

02

FarmLink Research Report 2016

The Strategic Use of Tillage Within Conservation Farming

GRDC Project code – DAN00152

Project Partners



Funding Partners



Trial Site Location

Harden (CSIRO long term trial), Cootamundra (Byrne Bros), Young (Chris Holland), Corowa (Andrew Simpson).

Report Author

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Introduction

Tillage can do damage to soil structural stability as measured by Wet Aggregate Stability (WAS): the damage is generally small, a 5-10% loss of macro-aggregates, but can exceed 15% loss of macro-aggregates in the instance of rotary hoeing.

Recovery time for WAS ranged from 1 to >4 years depending on the severity of the tillage (scarifying was mild) and the rotation and stubble management that followed (pasture phases are ideal for recovery). There is little to be concerned about from implementing a strategic tillage provided:

- That it is not frequent, say less frequent than once every five years based on data to be outlined.
- That we consider the well-known risks for erosion such as slope, groundcover, and current weather, and the considerations for tillage, such as the soil moisture at the time of the proposed tillage. Hence, we suggest leaving the tillage as late as possible to avoid the chance of erosive rainfall between tillage and crop establishment.

Background

There are obvious problems and contradictions associated with the adoption of complete zero tillage, which have been well documented. Briefly:

- Limestone applied to correct pH has to be incorporated into the soil or else it does little to ameliorate acidity.
- A lack of tillage causes nutrients such as Nitrogen and Phosphorous from plant residues to accumulate in a relatively shallow soil surface
- Zero tillage can favour diseases such as Rhizoctonia and Pseudomonads
- Conventional tillage has been found to suppress plant parasitic nematode populations compared with direct drilling.
- Tillage can be used to help lower numbers of snails and slugs prior to canola crops, and to lower mice numbers
- Integrated weed management might require the use of strategic tillage to manage herbicide resistance.
- In a mixed farming system, infiltration of rain can be poor following compaction by livestock in wet weather.
- Deep ripping is used to remove hard pans, while spading and delving are used to put clay into the surface.

How do we reconcile the philosophy of zero tillage (disc sowing), or even minimum tillage (knife points), with what is actually happening in practice? We asked ourselves one simple question:

How much damage is done to soil by occasional tillage, strategically applied, in an otherwise direct drilled system?

Methods

We selected three contrasting sites where some form of cultivation made sense; following limestone application within a cropping phase, following a five year pasture phase and before canola, and following a green manure crop. The sites were at Thuddungra between Young and Grenfell, Berthong near Cootamundra, and Daysdale near Corowa. A fourth site was the CSIRO long term trial at Harden which had 20 years of contrasting tillage and stubble management.

We measured a range of chemical, physical, and at two sites, biological properties of the soils to assess

what effects the implementation of tillage had on the soil. We also measured a range of agronomic variables to assess impacts on plant production. We followed these soil properties and plant yield variables over three to five years to measure the changes in time following tillage. For example, if there were detrimental effects from tillage, how long does it take for the soil to 'recover'?

In this report, we document the soil physical property known as Wet Aggregate Stability (WAS). This is a measure of the soil's structural stability; in particular how it behaves as it wets up following rain or irrigation. Macro-aggregates are defined as being bigger than 250 micron diameter and a high proportion of these is considered desirable. Micro-aggregates are defined as being less than 50 micron diameter and are not considered desirable (effectively dust).

Here, we show the results from one on-farm site (Daysdale) and from the CSIRO long term trial at Harden, which represent contrasting results.

Results and Discussion

Daysdale

The design at Daysdale involved three tillage treatments: on-going direct drilling (DD), one pass with a scarifier (Scar) or one pass with offset discs (Offs). Each tillage was applied in 2012 and again in another set of plots in 2013, with the tillage treatments for both years randomly distributed within the trial area so that we could assess any effect of the year of tillage. There were therefore six treatments: three different tillage operations by the two years of tillage, each with four replicates. We measured the wet aggregate stability (%WAS) of the soil in each plot at two depths; 0-5 and 5-10 cm.

The statistical analysis showed very few significant effects at this site (Figure 1). The macro-aggregates (>250 μm) at 0-5 cm depth showed lots of variability and no significant differences amongst the 6 treatments over the years. The micro-aggregates (<50 μm) at 0-5 cm depth showed one anomalous effect in April 2013 where offset discing produced a significantly ($P=0.03$) lower % of micro-aggregates (less dust) than ongoing direct drilling or scarifying. It was accompanied by a higher % of macro-aggregates but which failed to reach statistical significance. From 2014 to 2015 the use of offset discs in 2012 tended to produce a lower % of macro-aggregates and a higher % of micro-aggregates. Although not significant because of the variability in the data, the trend serves as a caution that small detrimental effects from the use of offset discs might have occurred.

At 5-10 cm depth there were three statistically significant differences amongst the six treatments over the period 2012-2015. There were no differences between the six treatments at 5-10 cm depth from July 2013 to April 2015, indicating that any of these minor effects of tillage on WAS had

been overcome within 12 months.

