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# Effective information and the influence of an extension event on perceptions and adoption

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## Abstract

Perceptions are known to play an important role in the innovation adoption decision. Once influential perceptions have been identified, there is the potential for information to influence adoption by changing these perceptions. In this paper, the influence of an extension workshop targeting grain growers' perceptions known to be associated with the adoption of integrated weed management and herbicide resistance management has been measured using regression analysis. Consistent with a Bayesian learning framework, the greatest influence on grower perceptions and intended adoption behaviour was observed where information could be delivered with a high degree of certainty and validity.

## 1. Introduction

The adoption of agricultural innovations is widely assumed to be a dynamic decision process involving learning and uncertainty. This approach is common to most recent economic studies of innovation adoption (e.g. Abadi Ghadim and Pannell, 1999; Cameron, 1999). A Bayesian decision theory approach to learning was first used by O'Mara (1971) and then further developed as a characterization of an individual's adoption behaviour (Feder and O'Mara, 1982; Lindner *et al.*, 1979). Essentially, the process involves the acquisition of information that is assimilated to update existing perceptions about the characteristics of an innovation. Obviously, growers do not actually utilise information in strict accordance with mathematical Bayesian theory. However, a Bayesian approach has been useful in modelling and as an approximation to help explain and predict adoption behaviour (e.g. Leathers and Smale, 1992).

Very few attempts have been made to directly test the consistency of the revision of perception by farmers with Bayesian theory (Lindner and Gibbs, 1990), but several empirical studies have demonstrated the influence of farmer perceptions on adoption decisions (e.g. Adesina and Baidu-Forson, 1995; Cary and Wilkinson, 1997). The purpose of this study is to determine the influence of information on farmer perceptions that are known to be determinants of adoption; and to determine the influence of perception changes on intended adoption behaviour. In an earlier study, several perceptions relating to integrated weed management (IWM) practices and herbicide resistance were shown to be determinants of the adoption of a suite of weed management practices by grain growers (Llewellyn *et al*., 2003). An experiment based around a single extension event targeting key perceptions has been used to test consistency with a Bayesian-based learning framework that has been adapted primarily from Lindner and Gibbs (1990).

## 2. A framework for the role of information and learning in IWM adoption

Consider an individual grower's perceptions of a factor shown to be important in IWM adoption. Here, we use the example of perceived efficacy (percentage of weeds killed) of a weed control innovation. Assume that the actual percentage weed control, X, achievable by adopting the IWM practice has a distribution with mean percentage control, $\mu$, and variance, $\sigma^2$ due to risk factors such as seasonal conditions. The grower is assumed to be imperfectly informed about the efficacy of the practice, and therefore holds a prior perception about likely percentage control that has mean $\gamma_0$ and variance $\delta_0^2$. Tsur *et al.* (1990) use a decomposed variance term incorporating a component relating to exogenous uncertainties such as seasonal conditions and a component reflecting the subjective uncertainty resulting from a lack of information. It is the latter component that can be influenced by information and learning relating to the IWM practice. For simplicity, a single term for the variance ($\delta^2$) is referred to here.

Information gained by the grower about the efficacy of the practice is assumed to have mean $\mu_x$ and variance $\sigma_x^2$, and to be obtained by random sampling from the distribution, X, as may be the case if the grower conducted an on-farm trial. Consistent with other adoption models, it is assumed that growers know this variance, the inverse of which can be interpreted as the precision or informativeness of the message (Lindner *et al*., 1979; Stoneman, 1981).

After information has been acquired, the available information can be described as the sum of the information in the prior perception, $\delta_0^{-2}$, and the new information, $\sigma_x^{-2}$.

$$\delta_t^{-2} = \delta_0^{-2} + \sigma_x^{-2} \quad (1)$$

An estimate of this posterior variance can be calculated using:

$$\delta_t^2 = \delta_0^2 \sigma_x^2 (\delta_0^2 + \sigma_x^2)^{-1} \quad (2)$$

and the grower's estimate of the mean percentage control, that is, the posterior mean, $\gamma_t$, can be calculated using:

$$\gamma_t = (1-\beta)\,\gamma_0 + \beta\,\mu_x \quad (3)$$

where

$$\beta = \delta_0^2 (\delta_0^2 + \sigma_x^2)^{-1} = \sigma_x^{-2} (\delta_t^{-2})^{-1} \quad (4)$$

The 'posterior' mean, $\gamma_t$, is the grower's perception of the mean percentage control following the processing of the information. From equation 3, this will have been shifted to a greater extent if $\beta$ is large. Obviously, new information with high precision ($\sigma_x^{-2}$) and a mean that differs largely from the prior mean, will have the most influence on the grower's posterior estimate of the mean percentage weed control achievable using the practice. Before this is related to the variables influencing IWM adoption, the nature of the variance associated with new information needs to be considered further.

