 respondents).

Downloaded by [68.117.130.162] at 18:56 12 October 2013

sample of Wisconsin organic farmers use cover crops in their annual grain crop rotation. For example, 78% of 138 corn growers incorporate a living green legume into the soil in spring prior to planting corn. The survey instrument did not capture more detailed crop rotation or cover cropping sequence information related to placement of winter wheat or alfalfa in the crop rotation before corn. Farmers in our sample who incorporate a legume in spring before corn planting may either be plowing in an alfalfa stand, or a winter hardy red clover that was frost-seeded into winter wheat and allowed to grow after wheat harvest until spring incorporation prior to the following year's corn crop (Clark 2007). It is unlikely that a cover crop is used between soybean and corn because this leaves too little time for cover crops to grow (Anderson and Mayerfeld 2012).

High tillage intensity during cover crop residue incorporation is the norm for our survey sample, particularly for legume incorporation before corn (Table 3). Hammond (1997) and Funderburk et al. (1983) showed that the likelihood of seedcorn maggot problems to grain crop seeds and seedlings increases with intensity of tillage. However, we found respondents had minimal knowledge of the ecological linkage between spring tillage incorporation of cover crops and field attractiveness to seedcorn maggot flies. Survey results revealed this low level of awareness can be attributed

Downloaded by [68.117.130.162] at 18:56 12 October 2013

to two factors, farmers' own experience and a lack of extension entomology resources pertaining to organic grain cropping systems.

Approximately two thirds of respondents have not experienced stand loss in organic corn or soybean when planted after spring tillage incorporation of either a legume or grass cover crop. Among the remaining one third of respondents who did experience stand loss in corn and soybean following spring tillage of a living green cover crop, these farmers did not know the cause of such stand losses. When asked directly if seedcorn maggot was impacting corn and soybean stands following a cover crop, 43% of all respondents did not know. Only 23 of 152 survey respondents had received any information on seedcorn maggot as a potential seedling pest in cropping systems where cover crop green manures are utilized, and those who do use university extension resources adapt IPM information for conventional cropping systems to fit their organic cropping system (Table 4).

Together, these results suggest that Wisconsin organic grain crop farmers' agronomic practices may already minimize seedcorn maggot risk, yet the cultural pest control benefits remain unrecognized by farmers (Bajwa and Kogan 2004). If true, this presents an information constraint in that farmers do not know how their agronomic practices affect cultural pest control, positively or negatively. Table 5 supports this conclusion as most of the cultural practices perceived by farmers to have seedcorn maggot management benefits in organic cropping systems either have no effect or are unrelated to the established cultural controls combining cover crop green manure management, seedcorn maggot phenology, and corn and soybean planting date.

Farmers in our survey sample are generally willing to wait 2.5–3 weeks to plant corn, soybean or vegetables after spring incorporation of a living green cover crop (Table 6). The waiting period allows cover crop residue to decompose and become less attractive to seedcorn maggot flies (Hammond and Cooper 1993). Interestingly, the majority of respondents appear to have adopted this agronomic practice, although the survey instrument did not capture their reasons for doing so and the highest frequency response of a 7–14 day waiting period does not reveal whether the mean interval between cover crop tillage and planting date is closer to 7 or 14 days (Figures 1–3). One explanation for survey respondents' low level of awareness about seedcorn maggot is that their current interval between spring tillage cover crop incorporation and planting date is already long enough, on average, to minimize field attractiveness to seedcorn maggot flies. Improved understanding of the connection between green manure cover crop management and seedcorn maggot phenology should help inform organic grain crop farmers' planting date decisions along with their more familiar considerations of weather, schedule, and yield constraints (Table 8).

When presented with an explanation of insect degree days, a majority of respondents indicated interest in using seedcorn maggot degree days to predict peak adult emergence and avoid planting corn or soybean during periods of highest risk, but none of the farmers in our survey are currently using insect degree days as part of their planting date decision (Table 6). These farmers identified a lack of knowledge about how to use insect degree days and a perception that insect degree day forecasting would be too time consuming as the main factors preventing them from using this cultural control strategy (Table 7).

