Removing soil compaction and increasing water use efficiency.

David Malinda and Rick Darling.

South Australian Research and Development Institute, PMB 2, Glen Osmond, South Australia 5064.
malinda.david@saugov.sa.gov.au

Abstract

More than a century cultivating at the same depth and at different soil moisture contents has left most southern Australian soils compacted. Compaction reduces yield and economical viability of many farms. The South Australian Research and Development Institute (SARDI) established a long-term conservation tillage trial in 1978 and took us 16 years of tillage research to realise that poor water use efficiency in South Australian red-brown earth was mainly associated with subsoil problems. We also found out that the use of no-till without first removing compaction would take more than 15 years to satisfactorily repair compacted subsoil. In 1997, equipped with the knowledge of our long-term research results, we set up a field experiment next to the long-term trial to develop a new tillage regime to test the benefits of varying tillage depths to ameliorate compaction and increase the depth of soil exploitable by plant roots with the aim of increasing yield and yield quality. It took 6 years to develop such a tillage system capable of removing subsoil compaction and sustaining yield. This tillage system is simply called “Tillage Rotation” (TR) or progressive tillage. The TR system took only 4 years to reduce BD from 1.9 t/m^3 to 1.34 t/m^3 and with consistent economic returns for each year. The project produced further questions on the technology developed. Due to these emerging questions, the TR concept, developed with one type of seeding point was then tested using six other points in order to establish their effectiveness in removing compaction and increasing yield. Trials were set up at different sites with different soils. The experimental technique was also tested in commercial paddocks. The results show that TR has the potential to increase yield and yield quality if the soil has no severe chemical constraints. However, the magnitude of yield increase is dependent on both soil type and seeding points used.

Media summary

A novel vertical progressive tillage regime that will increase crop yield and gross margin was developed

Key words

Soil structure, tillage, seeding points, Water Use Efficiency, Gross margin.

Introduction

In the 1960s, and 1970s, concepts of reduced tillage, the sowing of crops with modified ground engaging points, the retention of crop stubbles, and the inclusion of grain legumes in rotation with cereals, were being considered for use in the development of more conservative land management practices in order to improve soil physical, chemical and biological fertility, together with the design of appropriate farming equipment (Hamblin and Kyneur 1993). Most farmed Australian soils have developed subsoil physical constraints, in particular compaction (Greacen and Williams 1983). It took us 16 years of conservation tillage research to realise that poor water use efficiency in South Australian red-brown earth was mainly associated with subsoil problems and the use of no-till without first removing compaction would take more than 15 years to satisfactorily repair compacted subsoil and increase yield.

In 1997 the South Australia Research and Development Institute set up a Grains Research and Development Corporation funded field experiment to develop a new tillage regime to test the benefits of varying tillage depths to ameliorate compaction and increase the depth of soil exploitable by plant roots with the aim of increasing yield and yield quality. It took 6 years to develop such a tillage system capable of removing subsoil compaction, and capable of increasing roots in the subsoil and infiltration capacity together with sustaining yield (Malinda 2002). The system took only 4 years to reduce BD from 1.9 t/m^3 to 1.34 t/m^3.

The trial, however, produced further questions on the technology developed. Due to these emerging questions, the TR concept, developed with one type of seeding point was then tested using six other points in order to establish their effectiveness in removing compaction and increasing yield when TR (progressive tillage) is used. Trials were set up in 2002 and 2003 at different sites with 6 different soil types, two of which are given in Figure 1. The experimental technique is also being tested in commercial paddocks. Results will cover a few of these sites.

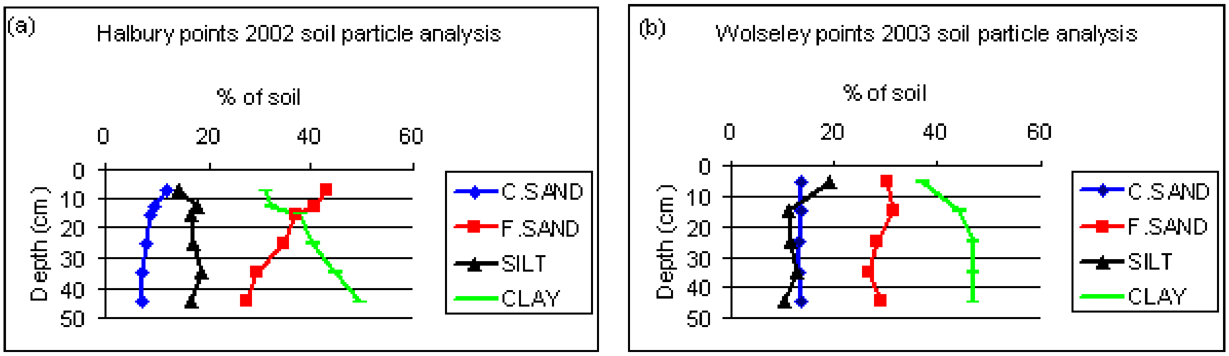

Figure 1. Soil particle size analysis for Halbury red-brown earth (a) and Wolseley sticky clay (b)

Methods

Halbury Subsoil Trial 1997-2003

The Halbury trial in South Australian has a red-brown soil and 450 mm of winter rainfall. The compacted depth was between 80 mm and 150 mm from the soil surface. The trial included three rotations: of continuous cereals of Wheat-Barley-Wheat-Wheat (WBWWWW); Wheat-Peas-Canola (WPeCaWPe); Wheat-Pasture-Pasture-Wheat-Peas (WPPWPe). All treatments received 80 kg/ha of N while under cereal crops and 12 kg/ha of P each year. Each rotation had three tillage regimes: conventional cultivation - CC (full soil disturbance at least twice before sowing with 175 mm points and 5 cm depth of cut); no-tillage – NT (sowing into uncultivated soil with 15 mm leading edge points and 7 cm depth of cut); and tillage rotation -TR (direct drilled up to 15 cm depth of cut but varying from year to year to avoid a consistent uniform depth of working). Tillage rotations was sown with super seeder points – 8 mm leading edge, 50 mm wing width and 40 mm wing depth and depth of cut alternative between 12 cm and 15 cm.