In practice, a grower will receive numerous pieces of information, many of which will come from sources that are only partly related to the grower's particular conditions. For those not yet using the IWM practice, information will most likely come from off-farm sources. The grower must then rely on processing that information to produce an estimate of the mean ($\mu_x$) and variance ($\sigma_x^2$). Leathers and Smale (1992) introduce a subjective probability relating to the perceived validity of a piece of received information denoted here as $\nu$. This acts on the posterior mean in a similar way to $\beta$ (equation 3). In their example, $\nu$ refers to the validity of an extension report. In other cases it may refer to the distance of the information source from the property; that is, the locational relevance of the information (Lindner *et al*., 1982). Consistent with this, Marra et al. (2001) found information generated on the decision-maker's own farm, such as that produced by past use of an innovation or a trial, to be weighted most heavily relative to other information sources in the decision to adopt a cropping innovation.

While most studies assume there to be multiple information sources, it is likely that the pieces of information gained in one year will not all be independent, as they will be derived under similar seasonal conditions (Fischer *et al*., 1996). In this case, the variance of the set of information pieces will be higher as the number of effective information sources, k, is less than n and therefore $\sigma_x^2/k > \sigma_x^2/n$. As described by Fischer et al. (1996), this is the concept of effective information. In the following sections an experiment examining the effectiveness of information relating to weed management is described.

## 3. Methods

### *3.1 Experimental design*

A pre-test/post-test experimental design was used with a one-year period between the initial measurement of growers' perceptions in March 2000 (see Llewellyn *et al*. 2002) and the final measurement in 2001 (Figure 1). A subset of growers was exposed to an extension treatment in the form of a workshop conducted in October 2000 that is described in the next section. This design has the advantage of being able to measure changes in individuals' perceptions for both participants and non-participants, and allows changes attributable to sources other than the workshop to be explained. A disadvantage is the inability to account for 'information leakage'. This refers to perception changes by non-participants that are a result of communication with participants (de Vaus, 1995). Hence the influence of the workshop on perceptions in the region may be underestimated.

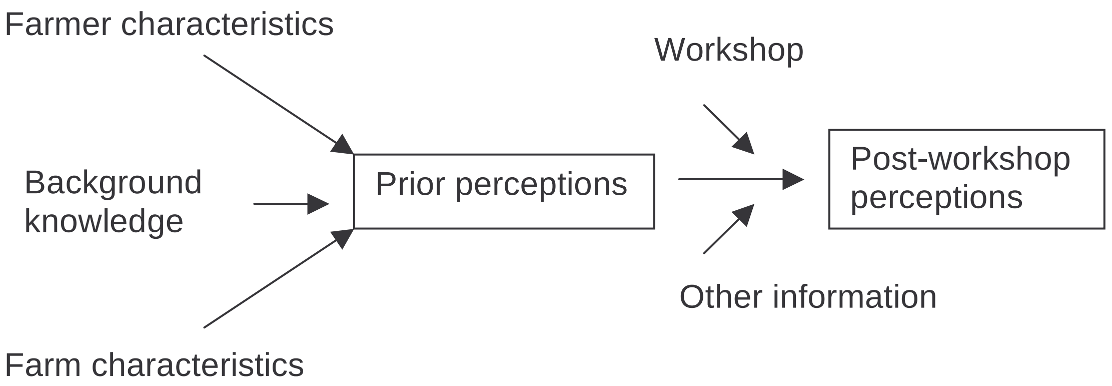


**Figure 1** Experimental design showing conceptualised influences on prior- and post-workshop perceptions.

The influence of the workshop on perceptions is determined using OLS regression techniques. Regression analyses include the pre-test perception as an explanatory variable, as indicated in Figure 1. This recognises that information results in an adjustment of prior perceptions. These prior perceptions may be dependent on farm and farmer-specific factors.

It is recognised that growers were most likely exposed to a range of information during the 12-month period between measurements that may have resulted in adjustments to their prior perceptions. This may include information from extension sources and learning from on-farm experience. An information exposure index (described in Llewellyn *et al*. 2003) was developed for each grower based on the first principal component (eigenvalue of 2, explaining 50% of the variance, weighing positively for all measures) extracted from measures of farm-specific information (commercial agronomist visits per year and consultant use) and non-farm-specific information (subscriptions to publications that often contain weed management information and the number of field days or cropping-related meetings attended). Some growers were also exposed to the targeted extension workshop described below. Recognising the role of on-farm learning, the confirmed use of an IWM practice during the 12-month period, is also included in the regressions.

