Extension Education Methods

Internet-based Decision Tools for Orchard Pest Management—Adoption in the Hood River Valley of Oregon

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ADDITIONAL INDEX WORDS. phenology model, pest control advisor, survey, tree fruit, site-specific

SUMMARY. The Internet has expanded access to real-time decision tools for pest management in agriculture. Starting in 2000, site-specific weather data and decision tools for key insect pests and diseases became available through the Internet to fruit growers and pest control advisors (PCAs) in the Hood River Valley of Oregon. Adoption of these decision tools was supported by educational programs conducted by extension. In this study, surveys were conducted to assess the importance of different sources of pest management information and the adoption of four Internet-based pest management decision tools by fruit growers and PCAs in the Hood River Valley. Growers relied on diverse sources for pest management information and ranked PCAs as the most important source for making pest management decisions. Grower use of the Internet-based pest management decision tools was relatively low despite computer ownership and Internet use that were higher than national trends. Growers preferred the website that provided the most complete access to up-to-date weather data and pertinent pest and disease models, despite somewhat less streamlined access. PCA use of the decision tools was proportionately higher, and included greater use of additional websites. Both growers and PCAs considered use of the Internet tools to have important benefits on pest management programs. In the Hood River Valley, fruit growers had access to technology-driven decision support tools, but continued to rely on more traditional information sources, particularly PCAs, for making pest management decisions. In view of trends in shrinking extension resources, these results suggest that the most efficient use of time and potential for greatest impact can be derived from focusing educational efforts on PCAs.

Many tree fruit crops require intensive pest management programs. Phenology models for important tree fruit arthropod and disease pests provide fruit growers with information that can help them

decide if treatment is necessary or when to treat for maximum efficacy (Jones, 1991). Adoption of these models by growers and PCAs could have significant impacts on the outcomes of pest management programs in terms

of efficacy and pesticide use as well as grower profitability.

Expert systems provide an example of decision support technology for agriculture in which computers are part of the delivery system. In describing their experiences with delivering an expert system for cotton (*Gossypium hirsutum*), Goodell et al. (1993) recognized several obstacles to the adoption of computer-based delivery systems by producers. These included lack of computer ownership and proficiency in their operation. Furthermore, they noted that producers might need to develop new skills to be able to collect the necessary field data, and they must learn to interpret and apply the information provided from the system.

The advent of the Internet has created an information revolution with many potential applications and a rapid pace of adoption in agriculture. Several studies have documented preferences for information access and delivery among farmers. Specific applications of Internet technology must consider the experience of the intended users and their perceptions about the potential benefits of use (Howell and Habron, 2004). Furthermore, technology-driven information delivery systems may not be appropriate for all audiences (Radhakrishna et al., 2003). In a study of the adoption of computers and the Internet for decision support among southeastern U.S. livestock and crop producers, Hall et al. (2003) suggested that, despite a trend toward increased adoption of the Internet, it may be necessary to maintain traditional channels of communication between extension and farm operators while simultaneously supporting progressive adoption by those later in the diffusion-adoption continuum.

Rapid advances in technology and expansion of Internet access have increased the capability for providing efficient and cost-effective means of decision support for agricultural producers with automated distribution of real- or near-real-time pest development information (Bajwa and Kogan, 2001). Although these types of automated systems are becoming more numerous, little information on their adoption by intended users exists.

In 1995, extension and research personnel at the Oregon State University (OSU) Mid-Columbia Agricultural Research and Extension

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I acknowledge Leonard Coop, Oregon State University Integrated Plant Protection Center, and Sally Duckwall, Oregon State University Mid-Columbia Agricultural Research and Extension Center, for website development and maintenance, and Joanne Kiyokawa, Oregon State University Mid-Columbia Agricultural Research and Extension Center for assistance with survey data entry.

Center, Hood River, established a weather station network to provide site-specific information on pest and disease management to the tree fruit industry in the Hood River Valley. Beginning in 2000, weather data and modeling capability became available through two websites managed by the OSU Integrated Plant Protection Center. Results of an informal survey conducted in late 2000 indicated that industry adoption of these resources was low. Frequent comments were that the websites were difficult and time consuming to navigate, and that the information generated was difficult to interpret. In 2001, two additional Internet-based tools were developed. One of these was a website that was integrated with an e-mail system of delivering alerts on pest or disease episodes. The other was a new website designed to require minimal time for accessing completed summaries of pertinent phenology models. Each website provided different features with varying levels of complexity, interactivity, and amount of time required to become proficient in their use and ability to access model summaries or complete model calculations. The main features of each website are listed in Table 1. Use of all four Internet tools was free of charge to anyone with Internet access.