Overall the effects of tillage on WAS at this site were minor and short lived, indicating that there were no detrimental effects of tillage to WAS that are likely to be of practical relevance.

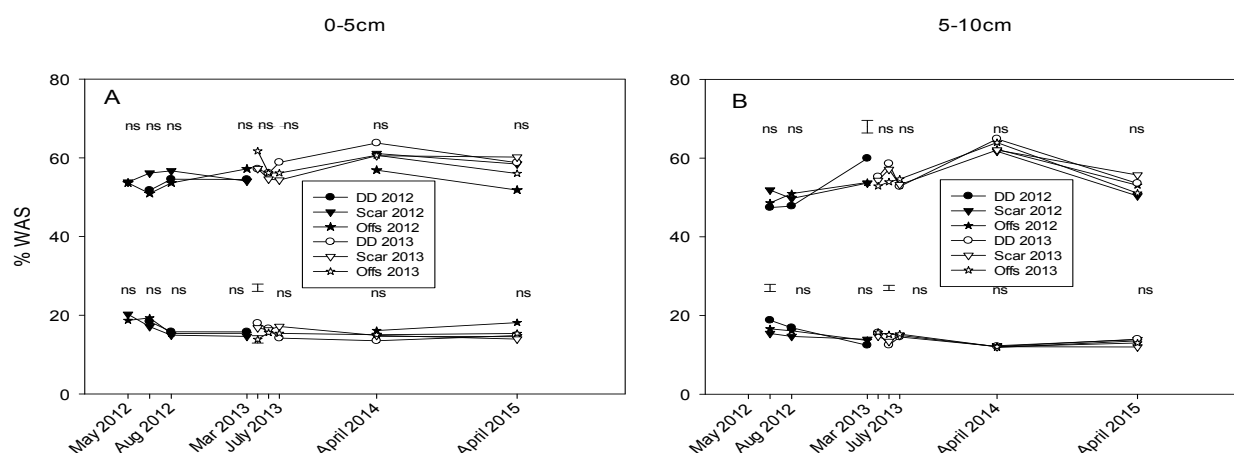


Figure 1: Change in Wet Aggregate Stability over three years at two depths at the Daysdale site.

The upper lines and symbols in each graph describe the macro-aggregate data while the lower lines and symbols describe the micro-aggregate data. The treatment key is given on each graph; filled symbols describe the 2012 site and hollow symbols describe the 2013 site. Error bars are for tillage main effects.

Harden Long Term Site

The CSIRO Long Term Experiment at Harden contained treatments that had been under direct drilling for 20 years, with stubble that had been either burnt or mulched. We split the plots and tilled half of each with a rotary hoe. This gave us four treatments, a two by two factorial: direct drilling with stubble retained (DD SR) or with stubble burnt (DD SB), and a single cultivation by rotary hoe with either stubble retained (RH SR) or stubble burnt (RH SB). In addition, we undertook measurements on two test strips; one strip under a double rotary hoeing, which we then sowed to pasture (ryegrass – subclover) and the other under a five-year-old pasture (phalaris) across the trial fence in the farmer's paddock.

Where the soil had been under DD SR for over 20 years, about 70% of the surface soil (0-5 cm depth) was in stable macro-aggregates (Figure 2). The five-year-old pasture in the farmer's paddock had a similar proportion of macro-aggregates. However, when the soil received two passes of a rotary hoe, the soil's macro-aggregation decreased to ~50%WAS, indicating a large increase in susceptibility to erosion. However, after two years of pasture the soil recovered from this loss

of aggregate stability. Conversely the increased micro-aggregation (dust) due to rotary hoeing was rectified after 12 months. Hence the damage caused by a severe cultivation was rectified in 12 to 24 months where a pasture was grown after the cultivation.

Under continuous cropping the recovery of the soil from cultivation was not so clear (Figure 3). The treatments were all previously under DD but were split for a single pass of a rotary hoe, not two passes as in Figure 2. The damage from the single pass was not so large, averaging about an 8% decrease in macro-aggregate stability. The DD SR treatment maintained the best macro-aggregate stability for stability of the soil's macro-aggregates, as is well known. The RH SB treatment produced the lowest macro-aggregate stability as expected, at about 60%. After two years (2011 to 2013) only the DD SR treatment was significantly better than the other treatments, though tillage and stubble effects re-emerged in 2014 only to disappear again in 2015. From a practical perspective the DD SR treatment maintained better soil structure in the surface soil over the four years of the trial while the other 3 treatments converged to a lower value of %WAS over two to four years.

Figure 3B shows the macro-aggregate stability at 5-10cm depth for the same four treatments. Here the macro-aggregate stability of the soil under DD was less than for the cultivated treatments. This indicates that some of the "damage" caused by tillage was simply due to mixing of the 0-5 and

5-10 cm layers of soil by tillage. Again, by two years there was no significant difference between treatments.

