Understanding the drivers of no-till adoption in Australian agriculture

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Introduction

From a traditional cropping system involving multiple cultivations of typically fragile soil, the shift to no-tillage farming represents one of the most substantial landscape changes in Australian agriculture. In the context of Australia's traditional wheat-sheep based farming systems, the no-till revolution has reduced soil degradation while facilitating major cropping intensification in response to economic drivers such as declining wool prices.

Beginning with study tours of North American conservation farming technology in the 1960's (see Thomas et al 2007), the introduction of no-till technology to Australian cropping has been occurring over decades. Given the current widespread success of no-till technology and cropping systems it is sometimes easy to overlook the fact that adoption of no-till farming systems in Australia is typically both relatively recent and still incomplete. In the majority of regions the most rapid increases in adoption have generally occurred in the past 10 years and a large proportion of growers are still in a period of adaptation. In some major cropping regions, increasing the proportion of growers using no-till and the extent of use of no-till by adopters remains a key natural resource management priority.

The opportunity to learn from past no-till adoption decisions and the need to learn more about opportunities for more extensive and sustainable use of no-till in the future has motivated the research summarised in this paper. The approach taken to explain no-till adoption rates has been one focused on information, learning and perceived relative advantage (Pannell et al 2006). Giving adequate attention to the range of factors that can determine whether an innovation offers real or perceived relative advantage to farmers compared to the status quo can allow a high proportion of adoption decisions to be explained (Llewellyn 2007). In turn, this can reveal new opportunities to target extension and research at factors in the adoption decision that can a) be influenced, and b) be influential in the adoption decision. In addition to previous socio-economic studies of factors influencing the rate of no-till adoption in Australian regions (e.g. D'Emden et al 2006), in this paper we also draw on more extensive new data on no-till adoption and trends from across the grain-producing belt of Australia (Llewellyn et al 2009).

A relatively broad definition of no-till seeding has been used throughout. The working definition of no-till is based around seeding with low soil disturbance and no prior cultivation, including crop seeding using either low disturbance points or 'zero-till' (with disc machines). The use of disc openers remains relatively low (generally well under 10% of growers), with the exception of the northern cropping region of NSW and Queensland where both winter and summer crops can be grown. The other major component of conservation cropping systems, full retention of crop residue, has been considered separately and not discussed in any detail here. This is mainly due to the increasing complexities of evaluating crop residue management in mixed (grazed) farming systems and where a range of only partially destructive crop residue management practices may be applied, such as those targeting weed seed kill or removal.

The studies reported on here have had three main aims:

- Use practice use and socio-economic data collected from grain growers to identify levels and trends in adoption of no-till and conservation farming practices across cropping regions.
- Identify factors influencing decisions to adopt and extent of use of no-till and conservation farming practices.
- Provide insights for R, D & E and policy to facilitate increased and sustainable use of no-till farming systems.

In this summary paper we start by looking at the current status of no-till adoption in Australia and the path that it has taken to reach the current high levels of adoption. In the second section we look at some of the socio-economic analyses that have helped to identify the major drivers of no-till adoption rates and what we have learnt to further progress this transformation of the cropping landscapes.

The current status of no-till adoption in Australian cropping regions

The diffusion of no-till adoption decisions across Australian grain producing states is shown in Figure 1. The results show that no-till seeding practices have now been adopted by the majority of grain growers in the regions studied. The proportion of growers using at least some no-till is now peaking at levels nearing 90% in many regions. The results are based on a study of no-till adoption across selected cropping regions of Western Australia, South Australia, Victoria, New South Wales and Southern Queensland involving interviews with 1170 grain growers in 2008 (Llewellyn et al 2009). Based on the year of first use, as stated by growers in 2008, the curves display the form of a classical diffusion curve; a long lead time with slow or no adoption followed by a steady increase before a rapid surge in adoption, before slowing as likely peak adoption is approached.