Human capital can influence farmers' ability to adjust perceptions given new information and can act to lower the cost of information acquisition (Goodwin and Schroeder, 1994; Pingali and Carlson, 1985), and may have influenced the prior perceptions of growers. In this study the measure of human capital was limited to a proxy variable identifying the attainment of a university qualification (25% of the sample population). Preliminary regression analyses suggested that the variable had no significant influence on changes in perceptions. Given this, and judgements about the limited level of influence this measure could have over a 12-month period, human capital was not included as an explanatory variable of post-workshop perception.

*The workshop*

In each region, two half-day workshops for separate groups of growers were held on two consecutive days during October. These were held in computer-equipped venues in the largest central town in each region. The workshops were titled 'Managing weeds and herbicide resistance in your local area' and all participants in the 2000 survey received an invitation. Information from various research sources relating to specific IWM and herbicide resistance factors was presented. This targeted information was presented by a researcher known to many grain growers in the state for work in the field of herbicide resistance and its management. The targeted variables are identified in the results section.

The workshops also included an active learning session using the Ryegrass Integrated Management (RIM) computer-based model (Pannell and Zilberman, 2001; Stewart, 2000), facilitated by an IWM extension officer from the Department of Agriculture. Working in pairs, growers used the bioeconomic model to test various IWM strategies and crop rotations for profitability and ryegrass population management over a 10-year period. Parameters in the model, such as the percentage control provided by weed management practices, were agreed upon following discussion of the local survey results. RIM-based workshops have been successfully run with numerous farmer groups in Western Australia. The objectives are to actively reinforce extension messages, stimulate discussion of herbicide resistance management strategies, 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.

*Sample and surveying*

The prior perceptions used in this analysis are those elicited from a survey of 132 randomly selected grain growers from within the Dalwallinu (DAL) shire (64 growers) and Katanning-Woodanilling (KAT) shires (68 growers) of Western Australia. Farm visits were conducted prior to crop seeding in February-March 2000 and interviews conducted with the primary cropping decision-maker(s) on each farm, based on a fully-specified questionnaire. Most questions on herbicide resistance and weed management focused on the cropping weed annual ryegrass and resistance to post-emergence ryegrass-selective herbicides - the most common form of herbicide resistance in Western Australia (Llewellyn and Powles, 2001). The two regions represent an area of the Western Australian wheatbelt where more intensive cropping and herbicide resistance is well-established (DAL) and an area where cropping has only relatively recently become more intensive and weed populations with serious levels of resistance are not yet widespread (KAT).

From the 132 farm businesses involved in the initial survey, 31 growers attended the workshops. In March 2001 return surveying was conducted, with 101 growers resurveyed. Reasons for growers not being resurveyed generally involved unavailability during the limited period spent resurveying in each area. If the same person could not be surveyed in each year, or the workshop participant was not surveyed in each year, the observation was dropped from the analysis. The number of workshop participants included in the analyses was 27, with 70 usable observations for non-participants. In some analyses, non-response to particular questions in any year has resulted in less than 97 observations. Where measuring perception and adoption changes was the primary objective, the question format used in the second questionnaire was identical to that used in the initial survey.

Self-selection for workshop attendance needs to be considered. The region-based design and the central workshop locations were intended to reduce any influence of distance. Accordingly, there was no notable difference in the mean time required to travel to the workshop venues. Farm and farmer characteristics that influence adoption can also be associated with attendance at extension events (Goodwin and Schroeder, 1994). A logit analysis (data not shown) was conducted to determine the influence of a range of variables including age, education, herbicide resistance status, and farm size on the likelihood of workshop attendance. Growers with a higher exposure index (described above) were found to be more likely to attend ($P = 0.02$). This was the only variable significant at the 5 percent level. The result indicates that the participants in the workshop are likely to have had a greater exposure to various other weed management information sources and are likely to be more active information-seekers. Information exposure and workshop attendance had a correlation coefficient of 0.29. As only five of the 101 growers in the second survey suspected that they might have developed their first population of herbicide resistant ryegrass during the 12 month period between surveys, this was not included as a variable in the following regressions.

## 4. Results

All perceptions of the percentage control provided by various IWM practices, and most perceptions relating to herbicide resistance[1], were elicited using triangular subjective probability distributions (Hardaker *et al.*, 1997). The IWM practices were weed seed catching at harvest (catching), weeds seed kill prior to harvest with a low-resistance risk herbicide (croptopping), crop sacrifice by mechanical or herbicidal means (manuring), delayed crop seeding, the use of two low-risk herbicides to control weeds prior to seeding (double knockdown), and higher

[1] The exception being the variable relating to resistance reversion which was elicited as a single probability expressed as a chance out of 10.

wheat seeding rates. For these perceptions, changes in both the expected value (EV) and coefficient of variation (CV) (as a measure of risk and/or uncertainty) are considered. OLS regression analysis is used for these and the perceptions of IWM value and resistance reversion. The intended adoption of the IWM practices is analysed using logit regression.