Given that macro-aggregate stability is most important for the surface soil, as protection from

erosion, Figure 3A indicates the need for caution when contemplating tillage. The impact of a single rotary hoeing on the surface soil caused an increased susceptibility to erosion, albeit only a 5-10% increase in risk on this soil.

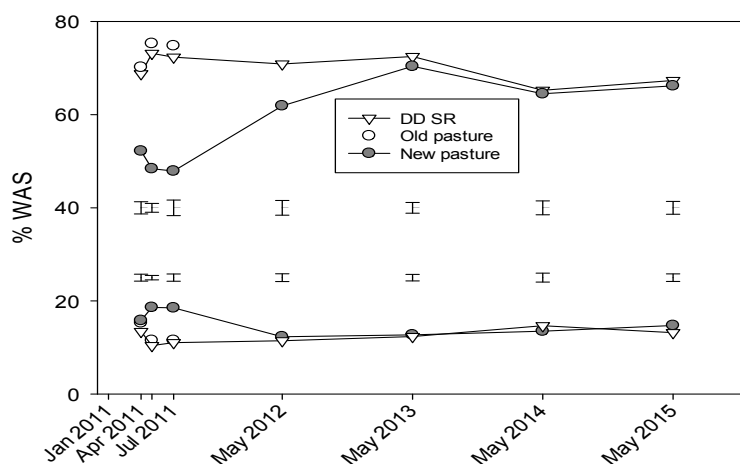


Figure 2: The wet aggregate stability (%WAS) of the pasture soils at Harden over 4 years (2011-2015).

The upper two lines represent macro-aggregates (> 250 µm) whilst the lower two lines represent

micro-aggregates (< 50 µm). The error bars are for the stubble by tillage interaction.

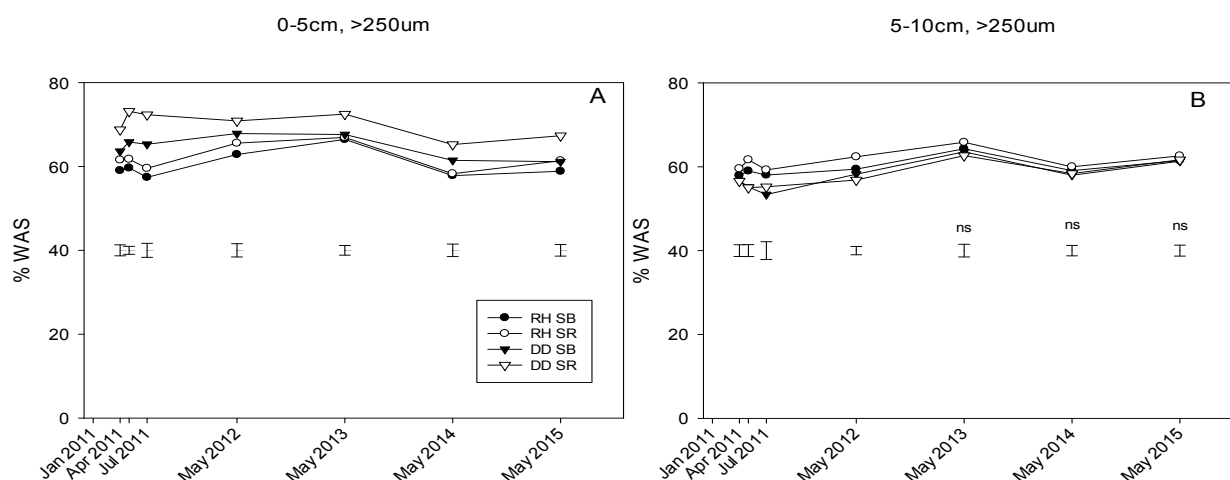


Figure 3: The wet aggregate stability (%WAS) of macro-aggregates (>250 µm) for the cropped soils at Harden over 4 years (2011-2015).

The error bars are for the stubble by tillage interaction at each depth.

Brief comment on the other sites

The Berthong site, like the Harden site, showed some longer term detriment from tillage to macro-aggregation in the surface 0-5cm when tilled in 2013 but not when tilled in 2012. The Thuddungra site showed some initial damage to soil structure at 0-5cm depth from off-set discs but recovery occurred within two years.

Conclusions from the data

Tillage can do damage to soil structural stability: the damage is generally small, 5-10% in terms of WAS, but can exceed 15% loss of WAS in the instance of rotary hoeing.

Recovery time for WAS ranged from one to >4 years depending on the severity of the tillage and the rotation & stubble management that followed. Including a pasture phase in the farming system

is likely to repair any damage to soil structure resulting from strategic tillage during the cropping phase.

Practical Message

There is little to be concerned about from implementing a strategic tillage provided:

- That it is not frequent, say less frequent than once every five years based on the above.
- That we consider the well-known risks for erosion such as slope, groundcover, and current weather, and the soil moisture at the time of the proposed tillage. Hence, we suggest leaving the tillage as late as possible so as to avoid the chance of erosive rainfall between tillage and crop establishment.

Useful Resources

<https://indd.adobe.com/view/d0d69075-611d-45eb-a24c-67c2efb94003>

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