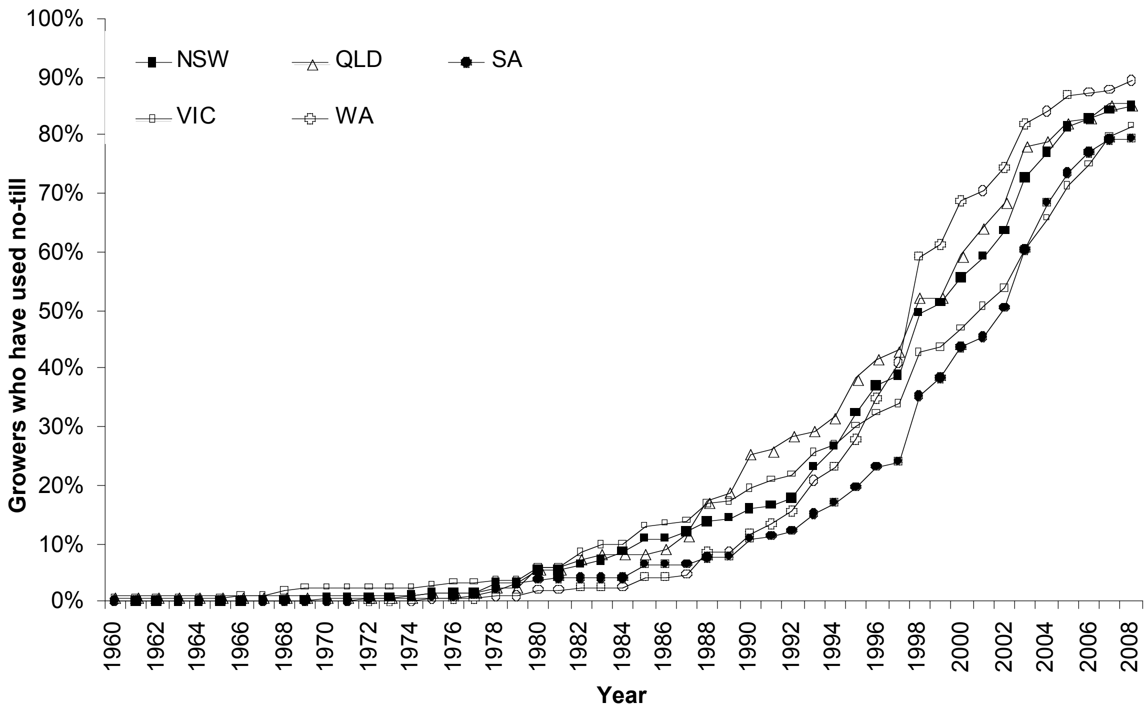

Figure 1. Cumulative proportion of growers who have used no-till from Australian cropping regions in the states of New South Wales (NSW), Queensland (QLD), South Australia (SA), Victoria (VIC) and Western Australia (WA).

In regions with relatively low adoption five years ago, there have been very rapid increases in adoption, particularly in the period 2003-2006. This result is consistent with the surge in adoption forecast in the 2003 study (D'Emden and Llewellyn 2006) and also consistent with the influence of low-rainfall years (e.g. the severe drought of 2002) as triggers for subsequent increases in no-till adoption rates. We argue that this can be largely explained through the acute observation/learning experience that very dry seasons provide in terms of the relative benefits of no-till e.g. benefits of moisture-conservation and seeding timeliness.

Many of the very large relative differences in adoption between states and regions that were clearly evident in 1998 have now closed substantially and are expected to close further over the next 5 years. Although some key regions appear set to peak at a lower level of adoption, in general, it appears that the large differences in adoption 10-years ago were reflecting time lags in the diffusion of no-till more so than major differences in the likely final proportion of growers using no-till. For example, in 2000 the proportion of growers using no-till in Western Australia was 57% higher than in South Australia. In 2008, the difference was only 12%.

