

EVAUATION OF AGRICULTURAL PROFESSIONALS' PERCEPTIONS AND KNOWLEDGE ON SUSTAINABLE AGRICULTURE: A USEFUL STEP IN THE DEVELOPMENT OF AN ONLINE EXTENSION PROGRAM

Fabian D. Menalled, Assistant Professor
Bruna I. Grimberg, Associate Research Professor
Clain A. Jones, Assistant Professor
Montana State University

Abstract

This study assessed needs, knowledge, and interests of agricultural professionals who were likely to enroll in an online extension course in sustainable agriculture. The objectives of the study were: to (1) describe their demographic characteristics, (2) identify their concerns and interests related to farming, (3) evaluate participants' knowledge and adoption of sustainable farming practices, and (4) use the evidence to implement a distance education program in sustainable agriculture. A questionnaire was distributed electronically through mailing lists and Web sites. Responses were analyzed using a text analysis and a Chi-square test to evaluate the existence of associations between interests and knowledge in sustainable agriculture. Despite the study participants' diverse professions and backgrounds, they identified similar constraints impeding the adoption of sustainable farming practices. They further proposed solutions, many of which are supported by current agroecological research, indicating a vast knowledge base regarding sustainable farming. The findings were used to develop and deliver an online extension program in sustainable agriculture. This study highlights the importance of understanding the levels of knowledge, concerns, and interests of the targeted audience. Incorporating this understanding into an extension program through peer-to-peer collaboration in discussion forums and electronic mail could facilitate the dissemination of innovate education approaches to teach sustainable agriculture.

Introduction

Traditionally, universities and the industrial sector disseminate agricultural information through printed materials, conferences, and field days based on a limited number of problems identified by researchers and administrators as important (Menalled, Landis, & Dyer, 2004). This approach to agricultural extension follows a top-down transfer of technology (ToT) model where farmers first become aware of an innovation, then gain additional knowledge, and finally adopt the proposed innovation (Röling & Jiggins, 2000). Three major limitations emerge when this approach to agricultural extension is used to teach sustainable farming practices. First, the ToT model does not take into account the participant's diverse practices and prior knowledge. Second, it does not monitor the usefulness of the conveyed information.

Finally, it fails to consider the many interdependent components that form agricultural ecosystems.

The lack of an educational system in which agricultural professionals exchange information and experiences has been cited as a barrier hindering the adoption of ecologically based farming practices (National Research Council, 1989). Replacing the ToT model with an approach to agricultural extension that considers the agricultural professionals' needs and prior knowledge represents a viable alternative to help agricultural professionals develop ecologically sound practices that enhance the sustainability of their agricultural systems. In this context, the active participation of local leaders is a key component determining the speed and success at which innovative practices disseminate from a small number of early adopters to a relatively larger number of late

adopters (Rogers, 1992, 2003). This concept is rooted on the following premises. First, sustainable agricultural education programs should address the specific needs of the targeted group of agricultural professionals. Second, learners' prior appreciation of sustainable agriculture must be considered as it provides invaluable information. Third, because ecologically sound agriculture benefits from collective learning and discussions, peer-to-peer learning should be at the core of sustainable agriculture dissemination. Fourth, as many ecological processes occur at scales larger than the field, it is necessary to adopt a whole-system approach to problem solving. Finally, moving to ecologically sound agriculture requires participation of not just farmers but entails the inclusion of crop advisers, agency personnel, and consumers (Röling & Jiggins, 2000).

Internet resources provide a unique opportunity to enhance the diffusion efficiency of sustainable agriculture concepts (Phillips, 1999). In recent years, universities across the United States have developed undergraduate and graduate curricula to deliver distance education programs in sustainable agriculture (Wilson & Moore, 2004). Despite previous studies that assessed factors related to the intent of agricultural professionals to enroll in online graduate programs in agriculture (Wilson & Moore) and the distance-education facilities available at different universities (Roberts & Dyer, 2005), a void exists in the literature on how to develop and deliver online extension/outreach programs on sustainable agriculture. Moreover, a large challenge that remains is to adapt this form of extension to new ideas about distance learning, including participants' prior knowledge of cropping systems, peer-assisted learning, and learners' ability to transfer and adapt their knowledge to their particular farms.