From 2001 through 2003, extension educational programs were conducted to increase competency among growers and PCAs in using these Internet-based pest management decision tools. Growers and PCAs were

provided with opportunities to learn how to access, use, and interpret the decision tools and the information they generated. These programs were presented in a variety of different formats in both small and large group settings. They provided an introduction to understanding and using predictive models for making pest management decisions. They addressed specific models that were available for key diseases and arthropod pests, including interpretation and application of results. They also provided demonstrations on accessing the models through the different Internet-based pest management decision tools. Structured training sessions were supplemented with informal small group or one-on-one sessions for growers and PCAs. Written support material included newsletter articles and an illustrated guide to using these resources. This study was conducted to document use and impact of these different decision tools by growers and PCAs in the Hood River tree fruit industry.

Materials and methods

Two surveys were developed to assess grower and PCA adoption of the different Internet-based pest management decision tools. Survey specialists were consulted to develop questions that would result in useful data (M. Engle, personal communication; R. William, personal communication). In Mar. 2004, grower surveys were mailed to all grower recipients (143) of the OSU Extension's Hood River County commercial horticulture newsletter.

At the same time, PCA surveys were mailed to all independent and chemical supplier affiliated PCAs (10 total) servicing fruit growers in the Hood River area. To increase response rates, follow-up postcards were sent to non-respondents.

The grower and PCA surveys each had two main sections. One section asked a series of questions to determine the importance of different sources of information for pest management decisions or recommendations, which included the Internet-based decision tools available on the websites, preferences for different website features, and perceived impacts of website use on pest management programs. These questions used a five-point Likert scale (Likert, 1932), with 1 = not important and 5 = very important. Questions on the frequency of past website use were asked with response categories of never, 1 to 5 times, 6 to 10 times, 11 to 15 times and 16 or more times in the past year.

Another question asked growers and PCAs that used the websites fewer than six times per year to indicate why.

The other survey section asked a series of questions to determine computer ownership and use, and Internet access and use. Questions on the comfort level of using computers and the Internet were asked using a five-point Likert scale, with 1 = rather not use and 5 = expert. Additional questions were asked to determine basic information, including acreage in tree fruit production (growers) or

Table 1. Main features of the Internet decision tools available to fruit growers and pest control advisors in the Hood River Valley of Oregon during the 2003 season.

Website ^z	Main feature	Update frequency	Login and password required	Mouse clicks required (no.) ^y
MCAREC Pest and disease model summary (Oregon State University Mid-Columbia Agricultural Research and Extension Center, 2005)	Summaries of pertinent models	1–3 times per week	No	2
Oregon fruit crop pest alert system (Oregon State University Integrated Plant Protection Center, 2005a)	E-mail alerts on pest events	Episodically	Yes	7
Table of online IPM weather data for the Hood River Valley (Oregon State University Integrated Plant Protection Center, 2005b)	Access to degree-day calculator with preset biofixes	15-min interval for data	No	1 + 1 to 2 per model and location
IPPC Online phenology and degree-day models (Oregon State University Integrated Plant Protection Center, 2005c)	Full featured degree-day calculator	Daily	No	6 per model and location

^zMCAREC = Mid-Columbia Agricultural Research and Extension Center; IPM = integrated pest management; IPPC = Integrated Plant Protection Center.

^yWith main page saved as favorite in web browser.

field service provided for (PCAs). The survey response data were summarized using Microsoft Excel (Microsoft Corp., Redmond, Wash.) to calculate response frequencies as a percentage of total responses.

Results

Seventy-six grower and eight PCA surveys were completed for response rates of 53% and 80%, respectively. Grower respondents represented about 7000 acres (2833 ha) and PCAs about 13,000 acres (5261 ha), or 47%

and 87%, respectively, of the orchard acreage in the Hood River Valley. When growers were asked about the importance of different sources of information for pest management decisions, 59% rated the websites as somewhat to very important, although only 14% rated the websites as very important (Table 2). Ninety percent of grower respondents rated PCAs affiliated with a chemical supplier as somewhat to very important, with 63% very important. Thirty percent rated independent PCAs as somewhat

to very important, with 17% very important.

Growers considered other sources of information important. Seventy-seven percent rated the extension-produced pest management guide as somewhat to very important, with 25% very important. Ninety-six percent of growers considered the extension newsletter somewhat to very important, with 33% very important. Growers also considered packing house field representatives as important sources of pest management information even though providing that information is not their main function.

When PCAs were asked about the importance of different sources of information for their pest management recommendations, 88% rated the websites as somewhat to very important, with 38% very important (Table 3). Eighty-eight percent of PCA respondents rated the extension-produced pest management guide as somewhat to very important, with 25% very important. All considered the extension newsletter somewhat to very important, with 25% very important.