It needs to be kept in mind that the curves (Figure 1) do not account for any disadoption. However, it is rare for growers who have adopted no-till to later cease use of no-till. This includes regions where no-till has been an extensive practice over a longer-term e.g. several Western Australian regions where herbicide resistance issues caused concerns about the sustainability of no-till (Walsh and Powles 2007). Less than 5% of all growers who have ever used some no-till no longer use any no-till. In general, the vast majority of Australian grain growers have made the decision to be using no-till in the near future. Based on grower expectations of future use, the proportion of growers using no-till is expected to exceed 80% in a majority of regions by 2013.

However, extensive practice change across landscape scale requires both the adoption decision and a high extent of use on the land managed by those adopters. Extent of use becomes particularly important in the Australian context where many farmers clearly prefer to retain the flexibility to use some cultivation. The results show that it remains common for no-till adopters to still use some cultivation. The proportion of growers in each state sowing their entire crop using no-till ranges from 43% in southern Queensland to 78% in Western Australia. The average percentage of crop sown using no-till by no-till adopters exceeds 70% in all regions. The remainder of the cropping area is sown using some form of cultivation either pre-seeding, full soil disturbance at seeding or both. In a few key erosion-prone regions, relatively low adoption rates together with relatively low extent of use mean that substantial crop areas are still being cultivated. The remarkable no-till revolution is not yet complete.

Factors explaining no-till adoption

Focusing now on socio-economic data, including perceptions, collected in 2003 (e.g. D'Emden et al. 2006; D'Emden and Llewellyn 2006), we find that the most common reasons stated for adopting no-till related to soil conservation/erosion prevention, seeding timeliness and moisture conservation. The most common reason stated for non-adoption was machinery costs. However, it is only when more sophisticated analysis is applied that the factors that differentiate adopters and non-adopter can be identified and the factors that are both influential and can be influenced can be determined. The results presented in Table 1 show the significant factors found to be associated with the adoption of no-till using both logit (D'Emden et al. 2008) and duration analysis (D'Emden et al. 2006). Duration (hazard) analysis allows the influence of variables that change over time such as prices, rainfall and farm size to be accounted for. As an example, where cross-sectional analysis and simple comparison of adopters versus non-adopters shows that larger farm size is significantly associated with no-till adoption, including farm size as a time dependent variable using duration analysis showed that the farm size at the time of the adoption decision was not significantly associated with greater likelihood of no-till adoption. Greater farm size expansion post-adoption is commonly observed.

Table 1. Factors significantly associated with earlier no-till adoption in southern Australian cropping regions

- Years since first awareness of nearby no-till adopter
- Higher education
- Use of directly paid consultant
- Higher participation in extension
- Higher perceived effectiveness of pre-emergent herbicide (trifluralin) in a no-till system
- Higher perceived soil moisture conserving benefits and improved seeding timeliness of no-till relative to conventional (i.e. full-cut) tillage
- Location (region/state)
- Fall in price of glyphosate herbicide
- Occurrence of a year much drier than average
- Higher average annual rainfall (i.e. adoption generally slower in very low rainfall regions)

82% of adoption decisions in 2003 correctly predicted by logit model (86% adopters;76% non-adopters). Only statistically significant factors listed. Source: D' Emden et al. 2006 & D' Emden et al. 2008

Information and learning

The results show that no-till adoption and use is clearly an information-intensive process. As well as greater interaction with consultants, researchers and groups of growers, the presence of nearby growers with experience with no-till was shown to be particularly important in explaining adoption. Where growers have had a longer time to observe no-till being practiced in their local district, the likelihood of adoption was higher. The study also found that the likelihood of growers trying no-till for the first time rose after drier than average years including droughts. This suggests that droughts and dry early-season conditions can be a prompt for adoption as some of the benefits of no-till such as moisture conservation and the ability to seed on less rain become most apparent. Consistent with the information processing and learning demands of a complex systems change (Rahm & Huffman, 1984) there was evidence that farmer education was associated with no-till use.

