New frontiers no-till farming systems

Summary

The cornerstones of conservation agriculture are permanent soil cover, minimal soil disturbance and diverse crop rotations. Yet these are often absent from Western Australian (WA) no-tillage (no-till) systems. This farming systems project, which started in 2006, was designed to test and further develop high quality no-till systems based on these conservation principles. A trial was established and key no-till components were successfully implemented. The plots were comprehensively benchmarked and improvements as a result of the new cropping systems will be assessed in the following three years. Greater adoption of these no-till principles by growers in WA has been measured.
Conclusions

This project was designed to test and further develop recommendations to improve the quality of no-till systems made by Rolf Derpsch, an international no-till consultant from Paraguay.

No-till, full stubble retention and crop rotation systems generally only reveal their benefits (such as increased organic matter) in the long term (Derpsch, 2005). Consequently, this research was planned on a long term basis. A multidisciplinary team of researchers from the WA No-Tillage Farmers Association (WANTFA), CSIRO, Department of Agriculture and Food WA (DAFWA) and the University of Western Australia (UWA) collaborated on this project.

This was a complex farming systems trial that incorporated the main components of no-till systems including permanent soil cover, minimal soil disturbance, diverse rotations, integrated pest and weed management and controlled traffic systems. Cover crops were grown once in the rotation to increase crop residue levels as rapidly as possible and ensure robust results. The trial was well set up and benchmarked. It was expected that changes and improvements as a result of this new cropping system would be assessed during the three years following the trial and beyond. Significant investment from GRDC and WANTFA and its partners was made. The trial was set up to facilitate future data collection - for the subsequent three years at least - and to provide results and information to help growers achieve practice change with improved and more sustainable cropping systems.

Early results showed that soil moisture from the previous season and summer rain could only be conserved with high levels of crop residue (about 4t/ha). Water loss through evaporation during summer was significant when residue levels were low (e.g. one to 2t/ha). Extension activities conducted through this project (and other WANTFA activities) have contributed to improvements in the adoption of the key components of high quality no-till systems since 2003. This includes more residue retention (less burning, grazing and ploughing), diverse rotations, interest in cover crops as break crops and for renovating paddocks and reduced level of soil disturbance at seeding through greater adoption of disc seeders in WA.

A survey of collaborators and industry partners showed that participants were familiar with the objectives of and treatments used in the project, were satisfied it was well managed and indicated there was sufficient communication about the project.

Recommendations

Between 2006 and 2009 the trial was in its initial stages. However, some recommendations could be made at that time from the project findings and closely related WANTFA research into high residue, no-till systems.
Initial results from this project indicated high levels of crop residue (about 4t/ha) helped retain soil moisture at seeding from the previous year and any summer rain received, compared to less water retention in areas with low crop residue levels (about one to 2 t/ha). This trial demonstrated that - if correctly set up - disc seeders could be used to successfully seed into residue levels as high as 6t/ha.

**Outcomes**

The overall outcome was to achieve positive practice change, leading to more profitable and sustainable farming systems. This was measured through a comparative survey undertaken between 2003 and 2009. This survey showed more WA growers were retaining stubble and less were burning in 2009 than in 2003. More growers in 2009 were also considering machinery such as disc seeders to handle heavy stubbles at seeding as a way of advancing their no-till systems. The survey results demonstrated that clear messages about the benefits of maintaining permanent soil cover were reaching growers.

**Economic outcomes**

This project was designed to assess the long term benefits of a high residue, no-till system, so there were no immediate economic outcomes recorded. However, the research highlighted that higher yields were being achieved compared to farm control plots, indicating there would be positive economic outcomes derived from increased grain sales. This occurred as a result of higher water use efficiency, resulting in more kilograms of grain produced/mn of rainfall. Depending on climate change developments at national and global scales, the project also identified a potential for growers to derive economic benefits from carbon credits as a result of storing organic carbon in the soil using this high residue no-till system.

**Environmental outcomes**

There were clear environmental outcomes from this work. The recommendation for high quality no-till cropping systems with permanent soil cover and high levels of residue would help eliminate soil erosion in the wheatbelt. An improvement in soil health, measured by increased nutrient cycling and organic carbon sequestered in the soil, could be expected. This project also promoted the use of break crops and integrated weed management methods to reduce crop diseases and herbicide resistance through greater diversity in the cropping system.

