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Targeting key perceptions when planning and evaluating extension

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Abstract. Early identification of farmer perceptions influencing particular farm management decisions provides the opportunity to more effectively focus investment in research and extension. A survey-based study examining the adoption of integrated weed management by Western Australian grain growers was used to demonstrate how identification of key farmer perceptions can help to guide research and extension priorities. It was found that the adoption of integrated weed management practices was influenced by grower perceptions of herbicide resistance-related factors and of the efficacy and economic value of integrated weed management practices in the farming system. However, there were generally no significant differences between the perceptions of practice efficacy held by users and non-users of the integrated weed management practices. As initial perceptions of efficacy were generally consistent with local field experience, it was expected that extension would not have a major influence on this variable. Consistent with this, participation by growers in a workshop based on the bio-economic farming systems model, resistance integrated management (RIM), did not result in changes in perceptions of practice efficacy. However, changes in the perceived short-term economic value of some weed management practices did occur where the broader value of practices to the farming system, not necessarily relating to weed control, could be demonstrated. This also led to more growers deciding to adopt those practices. For example, intended wheat seeding rates were shown to increase by 5 kg/ha as a result of participation in the extension activity. Determining the perceptions influencing adoption, and then identifying the major learning opportunities can be valuable in focusing research and extension. Measures of perceptions also allow learning to be evaluated. In the case study of adoption of the integrated weed management practices in WA, it seems that emphasis on developing and extending the farming-systems impacts beyond just weed and resistance management is likely to be more effective than focusing on the efficacy of the practices for controlling major weeds.

Additional keywords: adoption, Australia, herbicide resistance, learning, weed management.

Introduction

Many recent economic studies of the decision whether or not to adopt a new agricultural practice emphasise that the decision involves a dynamic learning process (e.g. Abadi Ghadim and Pannell 1999; Marra *et al*. 2003). Perceptions associated with the relative advantage or utility of a new practice are a common focus of this approach, with several empirical studies having demonstrated the influence of such farmer perceptions of technology characteristics on adoption decisions (e.g. Adesina and Baidu-Forson 1995; Cary and Wilkinson 1997).

The process where farmers revise and update their prior perceptions concerning an innovation by collecting and assimilating further information was first formalised in an economic model of the adoption process by O'Mara (1971). In an effort to further improve the specification of the adoption process, Lindner *et al*. (1979) used the approach to better explain the observed time lag between when a decision maker first learns of the existence of an innovation to when a decision is made to adopt it. Within this learning-based conceptual framework for adoption, major roles for agricultural extension include facilitating (and accelerating) the learning process and potentially influencing farmer perceptions via the generation, sharing and/or delivery of effective information.

To effectively target investment in research and extension it is useful to have an understanding of the major factors that influence farmers' adoption decisions in the farming system. A large number of adoption studies have been conducted with this broad objective, but the contribution of many such studies to improved planning of research and development and extension has often been disappointing. We propose that an important factor contributing to this disappointment is that relatively few adoption studies identify the influential

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perceptions in adoption decisions and even fewer consider the consistency or inconsistency of farmer perceptions with the existing state of knowledge (either from research or from practical experiences of the farming community). If perceptions (and misperceptions) are addressed, survey-based adoption studies have greater potential value in planning and evaluation of extension.

In the case of farming systems research and extension, an understanding of the key farmer perceptions can contribute to the initial phase of describing the farming system and clarifying objectives (Petheram and Clark 1998). This may be particularly useful where farming systems research is intended to produce information to be extended to a large number of farmers beyond the core participants. The initial measures of perceptions can also act as benchmarks in the monitoring and evaluation of extension outcomes. Long lag times can be expected for adoption of many new practices (e.g. Marsh *et al*. 2000). Therefore, measuring changes in key perceptions that are identified as being associated with adoption (i.e. learning) can also be a more appropriate form of evaluation than changes in actual adoption within a short time frame.

The adoption of integrated weed management (IWM) by Western Australian grain growers is used in this paper as an example of how a survey-based adoption study can be used to develop recommendations for extension. After background on IWM and the survey study of IWM extension, the paper is divided into 2 main sections. The first section discusses the perceptions and other farm and farmer factors shown to be influential in the decision to adopt a set of IWM practices. The second section uses an evaluation of an extension event to support recommendations for achieving change in weed management practices.

