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Factors influencing adoption of conservation tillage in Australian cropping regions*

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The purpose of this research is to improve understanding of conservation tillage adoption decisions by identifying key biophysical and socio-economic factors influencing no-till adoption by grain growers across four Australian cropping regions. The study is based on interviews with 384 grain growers using a questionnaire aimed at eliciting perceptions relating to a range of possible long- and short-term agronomic interactions associated with the relative economic advantage of shifting to a no-tillage cropping system. Together with other farm and farmer-specific variables, a dichotomous logistic regression analysis was used to identify opportunities for research and extension to facilitate more rapid adoption decisions. The broader systems approach to considering conservation tillage adoption identified important determinants of adoption not associated with soil conservation and erosion prevention benefits. Most growers recognised the erosion-reducing benefits of no-till but it was not an important factor in explaining whether a grower was an adopter or non-adopter. Perceptions associated with shorter-term crop production benefits under no-till, such as the relative effectiveness of pre-emergent herbicides and the ability to sow crops earlier on less rainfall were influential. Employment of a consultant and increased attendance of cropping extension activities were strongly associated with no-till adoption, confirming the information and learning-intensive nature of adopting no-till cropping systems.

Key words: adoption, conservation tillage, herbicide resistance, no-till, perceptions, weed management.

1. Introduction

Adoption of no-till cropping systems in Australia has facilitated the intensification of crop production due in part to reduced seeding times, increased retention of organic matter and reduced risk of soil erosion (see Chan and Pratley 1998; McTainsh *et al.* 2001). However, adoption has been slow in many regions, even though there has been considerable investment over a long period to demonstrate and promote its benefits (see examples in

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the review by Guerin and Guerin 1994). The motivation for this study is the potential for greater understanding of the modern farming systems context in which no-till adoption decisions are being made in order to reveal opportunities to increase the extent of no-till use.

Numerous studies have been conducted into the adoption of conservation tillage practices (e.g. Rahm and Huffman 1984; Norris and Batie 1987; Gould *et al*. 1989; Featherstone and Goodwin 1993; Westra and Olson 1997; Anim 1999; Wang *et al*. 2000; Caswell *et al*. 2001; Sheikh *et al*. 2003), but Australian examples are limited (e.g. Cary *et al*. 2001; D'Emden *et al*. 2006). Previous studies have generally had a very strong focus on soil conservation and erosion-prevention benefits of reduced tillage. In Australia, exceptionally high herbicide resistance risks create a unique adoption environment for reduced tillage cropping systems (Llewellyn *et al*. 2002). In addition to weed management issues, other considerations in the shift to no-tillage systems include disease risks, soil-water management and soil health (Chan and Pratley 1998).

No-till, as it is practiced today, is highly reliant on herbicides for weed control. As tillage is reduced, the reliance on chemical weed control generally increases (Allmaras *et al*. 1998; Radcliffe 2002; Hooper *et al*. 2003). Farmers in many major grain growing regions are already faced with an extensive herbicide resistant weed problem (e.g. Alemseged *et al*. 2001; Llewellyn and Powles 2001), with costlier forms of multiple resistance (e.g. Walsh *et al*. 2004) and glyphosate resistance (Preston 2005) becoming increasingly prevalent.

By identifying grower perceptions influential in the adoption decision, and possibly misperceptions, there is the potential to identify effective targets for research and extension (Llewellyn *et al*. 2005). Using this same approach it is possible to identify specific perceptions that are unlikely to be influenced by extension information or are unlikely to be of substantial influence on the adoption decision if they are modified by further learning. This understanding can allow research, development and extension activity to more effectively accelerate and improve adoption decisions.

The aim of this paper is to determine key farm attributes and farmer characteristics, including perceptions, influencing adoption of no-till by Australian grain growers. To do this, the broad biophysical, social and economic factors that can potentially influence the relative advantage of no-till over previous seeding systems are recognised in the methodology.

The following section describes the approach to considering adoption of no-till in a logit regression analysis framework, followed by a description of the variables used.