Even though a high percentage of growers considered the websites to be important to their pest management decisions, website use by growers in the previous year (2003) was relatively infrequent. The percentage of growers that used a website five or fewer times ranged from 78% to 92% among the different websites (Table 4). Growers that used the websites fewer than six times per year were asked to indicate why, and the two most commonly chosen responses were that they did

Table 2. The importance of different information sources to pest management decisions made by growers surveyed in the Hood River Valley of Oregon.

Information source	Proportion of respondents (%)				
	Not important	Somewhat important	Very important		
Website information	23	17	24	21	14
Supplier affiliated pest control advisor (PCA)	7	3	5	22	63
Independent PCA	60	10	0	13	17
Packing house field representative	15	15	28	19	22
Extension pest management guide	10	14	25	27	25
Extension newsletter	0	4	28	35	33

Table 3. The importance of different information sources to pest management recommendations made by pest control advisors surveyed in the Hood River Valley of Oregon.

Information source	Proportion of respondents (%)				
	Not important	Somewhat important	Very important		
Website information	0	13	25	25	38
Extension pest management guide	0	13	25	38	25
Extension newsletter	0	0	38	38	25

Table 4. The frequency of website use by growers during the 2003 season in the Hood River Valley of Oregon.

Website ^a	Proportion of respondents (%)				
	Never	1–5 times	6–10 times	11–15 times	16 or more times
MCAREC Pest and disease model summary (Oregon State University Mid-Columbia Agricultural Research and Extension Center, 2005)	74	18	3	6	0
Oregon fruit crop pest alert system (Oregon State University Integrated Plant Protection Center, 2005a)	84	8	1	7	0
Table of online IPM weather data for the Hood River Valley (Oregon State University Integrated Plant Protection Center, 2005b)	69	8	6	17	0
IPPC Online phenology and degree-day models (Oregon State University Integrated Plant Protection Center, 2005c)	75	8	8	8	0

^aMCAREC = Mid-Columbia Agricultural Research and Extension Center; IPM = integrated pest management; IPPC = Integrated Plant Protection Center.

Fig. 1. Grower responses indicating the reasons for low frequency (less than six times per year) of website use based on a survey of fruit growers in the Hood River Valley of Oregon.

Table 5. The importance of different website attributes to growers surveyed in the Hood River Valley of Oregon. Respondents were instructed: "For the website that you used most often, indicate the features that are important to you."

Website attributes	Proportion of respondents (%)				
	Not important		Somewhat important		Very important
Simplicity of use	8	0	10	31	50
Speed of access	11	2	15	30	41
Most up to date information	9	0	4	34	53
Information on specific pest(s)	9	4	7	30	50
Preset model parameters (e.g., biofix dates)	10	10	12	33	36
Interactive features such as e-mail discussion groups	31	33	21	7	7
Ability to set model parameters	16	16	33	21	14
Ability to import my own weather data	16	14	30	18	23
Access to raw weather data	15	9	26	28	22

not know about the websites and they do not use the Internet (Fig. 1).

Growers used the table of online integrated pest management (IPM) weather data for the Hood River Valley website (OSU Integrated Plant Protection Center, 2005b) more frequently than the other three websites (Table 5). This site provided access to all relevant arthropod pest and disease models with preset biofixes for different locations and the only real-time access to a pear scab (*Venturia pirina*) infection period model. It combined features that growers indicated were important to them, such as simplicity of use, up-to-date information, and access to information on specific pests.

Website use by PCAs was generally higher than that of growers. With the exception of the pest alert system website (OSU Integrated Plant Protection Center, 2005a), frequency of use for each website by PCAs was similar, with each used by at least half of the PCAs 11 to 15 times in 2003 (Table 6). For both growers and PCAs, the least frequently used website was the pest alert system website.

Most growers indicated that using the websites improved their pest management programs. Based on combined percentages from the somewhat to very much response categories, these included more informed pest management decisions (83%), more effective pest control (69%), improved timing of pesticide application (82%), reduced pesticide use (62%), and improved fruit quality (52%) (Table 7). PCAs indicated their website use had similar impacts on their pest management

Table 6. The frequency of website use by pest control advisors during the 2003 season in the Hood River Valley of Oregon.

Website ^a	Proportion of respondents (%)				
	Never	1–5 times	6–10 times	11–15 times	16 or more times
MCAREC Pest and disease model summary (Oregon State University Mid-Columbia Agricultural Research and Extension Center, 2005)	25	13	0	63	0
Oregon fruit crop pest alert system (Oregon State University Integrated Plant Protection Center, 2005a)	63	13	25	0	0
Table of online IPM weather data for the Hood River Valley (Oregon State University Integrated Plant Protection Center, 2005b)	25	0	25	50	0
IPPC Online phenology and degree-day models (Oregon State University Integrated Plant Protection Center, 2005c)	13	25	0	63	0

^aMCAREC = Mid-Columbia Agricultural Research and Extension Center; IPM = integrated pest management; IPPC = Integrated Plant Protection Center.