Insect degree day forecasting information is included in university extension recommendations for seedcorn maggot control in conventional agriculture systems (Calvin 2000; Delahaut 2007; Van Wychen Bennet et al. 2011). In conventional grain crop systems seedcorn maggot damage is infrequent as virtually all corn seed, and an increasing percentage of soybean seed, is sold with neonicotinoid insecticide seed treatment providing protection from soil insect pests (Krupke et al. 2012). When cover crops are used in conventional no-till or conservation tillage systems, herbicide burndown is used to terminate the cover crop in spring (USDA 2005). Therefore, seedcorn maggot degree day forecasting and planting date manipulation as a primary cultural control tactic is increasingly irrelevant in conventional grain cropping systems and has not been effectively communicated by university extension to farmers within the context of an organic cropping system perspective.

The role of land grant university extension information provision in organic or sustainable agriculture is evolving, with a history of mixed reviews. Previous farmer survey work found information on organic practices unavailable or difficult for farmers to access from traditional land grant university programs or county extension offices (Walz 1999). Similar farmer inquiry studies concluded that land grant university researchers' and extension system failure to respond to a segmented demand for information, outdated delivery methods, and a lack of value added to information from extension have caused organic farmers and graziers to rely more on private-sector information sources, and importantly their own on-farm experience (Beus and Dunlap 1992; McDowell 1992; Boehlje and King 1998; Lohr and Park 2003; Lyon et al. 2011).

Contrary to these assessments, organic farmers in our survey sample responded positively to land grant university extension resources and ranked University of Wisconsin-Extension fact sheets written for organic cropping systems as their most preferred source of information on organic insect pest management (Table 2). Our results are similar to other studies showing favorable attitudes toward extension and/or an expression of great need for extension information among organic and sustainable agriculture farmers (Napit et al. 1988; Agunga and Igodan 2007). Clearly, much of the existing entomology research literature can be cast within an organic cropping systems perspective, but the topical relevance and dissemination of information must be intentionally targeted to reach organic farmers (Duram and Larson 2001; Zehnder et al. 2007; Wheeler 2011).

Downloaded by [68.117.130.162] at 18:56 12 October 2013

PROJECT OUTCOMES AND CONCLUSION

Survey response data discussed in this article suggest that organic grain crop farmers in Wisconsin would implement seedcorn maggot cultural control if they had the appropriate knowledge context and access to extension entomology information. In response to this need, we developed print and electronic media IPM decision support tools and formed a university-community partnership via the eOrganic Community of Practice. This approach combines traditional extension methods used to reach conventional cropping system clientele with targeted approaches relevant to organic cropping systems based on experience and information shared by organic farmers in the survey.

The UW-Extension Ag Weather online seedcorn maggot degree day calculator tool overcomes perceived time constraints survey respondents had about accessing seedcorn maggot degree days (Table 7) (University of Wisconsin 2012b, 2012c). The UW-Extension publication "Insect IPM in Organic Field Crops—Seedcorn Maggot," although presented in a traditional extension publication media format, is written specifically for organic systems that utilize green manure cover crops and explains how to use the online insect degree day tool within this context (Holm and Cullen 2012).

Martens (2004) asserted that organic farmers' openness and willingness to share knowledge and information about their organic production expertise needs to be acknowledged and encouraged by land grant agricultural colleges. We concur with this approach and similar views of Wheeler (2011) that setting up forums for farmers to share their experiences with other farmers, agricultural researchers, students and extension educators, will foster sharing of knowledge. Our eOrganic webinar "Integrated Pest Management in Organic Field Crops" was one such forum where we targeted our information provision methods to the organic farming community. Participants valued the mix of practical and academic information relevant to their cropping systems perspective and especially appreciated hearing from an organic farmer as one of the webinar presenters. Participant comments collected by eOrganic webinar facilitators in a post-event evaluation include the following:

> The workshop allowed me to discover the research on seedcorn maggot concerning when to plant my crops; I liked having the farmer talk practicality and the research then backing up the topic; I think it was very helpful to have research-based speakers as well as speakers who are using cultural pest control methods on their farms; The description of insect degree days was useful and I need to research it more; Nice mix of practitioner and academia, both are vital to information gathering/sharing; The question and answer section at the end was spot-on to help make the talks relevant and practical. As an extension agent, we are the ones who will be searching for insect degree day data to make this useful to the organic farmers.

