How much is enough: the steep final steps to extensive no-tillage cropping in Australia

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Abstract

The current and future extent of use of no-tillage farming practices has major implications for the development of agronomic and natural resource management strategies. Using data collected from 1172 grain growers across 19 Australian grain growing regions we briefly characterise current no-tillage adoption by regions before exploring the agronomic and socio-economic factors influencing extent of use decisions. The proportion of growers using no-till was found to be starting to plateau near 90% in many regions. However, there are several regions where a much lower proportion of growers expect to adopt no-till in the medium term and the growers using some no-till in those regions were more likely to continue to cultivate a substantial proportion of their crop area. Results of binomial regression methods were used to identify agronomic and other factors influencing these extent-of-use decisions. The results suggest that the same extension and diffusion processes that have led to the current high levels of no-till use in some regions are not likely to lead to highly extensive use of no-till in all regions.

Key Words

Conservation tillage, no-till, farming systems, adoption

Introduction

The adoption of no-tillage cropping systems is seen as one of the major technology and natural resource management advances in Australian agriculture. It is a shift that has generated large gains in soil erosion prevention and crop production opportunities. The benefits involve both public and private benefit, with both industry (e.g. GRDC) and government (e.g. Caring for our Country) stating extensive use of no-tillage systems as a major objective. When it is considered that Australian agriculturalists first began investigating no-tillage technology in the 1960's (Thomas *et al.* 2007), the widespread uptake of no-till farming systems is a relatively recent process. It is also an ongoing process, with tillage remaining a common practice in many major Australian cropping regions.

In this paper we use region-specific data to challenge assumptions that the transformation of Australian broadacre agriculture to no-tillage systems is complete or that comprehensive adoption is inevitable in the medium term. This national study places the adoption of no-till cropping in Australian agriculture in the context of the well-developed socio-economic literature on technology adoption (e.g. Pannell *et al.* 2006). At the heart of this is the classic diffusion curve (Griliches, 1957) with its sigmoid form accommodating the often long lead times before the majority adopt a successful innovation, and differential peaks of adoption that are largely dependent on the relative advantage of the innovation among the heterogeneous populations of potential adopters. Using this approach we address the likelihood of extensive no-till adoption being reached in major cropping regions and the implications for agronomic research, development and extension and public policy.

Methods

The survey methodology was aimed at achieving a representative sample of commercial grain growers in selected regions. Study regions were established using clusters of Australian Bureau of Statistics 2009 Statistical Local Areas which were not intended to be representative of all cropping areas in the state. A phone interview was used due to the higher response rates and reduced self-selection bias usually achieved with this method compared to mail-out surveys. The questionnaire was developed to be as quantitative as possible to allow for cross-region multivariate analysis. A relatively broad definition of no-

till seeding was used in the study based around seeding with low soil disturbance (points or discs) and no prior cultivation. Farmers were contacted April-June 2008 based on random selection from the database compiled for each region using the extensive national farm contact database of Solutions Research. Only farms cropping greater than 200 ha in a 'typical' season were included. Data was collected from the nominated primary cropping decision maker in each household. Of all suitable households with a primary cropping decision maker contacted, 14% refused to complete the survey. Thirty-seven percent of all households first contacted led to contact with a primary cropping decision maker and a complete usable response. Data from 1170 respondents was analysed using several regression models including tobit in order to identify variables and potentially important factors associated with extensive no-till use (Table 1). Results from a logistic regression model to explain extensive no-till use (defined as >90% of 2008 crop area sown using no-till area) are presented here.

Results

Regional differences in peak adoption, extent of use and season-responsive increases in tillage

The cumulative proportion of current growers using no-till is shown in Figure 1 for selected regions, based on the reported year of first use on some area of crop land. Of note are the plateau levels of adoption now being reached and the regional differences in these plateau levels. A smaller but similar study of adoption levels in 2003 (D'Emden *et al.* 2006) did not find evidence of adoption plateaus at that time.