2. Adoption of conservation tillage: conceptual framework

Adoption of an innovation can be measured as extent of use, producing a continuous dependent variable, or simply use of the innovation, producing a dichotomous dependent variable. Here the initial adoption decision is used as the point of focus, as this is where 'off-farm' extension efforts can be most influential (see Marra *et al.* 2003). In this study the dichotomous, dependent variable approach is used, with no-till adoption defined as sowing (or planning to sow) any portion of crop using no-till in the 2003 growing season. The Western Australian and Victorian No-till Farmers Associations define no-till as one pass seeding with narrow/knife points with less than full cut-out (< 30 per cent soil disturbance) and zero-till as one pass sowing system using discs for minimal soil disturbance (VNTFA 2004; WANTFA 2004). For the purpose of this study, no-till was defined as using seeding equipment on which only knife points or disc openers were used for soil opening, in one pass with no prior tillage. Non-adoption was defined as not intending to use no-till for any portion of crop sowing in 2003.

Adesina and Zinnah (1993) stress the importance of farmer perceptions of innovation-specific characteristics in determining adoption. The present study is based on the adopter-perception paradigm (see Wossink *et al.* 1997), where growers are assumed to hold particular perceptions regarding the effects of an innovation, and that these subjective assessments can be important factors in their adoption decisions.

It is assumed that these perceptions, together with other farm and farmer characteristics, contribute to a grower's subjective utility of no-till. To adequately represent a range of possible effects within the farming system both positive and negative, and short- and long-term advantages, costs and risks need to be considered. Conceptually, adoption becomes more likely when the subjective utility of adoption (U_{NT}) increases relative to conventional tillage (U_{CT}), with adoption occurring when $U_{NT} > U_{CT}$. For an individual:

$$P_{NT} = f(f, g, p) \tag{1}$$

where P_{NT}, the probability of no-till adoption; f, a vector of variables describing the farm characteristics; g, a vector of variables describing the grower's personal characteristics; p, a vector of variables describing the grower's perceptions of the effects of no-till.

A dichotomous logit regression model using maximum-likelihood procedures was used to estimate the probability of no-till adoption. The STATA (v8) statistical package was used (see StataCorp 2003). Logit regression assumes a cumulative logistic probability function, so the model can be described as:

$$P_{NTi} = \frac{1}{1 + e^{-f(f_i, g_i, p_i)}} \tag{2}$$

3. Methods

3.1 Data collection

A survey of 384 growers across various agro-ecological regions within the winter rainfall (200–600 mm/year) dominated wheatbelt regions of South

Table 1 Number of responses, district councils and localities comprising survey sample regions

	Sample region	Number of responses
South Australia	North West Eyre Peninsula	40
	Lower/Eastern Eyre Peninsula	40
	Upper North	20
	Yorke Peninsula/Mid North	40
	Southern Mallee	41
	Northwest Mallee	41
Western Australia	Northern Wheatbelt	41
	Central/Eastern Wheatbelt	40
Victoria	Southern Wimmera	41
New South Wales	Upper Murrumbidgee	40

Australia (SA), Western Australia (WA), Victoria (Vic) and southern New South Wales (NSW) was conducted between March and October 2003. Interviews were conducted by telephone, with respondents' phone numbers randomly selected from publicly available farmer directories. The overall response rate was 51 per cent. Table 1 summarises the regional sample sizes and locations.

3.2 Personal characteristics

These included the number of years respondents had been aware of another grower in their district using no-till; the presence or absence of a farm management decision maker with a tertiary education; the employment of a directly paid consultant or advisor and the average number of days per year spent attending cropping extension events such as field days, seminars or workshops. Membership of a no-till farmer organisation was recorded (24 per cent were members), but could not be used in the regression analysis due to autocorrelation that was largely the result of almost all no-till organisation members (92 per cent) being adopters. Essentially there is a causality issue with this variable: is membership a suitable measure of influence on adoption, or is it a consequence of adoption?

As no-till adoption is hypothesised to be information-intensive, information and learning-related variables including the presence of a tertiary educated contributor to management decisions in the farming business and attendance of cropping extension events were predicted to have positive influences on the probability of no-till adoption (see Rahm and Huffman 1984; Westra and Olson 1997; Wang *et al*. 2000; Cary *et al*. 2001; Caswell *et al*. 2001).

Acquisition of conservation tillage equipment or re-configuration of existing equipment to fit a no-till system is likely to incur substantial up-front costs. If the benefits are mainly expected to be realised in the longer-term, those with stronger preferences for short-terms profits (i.e. a high discount rate) may be less likely to adopt the innovation. Respondents' discount rates were derived using a simple question relating to their valuation of money over time, that is, 'If you were offered $10 000 today, or a greater amount in 5 years, how much would the amount in 5 years have to be for you to wait to get the money and forego the $10 000 today?'.