Theoretical Framework

Standards for online teaching focus on design, contexts, processes, and content. Online contexts should facilitate the formation of a learning community in which participants have opportunities to collaborate and discuss common problems

leading to a peer-assisted approach to learning. The e-learning processes should incorporate participants' prior knowledge and needs, formative and summative assessments of participants' learning, use of variety of technologies, and emphasize collaboration between participants through interactive communication tools such as chat rooms and e-mail. Finally, the content aspect should be built on notions of equity between participants regarding access to technology, background knowledge, and quality teaching (Southern Regional Education Board, 2008).

This study was guided by the premise that constructivism is a suitable theoretical framework for online learning in sustainable agriculture. Constructivism proposes that direct experiences, reflection, and application of concepts are the building blocks used by individuals to construct their own perception of the world, preparing the learner for problem solving in ambiguous situations (Alston & English, 2007). In the process of doing and communicating, learners negotiate a common conceptual understanding (Airasian & Walsh, 1997). The inductive constructivism environment, where the instructor acts mostly as a facilitator in the learning-process and peer-to-peer knowledge dissemination prepares the learner for problem solving, can be used to develop an extension program in innovative agricultural practices. The knowledge base gained through critical discussions or arguments of participants' perceptions allows agricultural professionals to make informed decisions in the specific environmental, economical, and social situation where their farming activity takes place (Erduran, Simon, & Osborne, 2004; Simon, Erduran, & Osborne, 2006).

Purpose/Objectives

The purpose of this study was to identify the needs, knowledge, and concerns on farming issues of a community of agricultural professionals who are likely to enroll in an online extension program on sustainable agriculture. Specifically, this study sought to: (1) Describe selected demographic characteristics of agricultural professionals interested in sustainable agriculture; (2) Identify the concerns and

interests related to farming of a group of potential recipients of a distance extension program on sustainable agriculture; (3) Evaluate the study participants' knowledge about and adoption of sustainable farming practices; and (4) Use the gathered information to implement a distance education program in sustainable agriculture. These objectives were achieved through a questionnaire targeted to agricultural professionals that included farmers, Natural Resource Conservation Service personnel, certified crop advisers, and university extension agents. Although non-exclusive, this study concentrated on the northern Great Plains, the area bordered by Nebraska in the south, the western edge of Montana, the eastern edge of North Dakota and South Dakota, and the northern fringe of cultivation in western Canada (Blade, Clayton, & Lyon, 2002).

Procedures

This study was based on a questionnaire developed by six Montana State University specialists working in science education as well as ecological and economical aspects of sustainable farming. The content validity of the questionnaire was assessed by a panel of agricultural professionals recognized for their knowledge and contributions to sustainable agriculture. The review panel was composed of organic and no-till farmers as well as regional farm and food specialists. The questionnaire contained three short-answer questions, seven multiple choice questions, and 10 open-ended questions. Due to the interdisciplinary nature of sustainable agriculture, the questionnaire contained items related to cropping systems,

soil nutrition, agricultural economics, and weed ecology and management (Table 1).