Downloaded by [68.117.130.162] at 18:56 12 October 2013

Downloaded by [68.117.130.162] at 18:56 12 October 2013

A recording of our webinar and audience question and answer discussion is available online free of charge (eOrganic 2012b). Additionally, this webinar was selected by eOrganic as one of two presentations in the 2011 series approved for Certified Crop Advisor (CCA) continuing education credit through eXtension's campus website (eOrganic 2012c). In this course, CCAs pay an enrollment fee to watch the webinar, take a 10-question exam, and complete a questionnaire to receive one CCA pest management credit.

Overall results from this agroecology masters' student public practice project and our subsequent farmer engagement and information provision efforts through an existing community of practice will reduce the time and effort that organic farmers would otherwise need to spend collecting, deciphering and adapting land grant university entomology IPM information to meet their needs. This article presents one detailed cultural pest control IPM programming case study, yet exemplifies an innovative approach that can be applied to other pest-crop combinations or agricultural science disciplines by land grant university faculty, students, and farmers.

Future research on this and similar IPM program initiatives should expand on how farmers, extension personnel, university researchers, and other educators and agricultural professionals benefit. Additional work in this area could strengthen linkages between organic farmers and land grant university information provision efforts by publicly funded researchers, and help to inform agricultural development practice and public policy.

In conclusion, our project outcomes exemplify graduate student and farmer ability to effect change in land grant university extension entomology recommendations through content and delivery more clearly aligned with a cropping systems perspective.

REFERENCES

Agunga, R., and C. Igodan. 2007. Organic farmers' need for and attitude towards extension. *Journal of Extension* 45(6). http://www.joe.org/joe/2007december/a6.php (accessed May 7, 2012).

Altieri, M., and C. I. Nicholls. 2000. Applying agroecological concepts to the development of ecologically based pest management strategies. In *Professional societies and ecologically based pest management*, ed. National Research Council, 14–19. Washington, DC: National Academy Press.

Anderson, C., and D. Mayerfeld. 2012. *Cover crop case studies: Gary Sommers farm-cash grain (CIAS003)*, 1–4. Madison, WI: University of Wisconsin-Extension Cooperative Extension Publishing.

Ary, D., L. C. Jacobs, and A. Razavieh. 1990. *Introduction to research in education*. Orlando, FL: Harcourt Brace.

Bajwa, W. I., and M. Kogan. 2004. Cultural practices: Springboard to IPM. In *Integrated pest management: Potential, constraints and challenges*, eds. O. Koul, G.S. Dhaliwal, and G.W. Cuperus, 21–38. Wallingford, UK: CABI.

Beus, C. E., and R. E. Dunlap. 1992. The alternative-conventional agriculture debate: Where do agricultural faculty stand? *Rural Sociology* 57: 363–380.

Boehlje, M. D., and D.A . King. 1998. Extension on the brink—Meeting the private sector challenge in the information marketplace. *Journal of Applied Communications* 82: 21–35.

Boone Jr., H. N., E. M. Hersman, D. A. Boone, and S. A. Gartin. 2007. Knowledge of sustainable agriculture practices by extension agents in Ohio, Pennsylvania, and West Virginia. *Journal of Extension* 45(5). http://www.joe.org/joe/2007october/rb2.php (accessed May 8, 2012).

Broatch, J. S., and R. S. Vernon. 1997. Comparison of water pan traps and sticky traps for monitoring *Delia* spp. (Diptera: Anthomyiidae) in canola. *Canadian Entomologist* 129: 979–984.

Calvin, D. 2000. *Seedcorn maggot as a pest of field corn*. Pennsylvania State University. http://ento.psu.edu/extension/factsheets/seedcorn-maggot (accessed May 6, 2012).

Clark, A., ed. 2007. *Managing cover crops profitably*, 3rd ed. Beltsville, MD: Sustainable Agriculture Network.

Coe, M. 2011. *eOrganic 2010 webinars: Feedback from organic farming professionals*. Portland, OR: Cedar Lake Research Group, LLC.

David, M. B., L. E. Drinkwater, and G. F. McIsaac. 2010. Sources of nitrate yields in the Mississippi River Basin. *Journal of Environmental Quality* 39: 1657–1667.

Delahaut, K. 2007. *Seedcorn maggot (A3820)*. Madison, WI: University of Wisconsin-Extension Cooperative Extension Publishing.

Dillman, D. 1978. *Mail and telephone surveys: The total design method*. New York: Wiley-Interscience.

