FINAL REPORT

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

DAN00152

The strategic use of tillage within conservation farming

PROJECT DETAILS

PROJECT CODE:	DAN00152
PROJECT TITLE:	THE STRATEGIC USE OF TILLAGE WITHIN CONSERVATION FARMING
START DATE:	30.06.2011
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Summary

The origin of this project was in the confusion about the role of tillage in modern farming systems. The move towards minimum tillage had become clouded by the belief that complete zero tillage was required for the benefit of soil 'health', particularly soil structure.

The damage caused to soil structure, as measured by aggregate stability, using a single tillage undertaken for a specific agronomic purpose, was found to be minor. Further, the damage can be overcome within 1-2 years where the tillage is non-inverting, such as with a scarifier, or where a pasture phase follows severe tillage, such as with a rotary hoe. The tillage should occur close to sowing to minimise erosion risk.

Conclusions

Agronomically, there was a tendency for tillage to reduce or to have no impact on establishment of crops. However, this became a neutral to positive impact on grain yields. Therefore, any early moisture loss from tillage was minor compared with the benefits of tillage.

The use of steel had a negative impact on soil structure as measured by wet aggregate stability. Rotary hoeing was obviously the most damaging, while the impact of a scarifier was minor. Accordingly, recovery from tillage was rapid following the use of a scarifier. The recovery from inversion tillage by rotary hoe or offset discs was of the order of two to four years depending on the return of crop or pasture residues. Pasture residues ensured a rapid recovery of one to two years. However, in a continuous cropping system following the use of a rotary hoe, the damage to soil structure was longer term. While much of the damage to wet aggregate stability was simply due to mixing of the 0-5cm and 5-10cm layers of soil, the exposure of less robust 5-10cm soil to raindrop impact on the soil surface is an increase in erosion risk.

The impact of tillage on weeds, a minor component of this work, was completely site-year dependent - tillage controlled ryegrass at one site and promoted fleabane at another. Therefore, the use of tillage alone generally as a means of weed control is not recommended.An integrated approach to herbicide resistant weeds remains best management practice.

The impact of tillage on soil biology was almost entirely due to mixing of the fungi dominated 0-5cm soil with the more bacteria dominated 5-10cm layer. No net benefits or detriments from tillage were noted on soil biology composition or function, other than the field observations of reduced infection of cereals by rhizoctonia.
The benefit of adding nitrogen (N), phosphorus (P) and sulphur (S) nutrients to stubble for increasing soil organic carbon (SOC) has been demonstrated at the Harden site (Kirkby et al., 2016). However, at the three commercial farm trial sites, the benefit of added N, P and S remained low and possibly not significant.

The work on particulate organic matter (POM) and particulate organic carbon (POC) compared methods based on particle size and on weight (flotation). Recommendations will be made for a routine method for POM and POC. It was also found that the C content of POM is not 57% as generally presumed and in fact is not even a constant, ranging from 20% to 50%.

Recommendations

The data were interpreted as indicating that the strategic use of tillage causes minimal damage to soil structural stability. Recovery time is variable, from one year to more than four years depending on return of organic matter. Therefore, where tillage is a useful management tool for agronomic purposes, it is recommended that it can be confidently used by growers with the usual considerations of soil moisture condition and slope. It is proposed that minimum tillage is more sustainable than zero till.

There are two gaps in this work - geographical and technical.
The present project focused on southern New South Wales (NSW) and its sister project on southern Queensland (QLD). The relevance of this work to northern NSW and Victoria (VIC) can be presumed but there is an obvious need to test the relevance of this work to soils such as tenosols (sands) and calcarosols which occur in low rainfall areas, such as western NSW and the Mallee, and to the volcanic soils of south-western VIC.

When this work commenced, speed tillers were a novelty and were never expected to become so popular. This work was restricted to what was considered conventional tillage equipment at the time (scarifiers, offset discs, and rotary hoe). There is a need to assess the impact of this more vigorous form of tillage on soil properties.

Finally, in addition to the two gaps in this work, it is clear from the wet aggregate stability data that even a single tillage can increase the risk of structural breakdown in some soils in some seasons. It is, therefore, recommended that the strategic use of tillage be conducted so as to minimise the time between tillage and sowing in order to minimise the risk of storm induced erosion, particularly on sloping country such as around Harden and Cootamundra. This parallels the general acceptance of late burning. It is also recommended that the use of tillage be restricted to the type of activities that are outlined in the Information Package to growers, where tillage is considered within its broader agricultural context, not as a stand-alone answer for agronomic problems.

Outcomes

It has been demonstrated that the soil is resilient enough for increased flexibility in the strategic use of tillage. This flexibility enables:
The incorporation of limestone (potentially more than $100/ha net benefit).
A reduction of rhizoctonia severity where needed (uncertain $ benefit).
Integrated weed management where herbicide resistance is an issue (approx. $20/ha benefit).
Integrated pest management for slugs and snails, and combined with baits during mouse plagues ($20 to 50/ha).
Seed bed preparation following wet harvests or pugging by livestock (approx. $8/ha benefit).
Ripping to remove hard pans (current trials will assess the $ benefit).