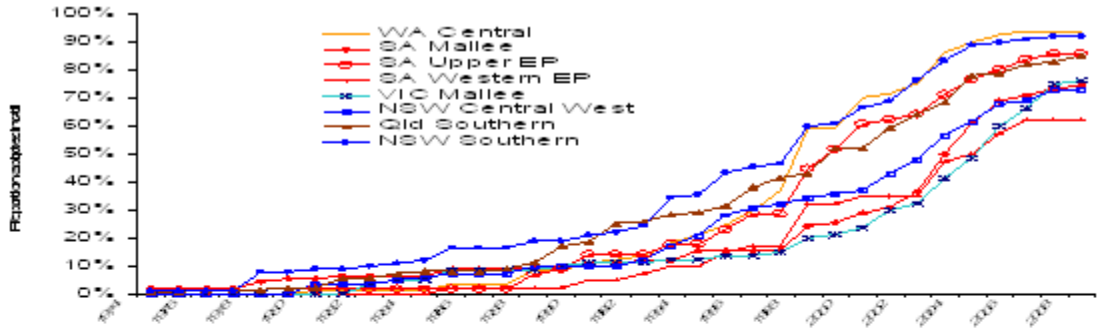

Figure 1. Cumulative proportion of growers using some no-till in five selected Australian cropping regions

The proportion of growers expecting to be using no-till in 5 years time provides further evidence that no-till adoption is peaking or has already peaked in many regions (Table 1). In five of the regions, >20% of growers state that they will not be using no-till in 5 years time. Large regional differences are also evident when comparing the proportion of growers using no-till extensively, based on ≥90% of 2008 crop under no-till as an indicator. The average extent of use by no-till adopters may also be peaking at a relatively low level in several regions (Table 1).

It has been very rare for no-till users to cease all no-till use and only 2% of current no-till users do not expect to be using any no-till in 5 years time. However, seasonal environmental and economic factors can have a substantial affect on the amount of tillage used in a particular year. Just as glyphosate price falls prior to 2003 are associated with increased no-till adoption rates (e.g. D'Emden *et al.* 2006), growers in many regions indicated that a 2007-08 glyphosate price spike led to their increased use of tillage. Over the entire national study of 1170 grain growers, 21% of no-till users reported increased use of tillage (e.g. greater area cultivated and/or more tillage passes) as a result of increased glyphosate prices (72% reporting no change and 7% reporting less tillage), compared to 32% of non-users reporting increased use of tillage as a result of increased glyphosate prices (61% reporting no change and 7% reporting less tillage). In 2010, some of the same low-rainfall regions have experienced similar responses with crop land monitoring confirming substantial increases in cultivation attributed to high summer weed levels, poor wheat price forecasts and a consequent economics-driven return to cultivation for weed control (Department of Water, Land and Biodiversity Conservation, 2010). In regions where it is more common that 100% of a farm's crop area is sown no-till, the glyphosate price rise had little or no reported influence on tillage use.

Table 1. Current and expected future use of no-till cropping by Australian grain growers.

State	Region (respondents)	Growers using no-till (%)	Growers using no-till on ≥90% of crop land (%)	Average extent of use by no-till adopters (% crop area)	Growers expecting to be using no-till in 5 years time (%)	Current adopters who expect to use no-till on ≥90% of crop land in 5 years time (%)	Average extent of use expected by current no-till adopters in 5 years time (%)
NSW	Central West (81)	62	28	73	69	44	85
	Northern (146)	82	42	79	83	53	87
	Southern (90)	89	43	75	90	47	82
	?Total (328)	78	39	77	81	47	85
QLD	Southern (123)	72	48	75	80	44	84
SA	Central (60)	85	62	89	83	68	94
	Lower EP (50)	84	66	93	84	70	95
	Mallee (90)	70	35	70	74	40	83

	Upper EP (56)	84	64	88	88	63	89
	Western EP (40)	55	35	82	60	30	82
	?Total (296)	76	64	83	78	54	89
VIC	Loddon (66)	77	35	75	86	45	80
	Mallee (80)	68	48	81	76	49	89
	Wimmera (70)	81	49	83	71	41	85
	?Total (216)	75	42	80	78	45	85
WA	Northern (61)	92	79	93	82	72	96
?	Central (81)	86	60	83	83	64	94
	Southwest (66)	91	86	96	91	82	97
	Total (208)	88	74	91	85	72	96
	All (n=1170)	84	46	76	80	53	88

Nb. Data from growers in the NSW Mallee is included in the overall analysis but not presented separately here due to low sample number.