3.3 Grower perceptions

Growers' perceptions of the effects of using a no-till system with stubble retention (NT) as compared to a system with full tillage and stubble removal (FC) were used as measures of perceived relative advantage and therefore expected to influence the decision to adopt no-till. A scale response question format was used to elicit perceptions of the long-term effects of a no-till system compared to one using full tillage. Respondents were given the aforementioned descriptions of the NT and FC systems, and then asked whether they thought long-term use of NT would lead to much lower, lower, the same, higher or much higher levels of a broad range of different farming systems variables in comparison to the FC system. These variables included crop disease, water infiltration, moisture retention, fertiliser costs, soil erosion, rainfall needed to allow reliable seeding, herbicide resistance risk and the effectiveness of pre-emergent herbicides (see D'Emden and Llewellyn 2006).

The use of pre-emergent selective herbicides is an important component of weed management in reduced tillage systems as fewer weeds are killed by tillage passes. It is estimated that the use of soil-applied pre-emergence herbicides in Australian winter broadacre crops has grown from < 1 million hectares in 1990 to about 6.9 million hectare in 2003 (O'Connell and Allard 2004), with the pre-emergence selective herbicide market dominated by trifluralin. As trifluralin requires coverage by soil to avoid volatilisation and its effectiveness on weeds can be reduced by contact with crop residue, its use in no-till systems requires some adaptation. It was expected that growers who perceive relatively poor efficacy of trifluralin under no-till would be less likely to adopt.

Growers were also asked to state their perceived cost of changing to no-till seeding equipment (per unit width). It was expected that those growers who perceived changeover costs to be relatively lower would be more likely to have adopted the innovation.

Respondents in this study were asked what proportion of their farm's soils they perceived to be prone to erosion. Those who considered greater proportions of their land to be erosion prone were expected to be more likely to have adopted no-till. Awareness of the 'problem' under existing practices, in this case soil degradation, has been hypothesised to be a leading factor in the adoption of conservation innovations (Sinden and King 1990; Cary and Wilkinson 1997).

3.4 Farm characteristics

Farm specific variables included location, average annual rainfall, arable area and cropping intensity. It was hypothesised that those with more intensive

Table 2 Descriptive statistics of variables by adopter ($n = 218$) and non-adopter ($n = 166$) groups (*indicate significant differences between means of adopter and non-adopters groups)

Variables and units	Mean			SD (All)
	All	Adopter	Non-adopter	
Western Australia (0/1)	0.21	0.85	0.15	0.41
South Australia (0/1)	0.58	0.42	0.58	0.50
Southern Wimmera (Vic) (0/1)	0.11	0.73	0.27	0.31
Upper Murrumbidgee (NSW) (0/1)	0.11	0.68	0.32	0.31
Rainfall (mm/year)	374	388**	356	78
Farm size ('000 ha)	2.27	2.45*	2.04	2.02
Cropping intensity (proportion of arable area)	0.66	0.71**	0.59	0.22
Time of no-till awareness (years)	16	17**	14	6
Education (0/1)	0.23	0.29**	0.15	0.42
Discount rate (%)	19	21	17	25
Soil erodibility (proportion of soil types)	0.45	0.47	0.43	0.36
Use of directly paid consultant (0/1)	0.33	0.46**	0.17	0.47
Extension attendance (days/year)	6.0	7.1**	4.6	4.5
No-till changeover cost ($'000/m bar width)	7.6	7.1	8.3	7.4
Herbicide resistance risk†	3.9	3.8	4.0	1.0
Pre-emergent effectiveness†	2.6	2.9**	2.2	1.2
Rainfall for reliable seeding†	2.3	2.0 **	2.6	1.0

*$P < 0.05$; **$P < 0.01$
†1, much lower; 2, lower; 3, same; 4, higher; 5, much higher.

cropping programs are likely to have greater potential to benefit from the no-till cropping technology and are therefore more likely to adopt. It is also expected that those with larger farm businesses (measured using arable farm area as a proxy) in general are more likely to make the upfront machinery investment (see Rahm and Huffman 1984; Norris and Batie 1987; Gould *et al.* 1989; Featherstone and Goodwin 1993; Westra and Olson 1997; Wang *et al.* 2000; Caswell *et al.* 2001).