Duram, L. A., and K. L. Larson. 2001. Agricultural research and alternative farmers' information needs. *The Professional Geographer* 53: 84–96.

El-Zik, K. M., D. W. Grimes, and P. M. Thaxton. 1989. Cultural management and pest-suppression. In *Integrated pest management systems and cotton production*, eds. R. E. Frisbie, K. M. El-Zik, and L. T. Wilson, 11–36. New York: Wiley.

eXtension. 2012. eXtension organic agriculture website. http://www.extension.org/organic_production (accessed May 8, 2012).

eOrganic. 2012a. eOrganic website. http://eorganic.info/about (accessed May 8, 2012).

eOrganic. 2012b. Webinars by eOrganic. http://www.extension.org/pages/25242/webinars-by-eorganic (accessed May 8, 2012).

eOrganic. 2012c. *How to earn CCA credit for watching eOrganic webinar recordings*. http://www.extension.org/pages/60988/how-to-earn-cca-credit-for-watching-eorganic-webinar-recordings (accessed May 8, 2012).

Funderburk, J. E., L. P. Pedigo, and E. C. Berry. 1983. Seedcorn maggot (Diptera: Anthomyiidae) emergence in conventional and reduced-tillage soybean systems in Iowa. *Journal of Economic Entomology* 76: 131–134.

Funderburk, J. E., L. G. Higley, and L. P. Pedigo. 1984. Seedcorn maggot (Diptera: Anthomyiidae) phenology in central Iowa and examination of a thermal-unit system to predict development under field conditions. *Environmental Entomology* 13: 105–109.

Hammond, R. B. 1995. Timing of plowing and planting: Effects on seedcorn maggot populations in soybean. *Crop Protection* 14: 471–477.

Downloaded by [68.117.130.162] at 18:56 12 October 2013

Hammond, R. B. 1997. Long-term conservation tillage studies: impact of no-till on seedcorn maggot (Diptera: Anthomyiidae). *Crop Protection* 16: 221–225.

Hammond, R. B., and R. L. Cooper. 1993. Interaction of planting times following the incorporation of a living, green cover crop and control measures on seedcorn maggot populations in soybean. *Crop Protection* 12: 539–543.

Hatfield, J. L., L. D. McMullen, and C. S. Jones. 2009. Nitrate-nitrogen patterns in the Raccoon River basin related to agricultural practices. *Journal of Soil and Water Conservation* 64: 190–199.

Holm, K., and E. Cullen. 2012. *Insect IPM in organic field crops: Seedcorn maggot (A3972-01)*, 1–6. Madison, WI: University of Wisconsin-Extension Cooperative Extension Publishing.

Ingels, C., M. Van Horn, R. L. Bugg, and P. R. Miller. 1994. Selecting the right cover crop gives multiple benefits. *California Agriculture* 48: 43–48.

Jacobson, L. M., M. B. David, and L. E. Drinkwater. 2011. A spatial analysis of phosphorus in the Mississippi River Basin. *Journal of Environmental Quality* 40: 931–941.

Knutson, C. L., T. Haigh, M. J. Hayes, M. Widhalm, J. Nothwehr, M. Kleinschmidt, and L. Graf. 2011. Farmer perceptions of sustainable agriculture practices and drought risk reduction in Nebraska, USA. *Renewable Agriculture and Food Systems* 26: 255–266.

Krupke, C. H., G. J. Hunt, B. D. Eitzer, G. Andino, and K. Given. 2012. Multiple routes of pesticide exposure for honey bees living near agricultural fields. *PLoS ONE* 7: 1–8.

Litwin, M. 1995. *How to measure survey reliability and validity*, 33–44. Thousand Oaks, CA: Sage.

Lohr, L., and T. A. Park. 2003. Improving extension effectiveness for organic clients: Current status and future directions. *Journal of Agricultural and Resource Economics* 28: 634–650.

Lozier, J., E. Rayburn, and J. Shaw. 2004. Growing and selling pasture-finished beef: Results of a nationwide survey. *Journal of Sustainable Agriculture* 25: 93–112.

Lyon, A., M. M. Bell, C. Gratton, and R. Jackson. 2011. Farming without a recipe: Wisconsin graziers and new directions for agricultural science. *Journal of Rural Studies* 27: 384–393.