Table 7. The impacts of grower website use on pest management programs in the Hood River Valley of Oregon. Growers were asked “How has your website use affected your pest management programs?”

Impact	Proportion of respondents (%)				
	Not at all		Somewhat		Very much
More informed pest management decisions	15	2	23	28	32
More effective pest control	18	13	27	31	11
Improved timing of application	12	6	16	43	22
Reduced pesticide use	22	16	36	18	9
Increased pesticide use	48	29	19	2	2
Savings in labor and material cost	25	27	27	14	7
Better yield	29	37	22	10	2
Better fruit quality	18	30	14	34	5

Table 8. The impacts of website use by pest control advisors (PCAs) on pest management recommendations and outcomes. PCAs were asked “How has your website use affected both your pest management recommendations to growers and the results of their pest management programs?”

Impact	Proportion of respondents (%)				
	Not at all		Somewhat		Very much
More informed pest management recommendations	0	0	14	57	29
More effective pest control	0	0	13	75	13
Improved timing of application	0	0	13	75	13
Reduced pesticide use	14	0	71	14	0
Increased pesticide use	14	43	43	0	0
Savings in labor and material cost	13	25	38	25	0
Better yield	13	13	38	38	0
Better fruit quality	0	0	50	50	0

recommendations to growers and the outcomes of grower pest management programs (Table 8).

Computer ownership and use, as well as Internet use among growers, were relatively high. Eighty-eight percent of growers indicated that they owned one or more computers and 84% used the Internet. Seventy-five percent considered their comfort using computers as adequate to expert, and 74% considered their comfort using the Internet as adequate to expert.

Discussion

The growers surveyed in this study relied on diverse sources of information for making pest management decisions. Primary among these were PCAs. Alston and Reding (1998) reported similar results in a survey of fruit growers in Utah. The difference in importance to growers between supplier-affiliated and independent PCAs may be due, at least in part, to the higher number of the former (eight) compared to the latter (two) servicing growers in the Hood River Valley. The high level of reliance on

PCAs explains, in part, the relatively low use of the Internet decision tools by growers. It is likely, however, that PCA use of the Internet tools had an indirect benefit to growers. And, although use of the Internet-based tools was proportionately higher among PCAs, both growers and PCAs considered them to have important benefits to pest management programs.

Lack of awareness and limited computer or Internet access were cited by Malone et al. (2004) as reasons for relatively low farmer use of Internet IPM resources. Lack of awareness may have been a factor in this study, but only a small proportion of growers indicated that being non-Internet users was a primary reason for infrequent use. Growers surveyed in this study had 26% higher computer ownership and 29% higher use of the Internet than the households surveyed nationwide (U.S. Department of Commerce, 2004).

Other studies have documented preferences for information access and delivery among farmers including the adoption of the Internet (Hall et al., 2003; Howell and Habron, 2004; Rad-

hakrishna et al., 2003). In this study, growers who used the Internet-based pest management tools preferred the table of online IPM weather data for the Hood River Valley (OSU Integrated Plant Protection Center, 2005b), which provided access to near-real-time weather data and pertinent pest and disease models. This website provided the most up-to-date weather data, which is critical in managing diseases such as pear scab, apple scab (*Venturia inaequalis*), and fire blight (*Erwinia amylovora*).

Differences in use of pest management decision tools and preference for website functionality between growers and PCAs surveyed in this study may reflect differences in the scope of activities between the two groups. Growers generally are interested in information pertaining to one or few orchard sites. PCAs, however, serve growers with orchards distributed broadly in the Hood River Valley, where elevation gradients result in differences of up to 2 weeks in crop and pest phenology between different locations. Use of additional resources may allow PCAs to detect trends in seasonal development of pests throughout the valley.

It is likely that the demand for information on diseases such as pear scab, apple scab, and fire blight might vary from year to year depending on weather conditions, potentially affecting grower and PCA preferences for different websites. Although weather conditions during Spring 2003 were generally not favorable for the development of fire blight, wet conditions resulted in several pear and apple scab infection periods. That could have influenced the frequency of use of the table of online IPM weather data for the Hood River Valley website (OSU Integrated Plant Protection Center, 2005b) by growers and PCAs.

The Internet provides a timely and efficient means of disseminating pest management information. Nonetheless, as extension resources continue to shrink, it is important to know which Internet-based tools have the most impact. These results suggest that in the Hood River Valley, there is a reduced need for posting pest alerts and model summaries that directly consume agent time. Furthermore, in situations when growers rely to a very large extent on PCAs, the most efficient use of time is to focus educational programs on PCAs rather than growers.

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