4. Results and discussion

4.1 Descriptive statistics

Table 2 shows the descriptive statistics for adopters and non-adopters for variables used in the regression analysis. For a description of other variables see D'Emden and Llewellyn (2006).

4.2 Logit analysis of no-till adoption

Results from the logit regression model for no-till adoption are shown in Table 3. There were 87 missing observations in the data, bringing the total number of observations in the analysis to 297. Fifty-nine per cent of the missing observations were adopters, with 75 per cent of the missing observations

Table 3 Logit regression estimates of coefficients associated with no-till adoption

Variable	Coefficient	S.E.	*t*-ratio	*P*
Constant	–5.35	1.79	–2.98	0.00
South Australia	–2.31	0.52	–4.39	0.00
Southern Wimmera (Vic.)	–1.05	0.70	–1.49	0.14
Upper Murrumbidgee (NSW)	–2.80	0.86	–3.26	0.00
Rainfall	0.01	0.00	4.52	0.00
Farm size	0.19	0.11	1.66	0.10
Cropping intensity	0.19	0.85	0.22	0.83
Time of no-till awareness	0.08	0.03	2.89	0.00
Education	0.74	0.43	1.71	0.09
Discount rate	0.00	0.01	0.64	0.52
Soil erodibility	0.44	0.48	0.91	0.36
Use of directly paid consultant	0.82	0.39	2.12	0.03
Extension attendance	0.10	0.04	2.27	0.02
Changeover cost	–0.03	0.02	–1.45	0.15
Herbicide resistance risk	–0.18	0.18	–1.00	0.32
Pre-emergent effectiveness	0.44	0.15	3.02	0.00
Rainfall needed for reliable seeding	–0.46	0.18	–2.61	0.01
N	297			
Chi-square (16 df)	158.94 ($P < 0.00$)			
McKelvey and Zavoina's R^2	0.60			
Predicted	Actual			
	1	0		
1	146	31		
0	24	96		
Total	170	127		

coming from a non-response to the changeover cost perception variable. An acceptable fit was achieved by the model, with a McKelvey and Zavoina[1] R^2 value of 0.60 and an adjusted count R^2 of 0.57. Eighty-six per cent of adoption decisions and 76 per cent of non-adoption decisions were correctly predicted.

Two measures of marginal effects (odds ratio effects and elasticities) of the logit model variables are shown in Table 4. Odds ratio effects show the proportional effect of a one unit change in the level of a variable (or the presence/absence of dummy variables) on the adoption odds ratio.[2] The 'elasticities' measure gives the percentage-point (pp) change in adoption probability in response to a 1 per cent increase from the mean of an independent variable or a change from 0 to1 for a dummy variable (estimated using the mfx command within Stata: see StataCorp 2003). Both odds ratio effects and elasticities assume that, while the variable in question is changed by one unit or per cent, all other variables remain at their respective means.

[1] See Veall and Zimmerman (1996).

[2] That is, if the probability of adoption is $P(bx)$ then the odds ratio is defined as: $\mathrm{OR}(x) = P(bx)/(1 - P(bx))$. The reported odds ratio effect is the proportional effect of a change in a variable x on the odds ratio; OR $(x + 1)$/OR (x). For the logit model this is equal to $\exp(b)$.

Table 4 Odds ratio effects and elasticities (*dy*/*ex*) from model of no-till adoption

Variable	Odds ratio effect†	*dy*/*ex*‡
South Australia*	0.101	–46.7*
Southern Wimmera*	0.351	–25.4*
Upper Murrumbidgee*	0.061	–57.2*
Rainfall	1.014	1.20
Farm size	1.208	0.10
Cropping intensity	1.208	0.03
Time of no-till awareness	1.086	0.31
Education	2.096	15.9*
Discount rate	1.004	0.02
Soil erodibility	1.547	0.05
Use of directly paid consultant	2.271	17.9*
Extension attendance	1.104	0.14
Changeover cost	0.969	–0.05
Herbicide resistance risk	0.838	–0.16
Pre-emergent effectiveness	1.552	0.27
Rainfall needed for reliable seeding	0.633	–0.24

†The Odds ratio effects show the proportional effect of a one unit change in the level of a variable (or the presence/absence of dummy variables) on the adoption odds ratio.
‡The percentage-point change in adoption probability in response to a 1% increase from the mean of an independent variable, apart from * discrete change of dummy variable from 0 to 1.