A postal survey conducted in 2009 as part of this project showed major changes in grower adoption and attitudes towards improving conservation tillage methods. It found 83% of respondents never cultivated their paddocks prior to seeding. There appeared to be a large reduction in the number of growers who burned crop residues - from 68% in 2003 to 38% in 2009. There was a notable increase in the number of growers using disc openers for seeding, up from 8% in 2003 to 25% in 2009. The majority of growers (61%) were interested in growing cover crops, but most said they would like more information about the benefits versus the costs before adoption. The main reasons for considering cover crops were soil health, soil fertility, soil nitrogen, weed control and soil cover to increase moisture retention.

**Social outcomes**

This project was about sustainable, productive and profitable farming and as such, its outcomes will help to maintain the viability of farming communities.

**Achievements/Benefits**

**Background**

The adoption of no-till in WA is widespread with approximately 86% of growers using these systems for a proportion of their cropping program (D‘Emden and Llewellyn, 2004). No-till crop production systems have major benefits for growers in Australia including improving timeliness of operations, moisture harvesting, erosion control and producing higher crop yields. These effects are easily quantifiable however, other benefits, such as increased soil biological activity and organic matter, occur over a longer time period (Sa, 2004). Growers are confident that the current system is more sustainable than previous production methods that involved tilling the soil. However, some of the expected long term benefits have not been realised and production appears to have plateaued. The sustainability of no-till in WA has also been questioned because herbicide resistance is increasing (D‘Emden and Llewellyn, 2004). With this in mind, WANTFA commissioned Rolf Derpsch - an international no-till consultant from Paraguay - to undertake a situation analysis of no-till in WA.

The main challenges identified in Derpsch’s report were lack of cover on the soil, inadequate diversity in the rotation, herbicide resistance and weed control. Practices such as over-grazing, burning, tillage and poor crop rotation were
contributing to these problems. WA's grain growing enterprises are dominated by cereals - particularly wheat - mostly due to poor economic returns from other crops when grown in dry conditions. As a consequence, the area sown to alternative crops such as canola, lupins and other grain legumes has declined in recent years.

Derpsch (2005) recommended that no-till systems in WA should essentially be based on full stubble retention, diverse rotations with cover crops and a more holistic approach to weed management. He recommended seeding with discs, as it seemed "that under a tyne system (with limited rotation options), no-till has reached a plateau and it appears difficult to advance the system to a higher level". His conclusion stemmed from the fact tynes would not be able to cope with the required increase in crop residues for the no-till system to progress.

This project was designed to test and further develop the Derpsch recommendations for improving the quality of the no-till system. No-till and full stubble retention - and crop rotation systems in general - only reveal their benefits (such as increased organic matter) in the long term (Derpsch, 2005). Consequently, this research was designed to run for a long period of time.

Major achievements

This was a complex and large farming systems trial. The main components of no-till systems - permanent soil cover, minimal soil disturbance, diverse rotations, integrated pest and weed management and controlled traffic systems - were successfully implemented. Cover crops were grown once in the rotation to increase crop residue levels in the trial as quickly as possible to ensure robust results. The trial was well set up and benchmarked and changes and improvements stemming from this cropping systems trial were assessed in the following next three years.

A significant investment was made to find collaborators for this trial and a multidisciplinary team was established to research and quantify the effects of this high quality no-till system. Dr Phil Ward (CSIRO) measured the water balance, Geoff Thomas and Bill McLeod (DAFWA) assessed diseases, Vivien Vanstone (DAFWA) assessed nematodes and Dr Pippa Michael (Curtin University) assessed weeds (with WANTFA staff), WANTFA staff assessed soil physical, chemical and biological components. Several industry collaborators also contributed to the project including CSBP (fertilisers), GPS-Ag (2cm accuracy autosteer), Dow AgroSciences and Syngenta (crop chemicals) and the College of Agriculture Cunderdin, DAFWA Geraldton and Ian Broad from the Mingenew Irwin Group (MIC) (machinery).