A fundamental assumption of any Bayesian learning model is that prior perceptions condition posterior perceptions. The null hypothesis that growers' prior perceptions are not associated with post-workshop perceptions is consistently rejected in this study. As expected, the prior perceptions measured in 2000 (and prior adoption intentions) are consistently significant in explaining the post-workshop perceptions measured in March 2001 (Tables 1-3).

It should be noted that although all models presented are statistically significant in explaining 2001 responses, several models account for a relatively small proportion of the response variance. This suggests that other unspecified factors influenced responses. There is also a possibility of considerable measurement error in the elicitation process and an element of randomness to growers' perceptions and adoption intentions. Comparable studies examining perception changes have reported difficulties in measuring perception changes (McDonald *et al*., 1997; Verstegen *et al*., 1998). For these reasons, statistical significance at the 10% level is commented upon in the following results section. The results demonstrate the value of accounting for interviewer bias. In several models the variable identifying the interviewer in 2001 is significant. There appears to be no consistent pattern to the direction of this influence, although it appears that slight inconsistencies in the presentation of different questions are being captured.

*4.1 Perceptions of herbicides and resistance*

These perceptions relate to the concept of herbicide resource depletion and replenishment (Llewellyn *et al*., 2001). The workshop included information targeting the number of years until a herbicide with a new mode of action may become available and the probability of a resistant ryegrass population reverting to susceptibility over time.

*Herbicide resistance development*

At the workshop it was emphasized that the median perception of surveyed growers regarding the number of diclofop applications was consistent with modelling and other weed science studies (i.e. an expected value of approximately 5 applications) (Llewellyn *et al.* 2002). The workshop presented an opportunity to influence the perceptions of growers who perceived that an exceptionally high number of herbicide (diclofop) applications could be used before resistance would develop. Given that the herbicide use scenario was hypothetical for growers, that is, the use of only the one herbicide annually for ryegrass control, the scientific knowledge that was presented regarding the number of effective diclofop applications was assumed to be of relatively high validity. Glyphosate resistance could not be discussed in this manner as there is little scientific evidence to support such a discussion. It was therefore expected that the information presented would most likely only act to reduce the expected number of diclofop applications perceived to be possible before the onset of resistance.

**Table 1** Models of growers' perceptions in 2001 of the expected number (EV) and uncertainty (CV) of herbicide applications before resistance develops, using OLS regression.

| | **Diclofop** | | **Glyphosate** | |
|---|---|---|---|---|
| **Variable** | **EV** | **CV** | **EV** | **CV** |
| **Workshop (1/0)** | -0.791 (0.433)* | -1.490 (1.474) | -2.648 (3.078) | -3.547 (2.927) |
| **Information exposure** | -0.267 (0.245) | -0.509 (0.835) | -1.331 (1.795) | 0.254 (1.664) |
| **Prior perception (2000)** | 0.358 (0.100)*** | 0.295 (0.110)*** | 0.550 (0.123)*** | 0.292 (0.124)** |
| **Interviewer (1/0)** | 0.667 (0.379)* | -2.574 (1.290)** | 10.274 (2.714)*** | 4.679 (2.579)* |
| **Constant** | 3.90. (0.685)*** | 12.789 (1.893)*** | 7.695 (2.740)*** | 13.972 (2.793)*** |
| **Obs.** | 96 | 96 | 94 | 94 |
| **F** | 5.57*** | 3.21** | 8.32*** | 2.29* |
| **Adjusted $R^2$** | 0.16 | 0.10 | 0.24 | 0.05 |

*P < 0.1; **P < 0.05; ***P < 0.01 (standard errors shown in parentheses)

Workshop attendance had a statistically significant negative influence on the expected number of applications before a ryegrass population becomes resistant to the herbicide diclofop (Table 1). The influence of workshop participation was not statistically significant for the equivalent variable for the herbicide glyphosate or for the CV for both herbicides (Table 1), although the sign was negative in each case. The results suggest that perceptions of the relationship between resistance selection pressure (applications) and resistance development can be influenced by extension.

*New herbicide availability*

A relatively large amount of time at the workshop was spent discussing the development of new herbicide products and the herbicide development industry. This included mention of the rapid screening processes for new compounds and the likelihood that new herbicides will be discovered at some time in the future. Information was presented on possible constraints to new herbicide development and the time frames observed from discovery to release. It was stated that there was no public knowledge of the development of any herbicide with a new mode of action for the post-emergent selective control of ryegrass. It was expected that the information presented at the workshop would act to increase the expected number of years until a new herbicide becomes available. Both the EV and the CV for the number of years have been found to be associated with IWM adoption (Llewellyn *et al*., 2003).