4.3 Location

As the highest proportion of no-till adopters were in Western Australia, regions from this state collectively form the baseline comparison for the other state (i.e. South Australia) and region (i.e. Southern Wimmera (Victoria) and Upper Murrumbidgee (New South Wales)) dummy variables. Respondents in South Australia and the Upper Murrumbidgee were significantly ($P < 0.01$) less likely than those in Western Australia to be no-till adopters, while there was no difference in the probability of adoption between the Southern Wimmera and Western Australian regions. Growers in the Upper Murrumbidgee and South Australia had (*ceteris paribus*) adoption probabilities of around 50–60 per cent less, respectively, compared to their Western Australian counterparts.

Possible region-specific factors that may not have been captured by the variables used in this analysis include the greater risk of root disease risks in highly calcareous soils in some South Australian regions (Coventry *et al*. 1998); the greater risk of sandblasting to newly germinated crops on the sandier Western Australian soils (Hamblin 1987); differences in summer rainfall distribution that may encourage cultivation for weed management in some regions and differences in the level of no-till farmer association activity and impact in different states.

Average annual rainfall had a highly significant ($P < 0.01$) positive influence on the likelihood of adoption. This finding is reinforced by the work of Caswell *et al*. (2001) who observed that high average monthly rainfall significantly increased the probability of adopting conservation tillage methods. Low rainfall areas, particularly in some of the South Australian mallee regions, tend to be more marginal and are known to have had relatively low levels of no-till adoption (Coventry *et al*. 1998). Growers in areas with lower and generally more unreliable rainfall may be less likely to able to bear the risk of such an investment in no-till cropping technology due to more inconsistent returns from cropping.

4.4 Personal characteristics and information

The length of time that growers were aware of no-till being used in their district had a highly significant ($P < 0.01$), positive marginal influence on adoption, with a 10 per cent increase in time since awareness increasing the probability of adoption by approximately 3 per cent (pp). These findings are consistent with the role of information quality and learning in a framework of the role of risk, uncertainty and learning in adoption of agricultural technology outlined by Marra *et al*. (2003) and demonstrate the value of being able to observe use within the context of local farming systems.

Those respondents with the presence of someone with tertiary training (i.e. a degree or diploma) directly involved in making management decisions had a higher probability of adopting no-till ($P < 0.1$). The employment of a directly paid cropping consultant ($P < 0.05$) and the number of extension events ($P < 0.05$) attended per year had significantly positive influences on the likelihood of adoption. No-till adoption was 18 pp higher if a cropping consultant was employed, while a 10 per cent increase in attending extension events increased the probability of adoption by 1.4 pp (Table 4).

Significant no-till perception variables were the effectiveness of pre-emergent herbicides and the amount of rainfall needed to allow reliable seeding ($P \leq 0.01$). The perceived extent of erosion prone soil on the farm was not significant. Herbicide resistance was generally perceived to be a higher risk under no-till. However, perceptions of herbicide risk did not significantly influence adoption, although it was negatively signed as expected.

Some of the personal characteristic and information related variables also had large marginal effects on the probability of adoption.

The results here show that growers' perceptions regarding the extent of their properties' soils that are susceptible to erosion were insignificant in explaining the decision to adopt no-till. The variable describing growers' perceptions regarding the cost of changing seeding machinery to a no-till arrangement were also insignificant in explaining no-till adoption ($P = 0.15$), but was in the expected direction. Factors more likely to benefit shorter-term crop production under no-till, such as earlier seeding and herbicide efficacy, appear to be of greater importance.

Variables representing the effort growers put into obtaining cropping information were significant in describing adoption. Cary *et al*. (2001) also found that the number of training activities undertaken by farmers had a significantly positive influence on the adoption of conservation tillage practices. The current results suggest that the no-till system is information intensive and that adopters are likely to incur significant information costs in implementing the innovation. Consistent with the information processing and learning demands of a complex systems change, numerous other studies into the adoption of conservation tillage practices have found education to be a significant indicator of the likelihood of adopting conservation farming practices (see Rahm and Huffman 1984; Wang *et al.* 2000; Cary *et al.* 2001; Caswell *et al.* 2001).

The increased information gathering undertaken by no-till adopters, including the use of paid cropping consultants, suggests that the shift to no-till cropping systems is associated with higher information and decision-related management costs. Future studies exploring benefits and costs of intensive cropping and no-till should consider these possible costs when evaluating the overall profitability compared to more traditional farming systems.