Background: integrated weed management and herbicide resistance

Grain growers in Western Australia face what is probably the most serious herbicide resistance problem in Australia (Llewellyn and Powles 2001; Walsh *et al*. 2001). The evolution of herbicide resistance in major cropping weeds threatens the sustainability of their herbicide-dependent cropping systems. Although resistance to some herbicides is already widespread, most grain growers have several herbicide options still available to control weed infestations in crops.

It is proposed that growers essentially face an optimal resource use decision where herbicide susceptibility is a potentially exhaustible resource (Llewellyn *et al*. 2001). Growers then choose the optimal levels of herbicide and IWM practice use to maximise their returns over the longer term. Within this framework, there are several socio-economic factors that are likely to influence grower willingness to invest in preventing herbicide resistance. These include the complexity of IWM and the information and learning costs associated with this; the ability to observe the profitability of IWM practices relative to herbicides; perceptions relating to the future development and cost of herbicide resistance and; the discount rate for future returns (see also Pannell and Zilberman 2001).

Through large research and extension initiatives, growers are being encouraged to adopt IWM practices to reduce selection pressure for further herbicide resistance (Powles *et al*. 1997). This study demonstrates methods that can help to identify effective approaches to achieving and monitoring outcomes from these initiatives.

Methods

The data presented comes from surveys involving 132 randomly selected Western Australian grain growers in March 2000 and 2001. With a fully specified questionnaire, grower perceptions relating to weed management practices, herbicides and herbicide resistance were elicited (see Llewellyn *et al*. 2002*a*, 2004), along with weed management practice use. Growers were from the Dalwallinu (64) and Katanning-Woodanilling shires (68). Following initial phone contact with primary cropping decision makers, the overall response rate was 88%. Properties managed by growers in the Dalwallinu shire (DAL) were larger on average than those in Katanning–Woodanilling (KAT) (3864 ha *v.* 1812 ha), had a greater proportion of land cropped (70 *v.* 55%), and received a lower average annual rainfall (approximately 325 *v.* 450 mm). The proportion of growers who reported that they had a herbicide-resistant weed population on an area of their farm was 70 and 47%, respectively.

Identification of key perceptions

The questionnaires focused on specific IWM practices for the control of the major cropping weed annual ryegrass. The practices included here are weed seed catching at harvest (catching), weed seed kill before harvest with a low-resistance risk herbicide (croptopping), crop sacrifice by mechanical or herbicidal means (manuring), delayed crop seeding, the use of 2 low-risk herbicides to control weeds before seeding (double knockdown), and higher wheat seeding rates.

In considering the economic value, or cost-effectiveness, of the IWM practices, growers were asked to consider all of the costs and benefits involved with their use and rate their perceived value on a scale of 1 to 9, with 5 being the value of an effective post-emergent selective herbicide. Perceptions of the efficacy of the various practices were elicited by asking growers to estimate the most likely (mode), highest possible and lowest possible percentage reduction in ryegrass that would result if they used the practice on their farm. An expected percentage control (weighted average) was then calculated (see Llewellyn *et al*. 2002*b*).

An empirical model explaining IWM adoption was constructed based on the herbicide resource management framework described above (see Llewellyn *et al*. 2002*b*). Growers were classified as IWM adopters if 3 or more of the practices listed above were to be used on their farm in the 2000 season. Influential factors in the decision to adopt IWM practices were identified with logit regression analysis of data from the March 2000 survey.

Evaluation of the effect of an extension activity on learning and adoption

To further examine the implications raised by the adoption study, an extension activity was conducted and the influence on key perceptions and intended adoption behaviour was evaluated. The intended learning outcomes of the extension activity were focused upon the perceptions that had previously been identified as being influential in the adoption decision.

From the 132 farm businesses involved in the initial survey in March 2000, 31 growers attended workshops conducted in October 2000. In March 2001, return surveying was conducted, with 101 available growers resurveyed, including most of those who participated in the workshop. The workshops were titled 'Managing weeds and herbicide resistance in your local area'. University of Western Australia and Department of Agriculture herbicide resistance researchers presented information from various research sources relating to specific IWM and herbicide resistance factors. This included information on the efficacy of the various practices, including the survey results, and information relating to the broader value of the double knockdown practice [modelling results that show its ability to prevent glyphosate resistance (Neve *et al*. 2003)] and higher wheat seeding rates (local trials showing no decline in grain quality at higher seeding rates).