Constraints to extensive adoption

The results of logistic regression analyses show the factors significantly associated with extensive no-till use (using no-till on ≥90% of 2008 crop area) (Table 2). Results using just those growers from lower-adopting southern regions (those where ≤70% of respondents are using no-till i.e. SA Mallee, SA Western EP, Vic. Mallee, NSW Central West) are also shown. Predictable factors consistently associated with extensive no-till use include newer seeding machinery and a higher proportion of land cropped (Table 2). Also predictable for a complex practice is the use of a consultant (Llewellyn 2007), which was also highly significant in the present study. In lower adopting regions higher education was also significantly associated with extensive use. Negative perceptions of crop disease and long-term reliability of wheat yields under a no-till system are also shown to be significantly associated with less extensive no-till use. The perception that no-till with stubble retention leads to greater soil moisture retention was shown to be associated with more extensive no-till use. Perceptions of reduced pre-emergent herbicide effectiveness were shown to be influential constraints to extensive no-till use across the full sample. Although not shown in Table 2, it is worth noting that with the other variables considered, WA growers still have a significantly ($P<0.001$) higher likelihood of extensive use than growers in the other states. This indicates

that there are other positive factors leading to higher extensive use in WA that are not being captured by the included variables.

Factors shown to have no significant influence (at P<0.05) included the proportion of the farm deemed to be erosion prone if not carefully managed. Other variables included but not found to be significantly associated with likelihood of extensive use were arable area managed (nb P<0.1 in all region sample), average annual rainfall; member of local farmer group; age; belief that, relative to cultivation, no-till will: reduce fuel costs; reduce days needed to get crop sown; and reduce soil erosion. The number of years since a farmer first observed no-till being used in their district positively influences the decision to first try no-till (D'Emden *et al.* 2008) but has no significant effect on the decision to use no-till extensively on the farm. It is worth noting that the subset of growers who do not expect to be using any no-till in 5-years time are much more likely to perceive that a no-till system does not offer erosion benefits and that this factor is significantly associated with no expected use in 5 years time (data not presented).

Table 2. Variables significantly associated with extensive use of no-till (≥90% cropped using no-till) based on logit regression analyses using all regions (n=1020) and lower adopting regions [b] (n= 258).

Variable	All regions	Lower-adopting regions
Arable area managed	+*	ns
Average proportion cropped	+**	+*
Age of current seeding machine	-**	-**
Pay a consultant for cropping advice	+**	+*
Higher education	ns	+*
Belief that no-till with stubble retention relative to a cultivation-based system will:		
• Increase moisture retention	+**	+**
• Reduce pre-emergent herbicide effectiveness	-**	ns
• Reduce long-term wheat yield reliability	-**	-*
• Increase crop disease	-**	-*
Correct classifications (%): All (Adopters/Non-adopters)	74 (72/75)	80 (66/87)

*P<0.05; **P<0.01; ns not significant. All models significant P<0.001. [b]SA Mallee, SA Western EP, Vic. Mallee, NSW Central West

Conclusion

No-till adoption and extent of use appears to be peaking, typically at high levels that have transformed agricultural landscapes. However, there are regional differences in these peaks, and stated expectations of future no-till use suggest that the large differences will not be reduced in the near future. Regions with a lower proportion of growers using no-till tend to also have a lower average extent of use by no-till users leading to ongoing extensive use of cultivation in several regions. These regions are also more likely to experience a seasonal return to greater tillage, for example, when weed management and market prices favour tillage over herbicides. Perceptions that a no-till system (relative to cultivation) will lead to less long-term wheat yield reliability, increase crop disease and not increase soil moisture retention are associated with non-adoption of extensive no-till use. It is therefore possible that some enabling innovation (e.g. further disease resistances) and learning-driven increases in adoption are still to occur. However, the region-specific trends and expectations suggest that over at least the short to medium term, cultivation will remain common in several major grain growing regions. The final steps to highly extensive no-till use in all Australian cropping regions are likely to involve a different set of adoption constraints.

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