The use of a private cropping consultant was associated with no-till adoption being approximately twice as likely. This has implications in regions where the ready availability of quality farm-specific advisory support is limited. Higher participation in extension, including farmer groups, was also significantly associated with adoption. Unfortunately, the specific role of the major farmer-led no-till farming associations in Australia (e.g. WANTFA and SANTFA) could not be statistically accommodated in the study. This was due to fact that almost every no-till association member was a no-till adopters and the membership trajectories of these groups tracked the diffusion of no-till very closely (membership of the major no-till farmers association peaked at over 1000 members each at the time of the most rapid adoption rates).

In terms of the farmer learning opportunities and perceptions, the perceptions that were not significant are of as much interest as those that were. Although soil conservation and erosion prevention was the most common reason for adoption stated by no-till users, perceptions relating to the erosion prevention benefits of no-till did not differentiate adopters and non-adopters. Essentially, non-adopters were well aware of these benefits. The results suggested that continuing to focus extension efforts on demonstrating soil erodibility and its prevention under no-till was likely to be less effective than focusing on learning around pre-emergent weed management options and the opportunities for more timely seeding under no-till cropping systems. Similarly, both adopters and non-adopters were generally well aware of the possible herbicide resistance risks in no-till systems.

No-till, weed management and glyphosate

The real and perceived cost-effectiveness of key herbicides such as glyphosate and trifluralin are shown to be influential in the decision to adopt no-till. For example, the results show that research and extension able to increase the perceived effectiveness of pre-emergence herbicides in no-till systems among non-adopters was likely to be much more influential on adoption decision-making than efforts to demonstrate the erosion-prevention benefits of no-till. Perhaps the finding that best demonstrates the integral role of weed management and herbicides in the adoption of no-till in Australian agriculture is the role of glyphosate price relative to the price of its substitute, diesel. The patent-related fall in the price of glyphosate (from approximately A$18.30/L in 1983 to A$4.50/L in 2003 after the fall) has played a significant role in increasing no-till adoption. The results suggest that if the glyphosate to diesel price ratio had stayed at 1983 levels (ceteris paribus) no-till adoption rates may have been halved.

The importance of the herbicide glyphosate in the economics of no-till adoption has long been recognised (Gray et al 1996). Just as glyphosate price falls prior to 2003 led to increased no-till adoption rates in Australia (D'Emden et al 2006), growers in 2008 have indicated that recent glyphosate price rises have led to their increased use of tillage in many regions. Over the entire national study of 1170 grain growers, 21% of no-till users reported increased use of tillage 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 regions where it is more common that 100% of a farm's crop area is sown no-till, the glyphosate price rise has had little or no reported influence on tillage use. Because a majority of growers in most districts still use some tillage, it should be expected that economic and agri-environmental factors will cause seasonal shifts in extent of tillage use. Importantly, very few no-till adopters have indicated a general ongoing shift to greater use of tillage.

Conclusions

The diffusion of no-till across diverse Australian cropping landscapes has been remarkable. The ongoing adoption and lack of disadoption has further confirmed that no-till is highly adaptable and adoptable. Extensive use has so far been sustained across a wide range of agro-ecosystems and the last 5 years have seen many regions with previously lower no-till adoption rapidly increase adoption to levels similar to early-adopting regions.

It needs to be recognised though that there will still be several regions with a combination of a relatively lower no-till adoption levels and lower extent of use. As is clearly evident each summer and autumn, dust storms with public cost are not yet a thing of the past in some Australian cropping regions. Unless current trends and stated expectations change, this will continue to be the case into the next decade.

Reaching the very high extents of no-till use and reduced erosion risk in these particular regions will most likely require new and innovative approaches to support adoption. It is likely that a new set of influential factors will need to be addressed. The enormous level of innovation, motivation, collaborative learning and action that has taken the no-till revolution to its current success gives confidence that this can be achieved.

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