The workshops also included an active learning session using the computer-based bio-economic simulation model RIM (Pannell *et al.* 2004; Stewart 2000). Working in pairs, growers tested various IWM strategies and crop rotations in the farming system for profitability and annual ryegrass population management over a 10-year period. The group agreed upon parameters used in the model, such as the percentage control provided by weed management practices. The objectives were to actively reinforce the extension messages, stimulate discussion of herbicide resistance management strategies and sharing of information, to facilitate consideration of profitability and weed management over a longer-term, and to demonstrate decision making based on selective herbicides being a potentially finite resource.

As shown in Figure 1, the evaluation method assumes that growers' previous perceptions incorporate the influence of farm and farmer characteristics, leaving learning in the period between measurements to be the contributor to differences between pre- and post-workshop perceptions. To account for the potentially large amount of 'other information' influencing farmers' perceptions in the intervening period, an index variable was included in the ordinary least squares (OLS) regressions based on each grower's involvement in learning opportunities (including field days, farmer groups, use of advisors and publications). This variable (described in Llewellyn *et al*. 2002*b*) is also intended to account for any selection-bias towards 'information-seeking individuals' among the self-selected workshop participants.

An additional explanatory information variable was also included to identify growers who used the particular practice during the 12-month period between the initial and final surveys. This recognises the potentially important role that recent on-farm experience with the practice can have in influencing perceptions. It is assumed that learning from on-farm use before 2000 is captured by the prior perception elicited in 2000.

Results

Identification of key perceptions

Influential factors in the decision to adopt a set of IWM practices were identified with logit regression analysis (see Llewellyn *et al*. 2002*b*). In general, growers' adoption of IWM practices was shown to be consistent with a herbicide resource management framework where herbicide efficacy is a potentially exhaustible resource due to herbicide resistance. Within this framework, grower perceptions relating to IWM practices and the herbicide resource were shown to be important, suggesting a potentially significant role for information and extension to improve decision-making and herbicide use strategies.

The 9 factors in the adoption model (listed below) were found to be significantly (P<0.05) associated with IWM adoption. They are listed below in declining order of their influence on adoption. Overall, the model was able to correctly classify 87% of growers as adopters or non-adopters.

Factors influencing adoption of IWM practices

i. *Perceived economic value of practices for weed control*. Growers perceiving higher economic value from adoption are more likely to adopt.
ii. *Education*. Growers with higher levels of education are more likely to adopt.
iii. *The resistance status of the farm*. Those with more resistance are more likely to adopt.
iv. *Perceived ryegrass control provided by a practice*. Those who believe the practice will provide higher ryegrass control are more likely to adopt.
v. *The amount of information/extension to which the grower is exposed*. Growers accessing larger amounts of information through advisors, agronomists, farmer groups, etc. are more likely to adopt.
vi. *Perceived number of years until the grower expects a new post-emergence, selective herbicide will become available*. Growers who believe that a replacement herbicide is further in the future are more likely to adopt.
vii. *Uncertainty of when a new herbicide will become available*. Growers more uncertain of when a replacement herbicide will become available are more likely to adopt.
viii. *The proportion of the farm in crop*. Growers with more of their farm in crop are more likely to adopt.
ix. *Future income discount rate*. Growers who do not have a relatively strong preference for income received today compared with in the future were more likely to adopt.

Overall, growers rated selective herbicides highly in terms of economic value, clearly ahead of almost all IWM practices (Llewellyn *et al*. 2002*a*). The analysis above identifies a number of factors that act against growers making a substantial investment in IWM practices to prevent or delay the onset of herbicide resistance, e.g. expectations of timely development of replacement herbicides by agri-chemical companies and the preference for returns in the shorter term. Therefore, of particular interest is whether growers have sound knowledge of the short-term cost-

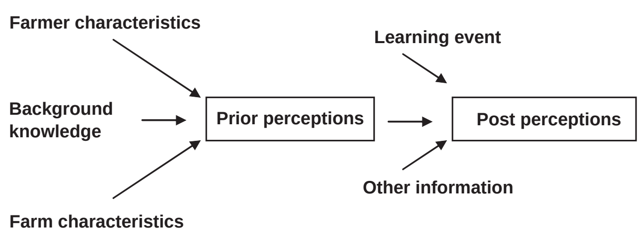

Figure 1. Influences on prior and post-workshop perceptions recognised in evaluation of perception changes.

effectiveness of the IWM practices for weed control. The importance of grower perceptions of the efficacy and economic value of IWM practices in influencing adoption (as shown above) suggests that there is a potential role for weed management extension to lead to management change. However, there appeared to be little potential to broadly influence perceptions of the efficacy of weed management practices as a study of these perceptions revealed that perceptions of non-users were generally consistent with those of users and with field trial experience. There did however appear to be some potential to influence the perceived economic value of some practices.