Two trial sites - at the College of Agriculture Cunderdin and Ian Broad’s Mingenew farm - were established. The Cunderdin site had heavy textured soil (sandy clay loam). The Mingenew site had light textured soil (sandplain). The plots were marked with differential GPS and buried steel markers. The sites were benchmarked in 2006 and early 2007 and set up for long term assessments. Two crop rotation phases were successfully completed with the third crop currently being grown (completing the first three phases in the rotation). Four seeders, each 4.5m wide, were acquired for the trial, representing a significant investment by WANTFA and its partners. Two disc seeders were acquired in 2008 (an NDF for the Cunderdin site and K-Hart modules on a combine seeder for Mingenew). Each trial site had a disc and tyne seeder that were used on the high residue and district practice treatments, respectively. Both sites had 2cm accuracy autosteer on the tractors that were used as part of the controlled traffic system. The controlled traffic system was established using multiples of 4.5m (seeder 4.5m, sprayer 9m and harvester 9m).

The project had a steering committee that met at least once a year to discuss and coordinate activities. A management team was set up for each site of local growers, agronomists and collaborating scientists to address on-site trial issues.

The Mingenew site had high populations of ryegrass and significant rotational differences were observed. Rotational differences in leaf disease severity were measured at the Cunderdin site. A build-up in lucerne flea beetle predator (snout mite) numbers was observed at Cunderdin, providing an early indication of differences between the systems. Activities and results each year were summarised in an annual Trial Summary document.

Significant extension and education activities were carried out in the three years of the trial. Students from the College of Agriculture Cunderdin, UWA and Curtin University attended lectures about the project and visited the sites in 2007, 2008 and 2009 to discuss first-hand these high residue no-till systems. WANTFA held at least two field days each year for growers, researchers and agronomists. Project information was extended through a trial results meeting and publications in the agricultural media. The trial results were also highlighted and presented at the Cunderdin College of Agriculture annual open day to about 150 people, mainly growers.
This project provided valuable data and information about a range of topics such as yield trends, rotations, water use efficiency, stubble handling, disc seeders and cover crops. It educated and updated growers on novel no-till developments and established a highly valued systems trial that has helped provide a foundation for future advances in no-till. The environmental and economic benefits of the new no-till system will be determined in the long term and the information will advance current crop production systems. This should produce higher and more sustainable profits resulting from increased yields, reduce the need for fertiliser inputs, improve soils, water utilisation and reduced erosion. Early results showed that soil moisture from the previous season and summer rain could be conserved only with high levels of crop residue (about 4t/ha). Water loss through evaporation over summer was found to be significant when residue levels were low (e.g. one to 2t/ha). There were significant rotational differences in crop water use. Lucerne flea was a major problem in the first and second years of the trial. An integrated pest management (IPM) approach in the third year, with reduced insecticide use, resulted in a build-up of predatory mites that kept this pest under control.

Other research
A review at the end of this project identified several opportunities for continued research and development (R&D).

1. A full evaluation of the nutrient requirements and budgets - especially nitrogen - under various carbon inputs.
2. A comprehensive weed monitoring strategy, as weed management in no-till systems remains a major challenge.
3. Whole farm economic modelling of treatments. This would provide additional information of value to growers.
4. A quantitative scenario analysis. This should include a sensitivity analysis for the effects of different seasons, input and commodity prices.

The survey carried out as part of this project also identified areas requiring additional research.

1. Disc seeder operation and associated agronomic aspects, such as herbicide application and optimal fertiliser practices with discs.
2. Integration of livestock with no-till systems to minimise the impact on crop yields.
3. Impacts of no-till and residue retention on soil health.
4. The benefits of controlled traffic systems, such as yield improvements and less compaction.
5. Further quantifying the scientific and economic benefits of cover crops (water capture/yield, weed control, soil fertility).

Additional information
Scientific papers
The following papers are derived from research performed prior to this project, but are relevant to the work undertaken during this trial:


Print publications related to the project 2008/09
Print publication related to the long term no-till project 2007


Print publications related to the long term no-till project 2006


Conference publications

A paper related to this project was presented at the 13th Agronomy Conference in Perth September 2006