The results indicate that a 10 per cent reduction in the mean grower perception of rainfall needed to sow a crop under no-till systems relative to full-tillage systems would lead to an increase in adoption probability of 2 pp, for example, from 64 to 66 per cent. If the mean grower perception of pre-emergent herbicides efficacy in an NT system compared to an FC system was increased by 10 per cent the probability of adoption would increase by 3 pp, that is, from the current 64 to 67 per cent.

Sowing timeliness is important in allowing crop establishment to take place earlier (i.e. with less opening-season rainfall), providing crops with the best opportunity to maximise yield through full utilisation of growing season rainfall (Ward *et al.* 1987). Long-term crop variety testing research has proven that, at least for some older varieties in short season growing conditions, the rate of yield decline following optimum seeding time has been estimated to be as much as 35 kg/ha/day (Fisher *et al.* 2006). The perception that long-term use of an NT system would allow crops to be sown with less opening season rainfall was a significant predictor of no-till adoption, and therefore, should be considered as a potentially effective target for extension aimed at increasing no-till adoption.

The effectiveness of soil-applied pre-emergent herbicides is related to the perceived availability of an effective weed control option at seeding when tillage is removed through no-till adoption. The results suggest that research and extension able to increase the perceived efficacy of pre-emergent herbicides in no-till systems will lead to greater no-till adoption. It should be noted that the recommended rate for some formulations of commonly used soil-applied pre-emergence herbicides are higher in minimum or no-till situations with high stubble loads. It is possible that some growers were assuming the same application rate in NT and FC systems when responding to this question.

A majority of respondents thought that the risk of herbicide resistance would be higher under a long-term no-till system with stubble retention compared to a system using full cultivation and stubble removal. Therefore many growers are adopting no-till with the expectation that such a system will lead to a greater probability of herbicide resistance developing on their property. The analysis suggests that expectations of herbicide resistance risks under no-till systems are not having a major influence on the decision to adopt no-till. There is evidence that herbicide resistance is a common factor in decisions by many current no-till adopters to reduce the extent of no-till use (D'Emden and Llewellyn 2006). The results highlight the need to use integrated weed management strategies in no-till systems to offset the risks of herbicide resistance.

5. Comments

The question of the extent to which the elicited adopters' perceptions regarding the technology are formed before or after the adoption decision needs to be considered. Adopters, having used the technology, refine their perceptions in accordance with their experience. Evidence from the technology innovation literature indicates that opinions regarding the relative advantage of a particular innovation can improve after adoption (e.g. Jiménez-Martínez and Polo-Redondo 2004). Further research to investigate the effects of no-till adoption on growers' perceptions of its relative (dis)advantages over full-tillage would require data collection through return surveys of new adopters. Nonetheless, the association between adoption and perceptions of herbicide effectiveness and sowing timeliness indicate the potential for extension efforts to target these perceptions.

It should also be recognised that there may be other social and economic factors, such as changes in the relative profitability of competing enterprises, changes in the relative prices of inputs and climate variability that influence the probability of no-till adoption. The time dependency of such factors excludes them from the logit modelling framework and would be more suitably accommodated by a statistical technique such as duration analysis (see Burton *et al.* 2003; D'Emden *et al.* 2006). For example, by using duration analysis, the latter study was able to demonstrate the significant positive influence of the declining relative price of the herbicide glyphosate on the rate of no-till adoption.

The significance of location by region also indicates that there are differences between regions and local farming systems that have not been fully specified and captured by variables in this study. Differences between regions in terms of agroecological conditions such as soil types, rainfall distribution, seasonal variability and weed spectra are likely to influence no-till adoption. Fully capturing such variables would require a more intensive survey methodology than that used in the present study.

6. Conclusions

The perception that a no-till system would lead to greater herbicide resistance problems was widespread. Awareness of the potential erodibility of farm soils was also high; however, neither of these factors was influential in determining whether growers were adopters or non-adopters at the time of the study. Research and extension efforts demonstrating soil erodibility and its prevention under no-till are likely to be less effective at increasing the likelihood of no-till adoption than a focus on early season weed management options and the opportunities for timelier seeding under no-till cropping systems. The study provides evidence that adoption of no-till systems is an information-intensive process and that there are likely to be opportunities for extension and localised information to accelerate the use of no-till by Australian grain growers.

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