To reach agricultural professionals who were likely to enroll in a distance extension program on sustainable agriculture, the questionnaire was distributed only electronically through the SurveyMonkey Web-based platform, which was selected based on broad functionality and a flexible architecture (Bauer & French, 2006). The questionnaire was advertised through the Extension Web site of Montana State University and several e-mailing lists of appropriate agricultural government agencies and professional associations. Periodic reminders were electronically sent to all mailing lists where the questionnaire was publicized to increase the sample size. Behavioral surveys often utilize mail questionnaires with a known sample, and several approaches have been suggested to handle non-response errors including telephone follow-up surveys, comparing respondents to population, comparing early to late respondents, and comparing respondents to non-respondents (Miller & Smith, 1983; Lindner, Murphy, & Briers, 2001). Because the sample of this study consisted of agricultural professionals who self-chose to answer the electronic questionnaire available only on the Internet, it was not possible to define the non-respondent population. It is possible that non-participating professionals could have different demographic characteristics, concerns, interests, and knowledge. However, and as discussed by Boyd and Murphrey (2001, p. 37), the importance of studies based on electronically delivered questionnaires "lies in the desire to develop learner-centered instruction."

Table 1

Examples of Short-Answer, Multiple Choice, and Open-Ended Questions Asked in the Questionnaire Conducted to Evaluate the Characteristics of the Agricultural Professionals Who Were Likely to Enroll in a Distance Extension Program in Sustainable Agriculture

Type of question	Example
Short answer	<ul style="list-style-type: none"> • The primary location of my work (office, farm) is in... • I have the following number of years experience working with agriculture • What are your major concerns regarding farm economics?
Multiple choice	<ul style="list-style-type: none"> • Which statement do you most agree with? (Choose one option) <ul style="list-style-type: none"> • Long-term <i>environmental</i> sustainability is my highest priority • Long-term <i>economic</i> sustainability is my highest priority • Long-term <i>optimization of environmental and economic</i> sustainability is my primary goal • Which of the following weed management topics are more important in your opinion? (you can choose more than one option) <ul style="list-style-type: none"> • Weed biological control • Crop-weed competition • Cover crops and weed suppression • Crop rotation and weed management • Herbicide resistance • Other (specify)
Open-ended	<ul style="list-style-type: none"> • For sustainable soil management, it is important to have plants growing on the soil at least part of every growing season. What specific agronomic practices would you implement that would be economically reasonable and ensure that the soil has some plant growth on it annually? • Most researchers believe that tillage is one major obstacle in achieving sustainability. Based on your experience, what are specific ways that one could reduce tillage?

The purposeful sample included 119 agricultural professionals, with 95 respondents from Montana, while the remaining respondents were mainly distributed in the western portion of the United States. Not all respondents completed the questionnaire, so the total number of cases considered for the analysis differed by question and ranged from 60 to 119. Because several respondents included more than one category, in many of the response

categories the total percentages added up to more than 100%.

The questionnaire items were analyzed qualitatively using a text analysis of the responses and quantitatively with a Chi-square analysis. Text analysis was conducted to identify emerging topics in the open-ended questions of the survey. Two researchers independently analyzed a subset of responses of the open-ended questions. Then, an expert for the question was contacted to verify the interpretations of the

answers. At this point, the researchers individually coded the responses of each open-ended question. Finally, an interreliability check of the coding was conducted based on a random pick of 60% of the other researcher's coded responses and re-coding them. An interreliability equal or greater than 85% was considered acceptable, and no further analysis was conducted (Grimberg & Hand, 2008). If the agreement between researchers was less than 85%, a second check was conducted within the expert's area to clarify discrepancies and the coding process was repeated.

Results/Findings

Selected Characteristics of Agricultural Professionals Interested in a Distance Education Program on Sustainable Agriculture

The study participants had diverse professions. Of the 119 respondents, 24% identified themselves as dryland producers, 23% as crop advisers and/or chemical dealers, 16% as extension agents, 11% as agency employees, 9% as irrigation producers, and 19% as either farmer

educators/facilitators, prospective organic farmers, or vegetable organic farmers. Also, respondents were active in a wide range of agricultural systems that involved, in many cases, several systems at a time. From a total of 104 responses, the most commonly represented agricultural systems were conventional-tillage wheat fallow and diversified cropping systems (72% of participants), no-till practices (64%), reduced input farming (38%), and organic farming (30%).