Evaluation of the effect of an extension activity on learning and adoption

Changes in perceived economic value of IWM practices. Workshop participation had a significant positive influence on the perceived value of the double knockdown practice and high wheat seeding rates (Table 1). These were the two practices where the workshop emphasised information on characteristics other than percentage control. Information included modelling results showing the expected effect of double knockdown use on reducing the risk of resistance to the herbicide glyphosate (see Neve *et al.* 2003) and local crop yield and quality data from high seeding rate trials. The workshop was not shown to be a significant influence (P>0.1) on the perceptions of value of any other practice, although the perceived value of manuring was positively influenced by workshop participation and close to statistical significance at the 10% level (P = 0.15) (data not shown). Consistent with learning frameworks where information and learning serves to update prior perceptions (e.g. Fischer *et al.* 1996), the prior perceptions held by growers were significant in explaining the post-workshop perceptions measured one year later.

Changes in perceived efficacy. As the expected percentage control elicited from growers in 2000 was generally consistent with field experience and research information, it was not expected that large changes in means would result from the workshop. The workshop variable did not significantly influence (P>0.1) the expected percentage control for any of the practices investigated here (regressions not presented). The study provides no evidence that workshop participation influenced the expected mean percentage ryegrass control attainable from these practices or their perceived reliability.

Table 1. Parameter estimates from OLS regression for factors influencing growers' perceptions in 2001 of the value of IWM practices for ryegrass control

†, P<0.10; *, P<0.05; **, P<0.01. Results shown are OLS regression models reduced with step-wise regression omitting variables not significant at the P = 0.2 level. F-test shows that a significant proportion of the variance in the sample is explained by the model

Variable	High seed rate	Double knockdown
Workshop participation	0.46†	0.69†
Information exposure	—	0.29
Prior perception (2000)	0.59**	0.20*
Constant	2.3**	4.3**
Observations	97	97
F-value	39**	5.5**
Adjusted R^2	0.44	0.12

Changes in intended use of IWM practices. Ultimately, most extension is intended to affect adoption. Unlike a farming systems research program, the extension activity used in this example is a single event and relatively simple. The time frame for evaluation was also relatively short (12 months). In addition, seasonal conditions can play a large role in the use of particular practices, making it less likely that there would be any correlation between workshop attendance and the use of a practice in the following season. Therefore it was not expected that the workshop would have a notable effect on the number of growers using particular practices in that year. For these reasons, the most appropriate possible measure of the effect of the workshop on adoption is intended future use.

In 2001, growers were asked if practices were intended to be used in the coming season. Growers' intended use of a practice in 2000 is used as an explanatory variable in the regression model. This is intended to account for growers who had made the decision to adopt before the initial survey. Intended adoption of high wheat seeding rates is measured using growers' expected average wheat seeding rate (kg/ha) for both 2001 and 2005, and was analysed with OLS regression. All other analyses are performed with logit regressions, with use or not use, as stated in 2001, as the dependent variable. The identity of the interviewer and the information exposure index were included as explanatory variables. As discussed above, the perceived economic value of practices was shown to be strongly associated with adoption. Consistent with this, changes in intended adoption resulting from the workshop were most expected for practices where perceived value had been influenced.

Changes in intended use of wheat seeding rates. There is strong evidence that the workshop has significantly influenced growers' intentions to use higher wheat seeding rates (Table 2). High wheat seeding rate was a targeted practice at the workshop, particularly in terms of general economic value. The RIM computer simulation exercise also demonstrates the benefit of higher seeding rates that result from greater crop competitiveness against weeds. OLS regression analysis was performed on the intended average wheat seeding rate to be used in 2001 and in four years time. A binary variable indicating whether growers used a high wheat seeding rate (>65 kg/ha) in 2000 was included in the model predicting the intended rate in four years time (as elicited in 2001). This is intended to account for any on-farm learning during the 12-month period. In each model the equivalent intended wheat seeding rate, as stated in 2000, is included as an explanatory variable. The coefficients shown in Table 2 suggest that, on average, an increase of 5.2 kg/ha in the 2001 intended seeding rate can be attributed to workshop participation.

Changes in other IWM practice use from 2000 to 2001. The workshop variable was significant in explaining intended use of double knockdown in 2001 (Table 2). Workshop and information exposure were not significant for the other practices (data not shown). In summary, the results suggest that the workshop positively influenced growers' intentions to adopt high wheat seeding rates and double knockdown following the workshop. This may be attributed to the influence of the workshop on the perceived economic value of the practices.