**Table 2** Models of growers' perceptions in 2001 of the number of years until a new selective herbicide becomes available, using OLS regression for expected value (EV) and coefficient of variation (CV), and the probability of a resistant ryegrass population reverting to susceptibility.

| | **Years until new herbicide** | | **Probability of resistance reversion** |
|---|---|---|---|
| **Variable** | **EV** | **CV** | |
| **Workshop** | 0.978 (1.804) | -4.932 (2.716)* | -1.416 (0.591)** |
| **Information exposure** | -0.457 (1.025) | 0.303 (1.551) | -0.463 (0.330) |
| **Prior perception (2000)** | 1.484 (0.262)*** | 0.342 (0.106)*** | 0.358 (0.085)*** |
| **Interviewer** | 2.424 (1.576) | 2.858 (2.358) | -1.066 (0.533)** |
| **Constant** | -0.437 (1.889) | 18.202 (3.056)*** | 2.188 (0.483)*** |
| **Obs.** | 97 | 97 | 96 |
| **F** | 9.53*** | 3.97*** | 10.54*** |
| **Adjusted $R^2$** | 0.26 | 0.11 | 0.29 |

*P<0.1; **P<0.05; ***P<0.01 (standard errors shown in parentheses)

Workshop participation was not found to be statistically significant in influencing the expected number of years until a new herbicide becomes available (Table 2). Workshop participation had a negative influence on the uncertainty (CV) of when a herbicide with a new mode of action for selective ryegrass control would become available. A possible explanation for this is that while growers were advised that a new mode of action herbicide is unlikely to be available within 5 years, the discussion of modern chemical synthesis and screening technology resulted in several growers becoming more confident that a new herbicide would become available in the medium-term future.

*Permanence of herbicide resistance*

Information was presented at the workshop on how and why ryegrass populations resistant to particular herbicides have not been found to revert to susceptibility. Although this factor was not found to be significantly associated with IWM adoption, growers' responses in the 2000 survey indicated that many held perceptions contrary to scientific knowledge. At the workshop, a simple message could be communicated based on scientific studies and Australia-wide observation of resistant populations. That is, the probability of this form of resistance regression occurring is very low, a field example has never been confirmed, and therefore resistance in ryegrass should be considered permanent. This information was assumed to be relatively high validity, have low variance, and be substantially different to the prior perceptions held by many growers. Therefore, workshop participation was expected to reduce the perceived probability of a resistant population returning to susceptibility.

As expected, the workshop participation was found to be significant in reducing the perceived probability of a resistant population returning to susceptibility (Table 2). The Workshop coefficient shows that the influence of workshop attendance was to reduce the perceived probability of a resistant population returning to susceptibility by 0.14 (or 1.4 out of 10). This relatively large shift in perception demonstrates the potential influence of information when a simple and certain message can be delivered to an audience holding misperceptions with a low level of certainty.

*Summary of the effect of the workshop on perceptions of herbicides and resistance*

Of the four resistance-related factors measured and presented here, the years until a new herbicide may become available and the probability of resistant populations reverting to susceptibility were targeted in the workshop by spending additional time discussing the available research and industry knowledge. Research knowledge of the number of herbicide applications until resistance was discussed more briefly. There is evidence to suggest that workshop participation has resulted in shifts in perceptions amongst the participant population for most of these variables.

The influence of the workshop was most evident in perceptions of the probability of resistant populations reverting to susceptibility. Participation in the workshop resulted in a perception of resistance permanence more consistent with research knowledge. There was also evidence to suggest that participation resulted in an expectation that herbicide resistance will develop with fewer diclofop applications. Given the lack of available evidence able to be presented relating to glyphosate resistance development, it was likely that the information would be of low effectiveness. Not unexpectedly, the workshop appears to have had no influence on this factor.

Workshop participation did not result in an increase in the expected number of years until a herbicide becomes available that can control any current resistant populations, but it did reduce the uncertainty relating to the time of availability. Based on the model of IWM adoption (Llewellyn *et al*., 2003), this may decrease the likelihood of IWM adoption. Notably, information exposure was insignificant in all models, suggesting that broader information exposure has not played a major role in adjusting perceptions of these very specific herbicide resistance factors over the 12-month period.

*4.2 Perceptions of IWM practices*

The perceptions of IWM practices included here relate to the efficacy of the IWM practices (percentage control) and the overall value of the practice. At the workshop, information on the value of high seeding rates was presented. This included information from Western Australian field research showing relatively consistent yields and quality. Modelling research demonstrating the value of the double knock technique in reducing the likelihood of glyphosate resistance development was also discussed. Some research information on percent ryegrass control was presented for croptopping, manuring and catching. In three of the four workshops held, participants who had used catching contributed information highlighting the management difficulties associated with catching and experience with high variation in efficacy. Reasons for expectations of croptopping control being lower in growers' paddocks than in research plots (e.g. uneven crop and weed ripening over large paddocks) were also raised by workshop participants.