Despite the wide distribution in areas of expertise and farming systems, the respondents were mainly long-time agricultural professionals. Overall, from a total of 109 respondents, 67% had 16 or more years of professional experience, 20% had between 6 and 15 years of experience, and 13% had less than 5 years of experience in agriculture. A Chi-square test indicated that expertise distribution was unequally distributed across areas of expertise with most of those with less than 5 years of experience being either irrigation producers or other professions including current and prospective organic farmers and journalists ($p < 0.001$) (Figure 1).

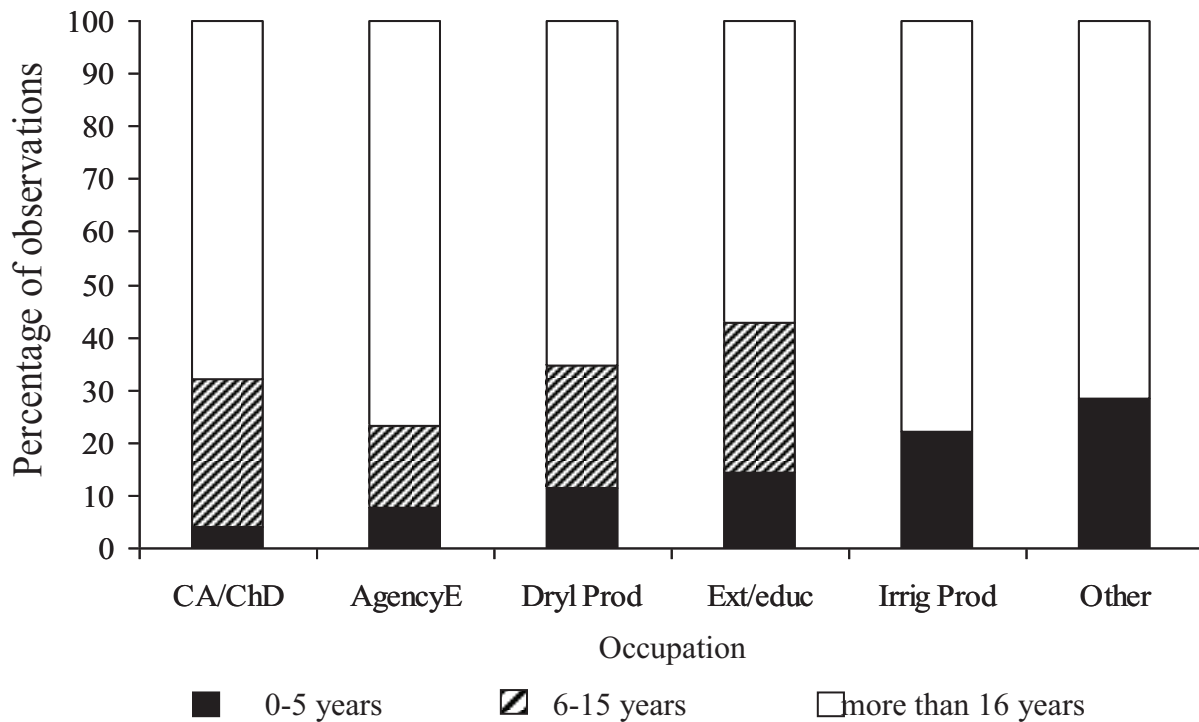


Figure 1. Professional activity and years of experience among the sustainable agriculture questionnaire respondents ($N = 109$). Note: CA/Chd= crop adviser and/or chemical dealer, AgencyE = agency employee, Dryl Prod = dryland producer, Ext/educ = education extension specialist, Irrig Prod = irrigated producer, and Other includes retired organic producer, prospective organic farmer, journalist, and rancher.