Martens, M. 2004. *Letter from NY: Confessions of a "foodie."* http://newfarm.rodaleinstitute.org/columns/Martens/2004/1204/foodie.shtml (accessed May 8, 2012).

McDowell, G. R. 1992. The new political economy of extension education for agriculture and rural America. *American Journal of Agricultural Economics* 74: 1249–1255.

Napit, K. B., G. W. Norton, R. F. Kazmierczak, Jr., and E. G. Rajotte. 1988. Economic impacts of extension integrated pest management programs in several states. *Journal of Economic Entomology* 81: 251–256.

Practical Farms of Iowa. 2011. *Cover crops: Frequently asked questions*. Ames, IA: Practical Farmers of Iowa and Iowa Learning Farms.

Rice, M., and J. Oleson. 2001. Seedcorn maggots love manured fields. Integrated Crop Management IC-486(6). http://www.ipm.iastate.edu/ipm/icm/2001/4-23-2001/sclove.html (accessed May 8, 2012).

Downloaded by [68.117.130.162] at 18:56 12 October 2013

Sanborn, S. M., J. A. Wyman, and R. K. Chapman. 1982. Threshold temperature and heat unit summations for seedcorn maggot development under controlled conditions. *Annals of the Entomological Society of America* 75: 103–106.

Schellhorn, N. A., J. P. Harmon, and D. A. Andow. 2000. Using cultural practices to enhance insect pest control by natural enemies. In *Insect pest management: Techniques for environmental protection*, eds. J.E. Rechcigl and N.A. Rechcigl, 147–170. Boca Raton, FL: Lewis.

Singer, J. W., S. M. Nusser, and C. J. Alf. 2007. Are cover crops being used in the US corn belt? *Journal of Soil and Water Conservation* 62: 353–358.

UC IPM. 2003a. About degree-days. UC IPM Online. http://www.ipm.ucdavis.edu/WEATHER/ddconcepts.html (accessed November 19, 2012).

UC IPM. 2003b. Phenology model database: Seedcorn maggot. UC IPM Online. http://www.ipm.ucdavis.edu/PHENOLOGY/ma-seedcorn_maggot.html (accessed May 8, 2012).

University of Wisconsin. 2010. UW Extension Ag Weather website. http://www.soils.wisc.edu/uwex_agwx (accessed May 8, 2012).

University of Wisconsin. 2012a. Agroecology website. http://www.agroecology.wisc.edu/ (accessed May 8, 2012).

University of Wisconsin. 2012b. Seedcorn maggot thermal model. http://www.soils.wisc.edu/uwex_agwx/thermal_models/scm (accessed May 8, 2012).

University of Wisconsin. 2012c. Degree day calculator. http://www.soils.wisc.edu/uwex_agwx/thermal_models/degree_days (accessed May 8, 2012).

U.S. Department of Agriculture. 2005. Valor—A residual herbicide for weed control in conservation tillage cotton systems. Conservation Systems Fact Sheet No. 02, Auburn, AL: USDA Agricultural Research Service National Soil Dynamics Laboratory.

U.S. Department of Agriculture. 2012. Organic Regulations, 7 CFR Section 205. USDA National Organic Program. http://www.ams.usda.gov/AMSv1.0/nop (accessed May 8, 2012).

U.S. Environmental Protection Agency. 2007. *Hypoxia in the northern Gulf of Mexico, an update by the EPA science advisory board*. EPA-SAB-08-003. Washington, DC: US Environmental Protection Agency.

Van Wychen Bennett, K., E. C. Burkness, and W. D. Hutchison. 2011. Seed corn maggot. University of Minnesota. http://www.vegedge.umn.edu/vegpest/seedmag.htm (accessed May 6, 2012).

Walz, E. 1999. *Final results of the third biennial national organic farmers' survey*. Santa Cruz, CA: Organic Farming Research Foundation. http://ofrf.org/publications/survey.html (accessed May 7, 2012).

Wheeler, S. 2011. Review of organic farming policy in Australia: Time to wipe the slate clean? *Journal of Sustainable Agriculture* 35: 885–913.

Zehnder, G., G. M. Gurr, S. Kuhne, M. R. Wade, S. D. Wratten, and E. Wyss. 2007. Arthropod pest management in organic crops. *Annual Review of Entomology* 52: 57–80.

Downloaded by [68.117.130.162] at 18:56 12 October 2013