In the regressions below, an additional explanatory information variable has been included. This binary variable (1 if used in past year) identifies growers who used the practice in question 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 prior to 2000 is captured by the prior perception elicited in 2000.

*Perceived economic value of IWM practices*

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 one to nine, with five being the value of an effective post-emergent selective herbicide. In addition to the practices targeted during the workshop, in terms of percentage ryegrass control, two practices (high wheat seed rates and double knock) were targeted in terms of their broader value to the farming system and profitability. Research results showing only a low risk of yield loss and a high likelihood of yield gain as a result of high seeding rates were presented. Research results demonstrating the low risk of selecting for glyphosate resistance when the double knock practice is regularly used (Diggle and Neve, 2001) were also presented. It was expected that this research information, in the absence of any comparable local source of observable information, would act to increase the perceived economic value of the practice.

Workshop participation had a significant positive influence on the perceived value of the double knock practice (Table 3). The perceived value of high wheat seeding rates and manuring was positively influenced by workshop participation and close to statistical significance. Use of practices in the past year resulted in a statistically significant positive influence on the perceived value of manuring, croptopping and delayed seeding. The information exposure index was not statistically significant for any practice.

**Table 3** Models of growers' perceptions in 2001 of the value of IWM practices for ryegrass control using OLS regression.

| Variable | High seed rate | Double knock | Manuring | Croptopping | Catching | Delayed seeding |
|---|---|---|---|---|---|---|
| **Workshop** | 0.410 | 0.688 | 0.569 | 0.106 | -0.330 | -0.131 |
| | (0.304) | (0.382)* | (0.477) | (0.379) | (0.416) | (0.483) |
| **Information exposure** | 0.129 | 0.249 | 0.235 | 0.154 | 0.006 | 0.417 |
| | (0.174) | (0.229) | (0.275) | (0.232) | (0.249) | (0.273) |
| **Prior perception (2000)** | 0.607 | 0.194 | 0.287 | 0.525 | 0.260 | 0.228 |
| | (0.084)*** | (0.094)** | (0.102)*** | (0.098)*** | (0.090)*** | (0.112)** |
| **Used in past year** | -0.154 | 0.338 | 1.440 | 0.738 | 0.300 | 1.019 |
| | (0.287) | (0.357) | (0.503)*** | (0.370)* | (0.689) | (0.583)* |
| **Interviewer** | -0.030 | -0.186 | -0.991 | -0.574 | -0.503 | -0.264 |
| | (0.294) | (0.340) | (0.430)** | (0.360) | (0.372) | (0.420) |
| **Constant** | 2.334 | 4.256 | 3.431 | 2.488 | 3.253 | 3.514 |
| | (0.331)*** | (0.517)*** | (0.524)*** | (0.467)*** | (0.442)*** | (0.535)*** |
| **Obs.** | 97 | 97 | 95 | 92 | 95 | 97 |
| **F** | 15.41*** | 3.55*** | 4.09*** | 8.17*** | 2.42** | 2.19* |
| **Adjusted $R^2$** | 0.43 | 0.12 | 0.14 | 0.28 | 0.07 | 0.06 |

* P < 0.1; **P < 0.05; ***P < 0.01 (standard errors shown in parentheses)

In summary, the results show that workshop participation had a positive influence on the perceived value of the double knock technique and possibly higher seeding rates. These were the two practices for which workshop information was mostly targeted at characteristics other than percentage control. Use of a practice in the past 12 months was shown to be significant for several practices. This contrasts with general information exposure, which was not significant in influencing the perceived value of any practice.

*Percentage ryegrass control*

As the expected values for percentage control elicited from growers in 2000 were generally consistent with research information, it was not expected that large changes in means would result from the workshop. As practice users generally had similar CVs to non-users, it appeared that variation due to environmental conditions dominated any uncertainty related to lack of knowledge. Therefore, there was no expectation of a large influence on growers' perceptions of variance about the mean (CV). Representative distributions elicited in the 2000 survey for the percentage control for all practices were presented briefly at the workshops. Participants were informed that users of the practices gave very similar distributions to non-users. The high level of variance associated with the information presented, the large amount of local 'neighbourhood' information sources available for most practices, and the consistency of most growers' prior perceptions of percentage control distributions with research knowledge, are all factors hypothesised to limit the influence of information such as that presented at the workshop.