These increased agronomic and economic benefits were estimated during the case studies which form part of the Information Package to growers.

This increased flexibility might, ironically, increase uptake of conservation farming by those who currently maintain traditional tillage practices, as they gain confidence in the new found flexibility of the system.

The environmental benefit is two-fold - minimum tillage will assist soil conservation against wind and water erosion almost to the same degree as zero tillage. On the other hand, the incorporation of lime into the soil to ameliorate acidity, also a cause of erosion, remains best management practice. A compromise of minimum tillage allows for apparently opposed practices to be optimised for multiple purposes as listed above.

The intangible social benefit will be that growers will no longer need to feel confusion arising from the conflicting advice that they receive about tillage. In fact, the research vindicates what was already becoming grower practice - a pragmatic use of tillage where the need arises.

Achievements/Benefits

"Did you blokes find anything that we hadn't already worked out?"
This was the question to us from agrower as the trial site on his property was being tidied up. He and his brother were basically modern growers with good rotations and minimal tillage practice. But they did till the soil at the end of the pasture phase and when incorporating lime. To them, the contradictions in extension messages were obvious, but so too had been their solutions to these conflicting messages. When it was needed, a plough of some sort was used. And so too for some of the steering committee of growers and advisers. Pure no-till was seen as a straightjacket rather than as an ideal system. Minimum tillage offered the best approach to their soil and agronomic problems.

What this project delivered was simply a justification for what is becoming common, current grower practice, rather than a great breakthrough in challenging conventional wisdom.

It is maintained that flexibility in the application of conservation farming principles is essential for managing the wide range of circumstances in which growers find themselves. Best management practice is not blind adherence to no till or to stubble retention, but rather, a sensible evaluation of each paddock, each year based on recent weather, stubble load, pests and diseases, and soil problems to be addressed. For this reason, case studies have been presented in the Information Package so as to guide growers and advisers through the sort of issues that need to be thought about before making a decision about tillage.

The project was an excellent collaboration between FarmLink, CSIRO, NSW Department of Primary Industries (DPI), and in the early stages Charles Sturt University (CSU). The service provided by some advisers is gratefully acknowledged. They were involved from the outset, through site selection, through evaluation of results and in the development of the Information Package. The regular participation of several collaborating growers at steering committee meetings rounded out the integrated overseeing of this project at all levels. The growers were very co-operative during the extensive site selection process and generous with their time and machinery as farm scale tillage with two implements (offsets and scarifiers) was undertaken at each site, and in consecutive years at Berthong and Daysdale. Hence the coordination provided by FarmLink involving growers, advisers and three research organisations was a major commitment.

A practical outcome has been successfully delivered to the grains industry based on four or five years of data at four sites. The use of even a single tillage does decrease the structural integrity of soil. However, in the case of common tillage implements, this damage is small and takes only one to two years for full recovery. Only the application of a rotary hoe on a sandy soil left some residual structural damage over the four trial years from 2011 to 2015. However, the potential benefits from tillage far exceed these small and short term losses of aggregate stability. Nonetheless, parallel with the adoption of late burning, it is recommended that tillage be undertaken only after adequate rain in autumn so as to minimise the time between tillage and sowing, and hence minimise any risk of erosion from exposed surface soil.

Other research

There are two research opportunities, covering firstly both geographical area and associated soil types, and secondly the type of tillage undertaken.

The role of strategic tillage has now been assessed in southern NSW by this team and in QLD by a project under the supervision of Yash Dang. No such research has yet been conducted in northern NSW, VIC, Tasmania (TAS) or SA. While it is likely that these results will apply, calcareous or sandy soils were not covered in either project. In relation to sandy soils, WA experience might apply in some of the Mallee and in western NSW but remains to be tested. The volcanic soils of south western VIC could also provide contrasting results to the two completed projects.

The apparent growth in the use of speed tillers means that there is a perception of the need for some form of tillage to handle crop stubbles, at least to incorporate stubble into surface soils. Speed tillers are an aggressive form of tillage that was not covered by either of the completed projects. Their growth in popularity was not foreseen.

Intellectual property summary

There is no commercialisation opportunity from this work. The project was largely a research program that has justified current grower practice rather than what was believed to be the ideal of zero tillage.

Additional information

Publications

Kirkby, CA, Richardson, AE, Wade, LJ, Conyers, M, Kirkegaard, JA. (2016). Inorganic nutrients increase humification efficiency and C-sequestration in an annually cropped soil. PLoS ONE 11 (Attachment 1).

Kirkegaard, JA, Conyers, MK, Hunt, JR, Kirkby, CA, Watt, M, Rebetzke, GJ. (2014). Sense and nonsense in conservation agriculture: Principles, pragmatism and productivity in Australian mixed farming systems. Agriculture, Ecosystems and Environment 187, 133-145 (Attachment 2).

Conference Paper:
Kirkegaard, J, Conyers, M, Hunt, J, Kirkby, C, Watt, M and Rebetzke, G (2011). Sense and nonsense in conservation agriculture:

Principles, pragmatism and productivity in Australian mixed farming systems. In 5th World Congress of Conservation Agriculture, September 2011 Brisbane, Australia.