Achieving long-term economic and environmental sustainability was a main priority of the respondents. From a total of 65 respondents, 15% considered achieving long-term environmental sustainability their highest priority, 5% considered long-term economic sustainability their primary goal, and 80% were interested in the joint achievement of economic and environmental sustainability. All agency employees considered long-term optimization of environmental sustainability their highest goal. On the other hand, five crop advisers/chemical dealers, two dryland producers, and three extension

agents considered achieving economic sustainability their main priority. The percentage of agricultural professionals whose goal was achieving either economic, environmental, or economic and environmental sustainability was not equally distributed across groups with different years of professional experience. More respondents with more than 16 years of experience were interested in achieving environmental sustainability than what could be expected from a random distribution of goals across years of experience (Chi-square test, $p < 0.001$) (Table 2).

Table 2

Number of Agricultural Professionals Whose Long-Term Goal Was to Optimize Economic, Environmental, or Economic and Environmental Sustainability (n = 65)

Long-term goal	Number of years as agricultural professional		
	0-5	6-15	More than 16
Economic sustainability	0	5	5
Environmental sustainability	0	3	1
Economic and environmental sustainability	6	6	40

The text analysis of the responses indicated that the most relevant economic concerns related to the increased cost of farming inputs (82%). Other economic concerns included the loss of small family farms to corporate and investment firms (16%), the amount of government regulations (16%), the lack of market diversity (16%), and the economic impact of dealing with environmental issues (11%). Only 5% of the organic producers expressed concerns regarding the economic challenges and expenses associated with this approach to farming.

Concerns and Interests Related to Sustainable Farming Systems

Regarding concerns and interests of the study participants on issues related to the management of cropping systems, from a total of 65 respondents, 34% were concerned about environmental issues such as soil health, nutrients, and water management; 34% were concerned about crop market prices; 32% expressed concern about weeds, diseases and insect pest management; and 25% were concerned about the extensive use of monoculture. Less common concerns included the access to information and proper technology (15%) and problems associated with the transition to organic or no-till farming practices (4%).

Nutrient availability represents a limiting factor affecting the sustainability of Northern Great Plains farming enterprises (Grant, Peterson, & Campbell, 2002). Accordingly, a large proportion of the participants were interested in the adoption of ecologically sound nutrient management practices. From a total of 82 respondents,

73% indicated interest in the use of nitrogen-fixing crops as an approach to enhance soil fertility, and 55% indicated interest on increasing fertilizer use efficiency. Nutrient management in organic systems interested a relatively minor proportion of the study's participants (26%).

Nearly 95% of 82 respondents were interested in the use of ecologically based practices such as crop rotation in the management of agricultural weeds. For this group, reduction of crop yield and quality due to crop-weed competition and the selection of herbicide-resistant biotypes were cited as relevant topics associated with the adoption of sustainable farming practices (58% and 56%, respectively). Despite the high interest in the use of ecologically based practices, only 38% and 25% of the respondents were interested in the use of cover crops and biological control agents, respectively.

When asked to identify the five most troublesome weeds affecting their production systems, the study participants identified species with a wide range of biological characteristics. From a total of 62 respondents, the top weed perceived as problematic was kochia (*Kochia scoparia*), an annual dicot species. Wild oat (*Avena fatua*) and downy brome (*Bromus tectorum*) were cited as the most problematic annual monocot weed species. Finally, field bindweed (*Convolvulus arvensis*) and Canada thistle (*Cirsium arvense*), two perennial species that reproduce through seeds and extensive root systems, were cited as problematic dicot species. Two of these weed species (kochia and wild oat) have developed resistance to different herbicides

across the Northern Great Plains (International Survey of Herbicide Resistant Weeds, 2007).