As expected, the workshop variable did not significantly influence ($P > 0.1$) the percentage control EV or CV (regressions not presented) for any of the practices investigated here. Information exposure and use in 2000 was also not significant in any regression model. The study provides no evidence that workshop attendance influenced the perceived mean percentage ryegrass control attainable from these practices or their perceived reliability. The possibility that measurement error associated with the elicitation of triangular distributions could have contributed to the lack of significance in the models needs to be acknowledged. However, regressions conducted using the growers' modal responses (i.e. the single percentage control figure stated as 'most likely') produced similar results, with workshop attendance remaining insignificant in all models.

*Summary of perceptions of IWM practices*

The targeted information in the workshop had the intended influence on growers' perceptions of practice value. A significant positive influence was recorded for the two practices targeted: high wheat seeding rates and double knock. The information largely related to characteristics other than the level of weed control. In the case of high seed rates, the information suggested that the practice should not be devalued due to the risk of reduced yield and grain quality in drier years. Information on the double knock highlighted its potential value in slowing the development of glyphosate resistance. There was no evidence to suggest that workshop information on the percent ryegrass control influenced grower perceptions. As hypothesised, the high level of variance associated with practice efficacy and the role of farm specific factors is likely to limit the influence of 'remote' forms of extension information. The relative influence of this information is also likely to be lower where the diffusion process is at a stage where most growers can observe the efficacy achieved by neighbouring users. The workshops also raised justification from growers for some differences in efficacy between paddock and field trial research conditions. It should also be noted that for most practices the average grower response was consistent with research opinion.

Providing information on the benefits other than percentage ryegrass control may be a relatively effective approach to encouraging adoption. This tentative conclusion is based on the observation that the workshop was shown to influence the perceived value of some treatments, while the perceived control percentage for any treatment was not influenced. The results suggest that extension should target factors other than just those relating to resistance management. This argument is supported by the relatively high use of practices offering lower weed control but other benefits. Examples of information that may be effective are: the feed value of seed catch material; reduced frost risk through delayed seeding; reduced risk of glyphosate resistance through use of double knock, and yield gains through increased seeding rates. In essence, the results suggest that information on the broader economics of IWM practice use within the farming system may have the greatest impact on adoption.

*4.3 Changes in intended use of IWM practices*

Ultimately, most extension is intended to affect adoption. Given the short time frame of this study and the one-off nature of the intervention, it was not expected that the workshop would have a notable effect on the number of growers using particular practices. 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. For these reasons, the most appropriate measure of the effect of the workshop 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 are used as an explanatory variable in the appropriate model. This is intended to account for growers who had made the decision to adopt prior to 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 using OLS regression. All other analyses are performed using logit regressions, with use/not use (1/0), as stated in 2001, as the dependent variable. The identity of the interviewer and the information exposure index were included as explanatory variables. Perceptions of the economic value of practices was shown to be strongly associated with adoption (Llewellyn *et al*., 2003). Consistent with this, changes in intended adoption resulting from the workshop were most expected for practices where perceived value had been influenced.

*Wheat seeding rates*

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 (> 65kg/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.

There is strong evidence that the workshop has significantly influenced growers' intentions to use higher wheat seeding rates (Table 4). The coefficients suggest that, on average, a 5.2 kg/ha increase in the 2001 intended seeding rate and a 8.5 kg/ha increase in the expected rate to be used in four years time (2005) can be attributed to workshop participation. Although not significant at the 10% level, the use of a high seed rate in 2000 appears to have had a negative influence on the intention to use high seeding rates in the future (Table 4). Unlike for other practices, the sign for high seed rate use in 2000 was also negative for the perceived value of high seed rate (Table 3). The negative direction of this variable may be explained by the seasonal conditions of 2000; an unusually dry season in which high crop density can exacerbate the effects of water stress on yield and quality.

**Table 4** Models of growers' intended average wheat seeding rates (kg/ha), using OLS regression.

| Variable | Rate in current year | Expected rate in 4 years time |
|---|---|---|
| **Workshop** | 5.196 (1.896)*** | 9.134 (3.249)*** |
| **Information exposure** | 1.478 (1.121) | 0.261 (2.033) |
| **Expected rate stated in 2000** | 0.780 (0.084)*** | 0.982 (0.145)*** |
| **High rate used in 2000 (1/0)** | - | -5.416 (4.141) |
| **Interviewer** | -3.206 (1.701)* | -2.908 (2.935) |
| **Constant** | 19.409 (5.354)*** | 9.154 (8.563) |
| **Obs.** | 97 | 97 |
| **F** | 28.71*** | 20.79*** |
| **Adjusted $R^2$** | 0.54 | 0.51 |

* P < 0.1; **P < 0.05; ***P < 0.01 (standard errors shown in parentheses)

*Changes in other IWM practice use from 2000 to 2001*

Logit regression models of intended use of IWM practices other than high wheat seeding rate in 2001 are presented. No model is presented for catching as intended use in 2001 was perfectly predicted by intended use in 2000, indicating that no grower in the sample was intending to use catching for the first time in 2001. The workshop variable was significant in explaining intended use of double knock in 2001 (Table 5). Growers with higher information exposure were also significantly more likely to intend to use double knock in 2001. Workshop and information exposure were not significant for the other practices. In summary, the results suggest that the workshop positively influenced growers' intentions to adopt high wheat seeding rates and double knock following the workshop. This may be attributed to the workshop's influence on perceptions of the economic value of the practices.