Given the well-recognised time lags involved in the adoption process, the influence of the workshop on IWM practice use was not expected to be observable within the study period. Although it is recognised that stated intentions do not necessarily translate into actual behaviour, there is evidence that the evaluation method has measured some changes in intended practice use. The data shows a large significant change in wheat seeding rates and evidence of a positive influence on the intention to adopt double knockdown.

Discussion

Determining the key perceptions (and other factors) influencing adoption and then identifying the major learning opportunities can be valuable in focusing research and extension. If learning activities can be targeted at perceptions known to be associated with adoption, investment in learning activities may be more likely to lead to management change.

As demonstrated here, the initial measurements of perceptions identified as being important in an adoption decision can also be useful in evaluating the effect of an extension or farming systems research program. This is particularly the case where it is unrealistic to expect all potential adopters to have completed the learning and decision-making process necessary for an informed adoption decision within the evaluation time frame, and where the objectives of a program may be primarily focused upon learning rather than adoption.

It needs to be recognised that conducting the formal surveying and analysis required for these purposes is likely to be more time-consuming and costly than methods often used as part of a farming systems research and extension process, e.g. rapid rural appraisal (Petheram and Clark 1998). The quantitative approach is also likely to require the time and repeat cooperation of a greater number of farmers. The cost-effectiveness of this greater investment in diagnosing constraints, opportunities and outcomes, as demonstrated here, will be dependent on the size of the research-extension program, the potential for the information generated by the program to be of value beyond the core participants and the potential for the findings to inform other programs.

In the case of improving weed management by Western Australian grain growers, the results highlight both opportunities and limitations. Growers were found to have a generally high level of awareness of the efficacy of various IWM practices and of herbicide resistance evolution. However, there are a number of socio-economic factors that act against growers making the decision to pre-emptively adopt IWM to prevent herbicide resistance, including a common expectation that the availability of cost-effective herbicides for control of major weeds will be ongoing.

Weed management research and extension is commonly concerned with the efficacy of practices and understanding of the risk and management of herbicide resistance. The results of this study indicate that greater adoption of IWM practices may be more likely if the broader benefits of using additional IWM practices can be developed and communicated.

One possible avenue to achieving this is through the concerted development and extension of aspects of IWM

Table 2. Parameter estimates from regressions for factors influencing growers' intended average wheat seeding rates (kg/ha) (OLS regression) and use of double knock down (logit regression) in 2001 (n = 97)

*, P<0.05; **, P<0.01. Results of the OSL regression shown are reduced models with step-wise regression omitting variables not significant at the P = 0.2 level. F-test shows that a significant proportion of the variance in the sample is explained by the model

Seeding rate		Double knockdown	
Workshop participation	5.2**	Workshop participation	1.4*
Information exposure	1.5	Information exposure	1.1**
Expected rate stated in 2000	0.8**	Use intended in 2000	1.1*
Interviewer	–3.2	Interviewer	—
Constant	19.4**	Constant	–0.46
F-value	28.7**	Chi-square	31**
Adjusted R^2	0.54	Pseudo R^2	0.24
		% Predicted correct:	75

practices, beyond just weed and resistance management. As examples, some opportunities may lie in using farming systems approaches to develop the use of seed catch material as a fodder source and reducing frost risk through delayed seeding. The study results point to the need for farming systems approaches to develop and extend the broader attributes of IWM practices that may add to their overall profitability. This recommendation is supported by the evaluation of the extension activity in this study, which was based on an interactive session using the bio-economic cropping systems model RIM.

The perceived economic value of some practices was positively influenced during the workshop, most likely by information relating to characteristics other than weed control efficacy. Consistent with expectations, increasing the perceived economic value of a practice in the farming system resulted in an increase in intended adoption. The study emphasises the potential for a multi-disciplinary farming systems approach to lead to learning opportunities for greater IWM adoption.

Conclusion

Early identification of farmer perceptions influencing particular farm management decisions provides the opportunity to more effectively focus investment in research and extension. This is likely to be particularly useful where important misperceptions can be identified. Focussing extension information on aspects of a farming system that are already well understood and accurately perceived by farmers is unlikely to be beneficial, but is at risk of occurring without the sort of survey work presented here. Identification of key perceptions in adoption decisions can help in planning and evaluating both research and extension. Use of this approach seems likely to lead to greater integration and synergy between farming systems research and agricultural extension.

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