Knowledge and Adoption of Sustainable Farming Practices

Participants demonstrated a vast knowledge base regarding sustainable farming practices. For example, only 14% of 71 respondents indicated that weed management strategies should not tolerate the presence of some weeds in their fields. A significant proportion of participants had a neutral or positive perception toward the presence of weeds in croplands. Thirty-four percent of the respondents perceived weeds as valuable components of their farms as they could harbor beneficial organisms and reduce soil erosion, and 16% expressed that tolerating the presence of weeds could save money. This approach to weed management is supported by theoretical and experimental evidence (Liebman, Mohler, & Staver, 2001). The number of years of professional experience was not a significant factor determining the acceptance level of weeds (Chi-square test, $p = 0.66$).

In accordance with the relatively high weed tolerance expressed by the respondents, 43% of 70 respondents had developed weed threshold management levels, 23% utilized other approaches, including adaptive management and development of integrated management approaches, and 13% relied on advice provided by "experts" such as extension agents and/or sales representatives. Only 21% managed weeds as soon as they are noticeable. No significant differences in the number of years of experience among agricultural professionals with different weed management approaches were found (Chi-square test, $p = 0.62$).

When asked how they would manage farming systems so that weeds capture fewer nutrients, 45% of 61 respondents suggested the use of herbicides or chemical fallow, 29% considered using crop diversification through intercropping or increasing crop rotation, 14% favored the establishment of more competitive crop stands, and 14% suggested the utilization of cover crops. Other management practices suggested by the study participants as valid approaches to

reduce nutrient capture by weeds included modifying planting dates (13%) and seedbank management (13%). Again, these practices are all supported by experimental evidence (Zimdhal, 2004), suggesting that the respondents had a strong knowledge base of sustainable farming. Only 9% of the respondents did not know any appropriate management practice to reduce the weed capture of nutrients.

Soil erosion is a major problem threatening the sustainability of farming in the northern Great Plains and reduced- and no-till practices have been proposed to minimize the extent of this environmental problem (Cannell & Hawes, 1994). When asked about specific practices to reduce tillage, 58% of 62 respondents favored the adoption of commonly used practices such as chemical fallow. Forty-four percent of the respondents recommended reduced tillage practices that do not include herbicides including the use of heavy harrow, high speed spiking to stimulate fall germination, or shallow tillage. Other practices included improvement in irrigation techniques (3%) and the integration of animals into the farming system (3%). These practices have been found to reduce soil erosion and/or improve soil quality, indicating that the respondents had a good understanding of sustainable soil practices (Lal, 2003).

To evaluate the respondents' approaches to further enhance soil sustainability, participants were asked "What specific agronomic practices would you implement that would be economically reasonable and ensure that the soil has some plant growth on it annually?" Of the 60 respondents, 31% suggested the utilization of cover crops such as alfalfa, clover, green manure, perennials and grass; 26% of the participants suggested crop management through rotations and intercropping; and 15% of the participants proposed nitrogen-fixing crops such as pulse crops. Other management practices suggested by the respondents included leaving residue and stubble (11%), utilization of no-till practices, and allowing weeds to grow in crop fields (5%). In accordance with the previously analyzed responses, agroecological research supports the usefulness of these practices (Gliessman, 2001).

Implementation of a Distance Education Program in Sustainable Agriculture

The information gathered from this study was used to develop the Sustainable Crop Management Workshop, an 8-week distance extension course on sustainable agriculture. The extension course was delivered using WebCT, a flexible computer-assisted platform for distance education. WebCT was chosen because it allows the construction of interactive learning environments where learners actively participate through electronic mail as well as asynchronous and synchronous discussion forums (Kayler & Weller, 2007). Although previous studies have shown improved learning outcomes when WebCT was compared with conventional Web site-based courses (Romanov & Nevgi, 2006), to our knowledge, no previous study has systematically evaluated its applicability to develop extension activities related to sustainable agriculture.