**Table 5** Models of growers' intended use of IWM practices in 2001, using logit regression.

| Variable | Double knock | Croptopping | Delayed seeding | Manuring |
|---|---|---|---|---|
| **Workshop** | 1.522 | 0.094 | 0.391 | 0.375 |
| | (0.685)** | (0.653) | (0.518) | (0.695) |
| **Information exposure** | 1.207 | 0.643 | 0.381 | 0.150 |
| | (0.425)*** | (0.436) | (0.318) | (0.430) |
| **Use intended in 2000** | 1.187 | 2.813 | 1.285 | 1.129 |
| | (0.511)** | (0.602)*** | (0.443)*** | (0.840) |
| **Interviewer** | -0.585 | 0.216 | -0.085 | 1.938 |
| | (0.532) | (0.607) | (0.460) | (0.870)** |
| **Constant** | -0.220 | -2.048 | -0.536 | -3.634 |
| | (0.433) | (0.503)*** | (0.373) | (0.870)*** |
| **Log likelihood:** | -49.2 | -39.5 | -60.51 | -32.0 |
| **Chi-square** | 32.33*** | 43.98*** | 13.20** | 8.66* |
| **Pseudo $R^2$** | 0.25 | 0.36 | 0.10 | 0.12 |
| **% Correct[a]:** | 76 (81/69) | 85(75/89) | 64(65/63) | 88 (0/100) |

[a] Overall percentage correctly classified (users correctly classified (sensitivity)/non users correctly classified (specificity)) * P < 0.1; **P < 0.05; ***P < 0.01 (s.e. shown in parentheses) n = 97.

*Summary of changes in IWM use*

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 workshop has resulted in 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 knock.

## 5. Summary

An experiment was conducted to determine the influence of an extension workshop on grower perceptions of, and intentions to adopt, IWM practices. The analysis accounted for prior perceptions (or prior adoption intentions) and other information sources, based on a Bayesian-based learning framework. The results highlight both opportunities and limitations for targeted extension events to influence growers' herbicide resistance management decision-making. Consistent with the hypothesised characteristics of effective information, where information could be delivered with a high degree of certainty and validity to a population holding perceptions inconsistent with the information being presented, the greatest influence on grower perceptions was recorded. This was most evident in the case of the probability of resistance reverting to susceptibility. The influence of the information on grower perceptions was likely to be greater in this case as few growers were likely to have held highly developed prior perceptions of this variable due to the lack of observable local field experience.

Targeted information also resulted in changes in growers' perceptions of the number of consecutive herbicide applications able to be applied before resistance develops. As this scenario is hypothetical for most growers (i.e. particular selective herbicides are very rarely applied consecutively as the only form of weed control), it is likely that many growers did not hold highly developed prior perceptions for this variable. Information that was presented relating to the time lag before herbicide companies would release a new herbicide could not be based on research evidence and held a high level of acknowledged uncertainty. This is likely to explain the lack of influence this information had on the expected number of years until such a product would become available to growers. The variance associated with IWM practice efficacy over seasons, within farms, and between farms, is likely to explain the lack of influence on perceived efficacy. The perceived economic value of some practices was positively influenced by targeted information presented during the workshops. This may largely be attributed to characteristics of the practices other than weed control efficacy. Consistent with the adoption model for IWM practices (Llewellyn *et al*., 2003), increasing the perceived value of a practice resulted in an increase in intended adoption.

*Implications*

The results demonstrate a role for targeted extension in influencing grower perceptions and adoption intentions. Information is less likely to be effective in influencing perceptions if it has a high level of associated variance and uncertainty. Information that can be presented with certainty, relating to factors for which growers have received relatively little previous information, is likely to be most influential. Obviously, information will be more influential if it is targeted at perceptions known to be inconsistent with the information to be presented. If targeted perceptions are associated with the adoption decision, greater adoption can result. The results are encouraging for those developing extension programs aimed at herbicide resistance management. Although the diffusion process for IWM practices has generally advanced beyond the early period in which extension is expected to have the greatest influence (Feder and Umali, 1993; Lindner, 1987; Marsh *et al*., 2000), a single information-based extension event has been shown to improve grower knowledge and influence adoption decisions.

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