The Sustainable Crop Management Workshop has been offered three times, in fall 2006, fall 2007, and fall 2008. Topics discussed focused on sustainability, nutrient management, diverse cropping systems, weed and disease management, and farm economics. Each year, a total of 25 participants were expected to spend an average of 6 hours per week on this workshop. Certified crop advisers were eligible to receive 25 continuing education units if they successfully completed the workshop. To facilitate the involvement of those with slow Internet connections, participants were provided with a booklet containing the readings for each module and a CD with information about the course and the modules. Because of the diverse professions and other commitments of the participants, the asynchronous discussion forums and electronic mail was preferred during the workshops. These discussion forums and e-mails facilitated participant interaction. A total of 1,541 messages were posted in the discussion rooms and 1,163 electronic mails were shared among the participants of the three workshops.

Conclusions

Developing sustainable agriculture outreach curriculum requires an explicit acknowledgement of the participants' previous knowledge, needs, and concerns (Francis & Carter, 2001; Staver, 2001). The analysis of a questionnaire allowed us to reach our goal of identifying the needs, knowledge, and concerns on farming issues of a community of agricultural professionals who are likely to enroll in an online extension program on sustainable agriculture. Specifically, this research demonstrated that this group of agricultural professionals had a strong understanding of the ecological basis supporting farming. It further identified similarities among potential participants of an online extension program in sustainable agriculture. For example, the study's participants were mainly composed of professionals who had been associated with agricultural production for a relatively long period of time for whom securing the environmental and economic sustainability of their farming enterprise is a priority. Soil health, nutrient management, and soil moisture conservation were major concerns expressed by the study's participants. Other concerns included input costs, pest management, and the use of crop rotation, cover crops, and intercropping. This information was used to develop and deliver an online distance extension program in sustainable agriculture tailored to the needs and concerns of agricultural professionals.

Recommendations and Implications

Based on the results and findings of this research, the following recommendations are proposed:

1. Understanding the demographic characteristics, levels of knowledge, concerns, and interests of the targeted audience provides valuable information for the design and delivery of online extension program on sustainable agriculture. Because

of this, the design, implementation, and analysis of questionnaires represent a valuable approach to gather the required information to tailor the contents of the education program to the knowledge base and needs of the students.

2. The knowledge base of agricultural professionals who are likely to enroll in a distance education program on sustainable agriculture is strong. Incorporating this understanding of the ecological basis supporting sustainable farming into an extension program facilitates the dissemination of innovative practices. To that end, efforts should be made at promoting peer-to-peer collaboration in discussion forums and electronic mail in the design and delivery of an online extension program in sustainable agriculture.
3. Given the limited ability to assess the non-respondent population in a questionnaire openly distributed through Web sites and mailing lists, one should be cautious about making generalizations to populations of different geographic areas than the one studied.

In summary, this study represents a first attempt to characterize the needs, knowledge, and concerns on farming issues of a community of agricultural professionals interested in participating in an online extension course in sustainable agriculture. In doing so, this study identified areas of interest and approaches to enhance the sustainability of the farming enterprise. Many of the solutions to enhance farm sustainability possessed by the participants of this study are supported by current agroecological research (Gliessman, 2006). This information was used to develop and deliver an 8-week Sustainable Crop Management Workshop utilizing the WebCT platform, which proved to be a useful resource to facilitate students' participation in discussion forums and exchange of information. Future studies could formally assess the applicability of the WebCT platform in extension activities related to sustainable agriculture in

comparison with more traditional approaches used in extension.

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FABIAN D. MENALLED is an Assistant Professor in the Department of Land Resources and Environmental Sciences at Montana State University, 719 Leon Johnson Hall, Bozeman, MT 59715-3120. E-mail: menalled@montana.edu.

BRUNA I. GRIMBERG is an Associate Research Professor at the Science Math Resource Center at Montana State University, 401 Linfield Hall, Bozeman, MT 59715. E-mail: grimberg@montana.edu.

CLAIN JONES is an Assistant Professor in the Department of Land Resources and Environmental Sciences at Montana State University, 807 Leon Johnson Hall, Bozeman, MT 59715-3120. E-mail: clainj@montana.edu.