Halbury Points Trial

In 2002, work started on testing the effectiveness of TR in rehabilitating subsoil compaction using 6 other point types: This trial comprised 2 depth groups and 6 point types (Primary Sales Knife Point, Agpoint-Wing Probe 61SPWL-AT, Primary Sales Super Seeder-PR94-TW, Primary Sales Deep Blade-PR2-DB, Keech Narrow DDP18WT and Keech Tooth-DDP12LKT1). The two depth groups were based on the depth of the compacted layer. Group 1 started at 10 cm depth of cut in 2002 for all six points. In 2003 progressive depth of cut in group 1 was at 13 cm for all points except Primary Sales Knife Point, which will remain at 10 cm depth of cut every year (upper depth control). In depth group 2, all points' depth of cut was 15 cm in 2002 and will remain at 15 cm for subsequent years (lower depth control). Only results for 2003 are given here.

Wolseley Points Trial

This trial was established in 2003 in a heavy clay soil as shown in Figure 1b. The mean annual rainfall is 470 mm/yr. This trial is testing TR using 4 point types: Primary Sales Knife Point, Agpoint-Wing Probe

61SPWL-AT, Primary Sales Super Seeder-PR94-TW, and Keech Tooth-DDP12LKT1. Primary Sales Knife Point (control) depth of cut is a constant 10 cm each year. Other points' depth of cut increases each year to reach a depth of 22 cm.

Kapunda Farmer's Property Points/Subsoil Trial

The TR technology was tested in collaboration with a farmer at Kapunda (South Australia) on a clay soil (red sodosol) using his own seeding equipment. Compaction was concentrated in the 8 cm to 18 cm soil layer. Three treatments were assessed in this trial. The control was cultivation with a double disc coulter to a depth of cut of 5 cm. Treatment 2 and 3 depths of cut using knifepoint were 10 cm and 17 cm in 2002 and 15 cm and 18 cm in 2003 respectively. All treatments were then seeded with double disc coulter.

Results

Halbury Subsoil Trial

The tillage rotation regime has consistently increased water use efficiency (Table 1). Using TR, the average gross margin was $50/ha greater than conventional cultivation. Analysis of the subsoil in 2003 indicates big differences in soil chemistry in the deeper depths. For example, comparing TR with CC, Nitrate N of the 0-60 cm depth was up by 97%, 42% and 170% for WWWWW, WPeCaWPe and WPPWPe respectively. Most suprising, there were massive concentration of sulphur and electrical conductivity between TR, NT and CC at 30-100 cm (but in particular at 40-50 cm) (Figure 2). In WPPWPeW, high concentrations of sulphur (206%) and conductivity (94%) at 30-100cm and Nitrate N (213%) at 0-100cm were recorded between TR and CC (Figure 3). These differences were not expected and have implications for vigorous biological activities and/or leaching. Work is continuing to find out how this came to be.

Table 1. Halbury Subsoil Water Use Efficiency (% of potential yield)

Water use efficiency	WBWWWW			WPeCaWPe			WPasPasWPe		
	TR (%)	NT (%)	CC (%)	TR (%)	NT (%)	**CC** (%)	TR (%)	NT (%)	**CC** (%)
1997 Wheat	60	53	54	60	53	54	60	53	54
1998 Barley	87	92	91						
1998 Peas				60	61	55			
1998 Pasture									
1999 Wheat	87	81	74						
1999 Canola				50	37	46			

1999 Pasture									
2000 Wheat	65	59	54	103	94	98	107	98	96
2001 Wheat	48	46	43						
2001 Peas				55	57	51	53	47	50
2002 Wheat	118	108	79	208	191	180	193	193	172
2003 Wheat	98	98	87						
2003 Peas				52	54	39			
2003Pasture							84	72	72

Halbury Points Trial

The upper control produced better yield than other points in depth 13 cm (progressive tillage) except Super Seeder points. The Primary Sales Knife point and Primary Sales Super Seeder points produced high grain yield at 15cm (lower depth control) compared with all other points at the group 1 and group 2 depths. (Figure 2). Depth of cut did not make any difference in yield for Agpoint Winged, Keech Narrow and Keech Tooth.

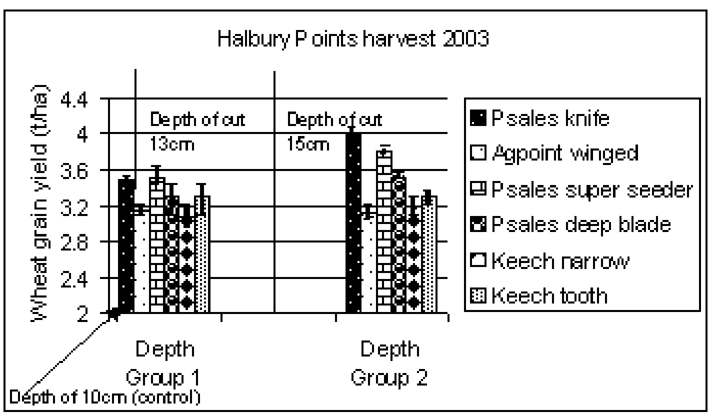

Figure 2. The effect of different seeding points and depth of cu t on grain yield at Halbury South Australia. Vertical bars are SE of means.

Wolseley Points Trial.

Yield - Super Seeder and Keech Winged points slighhtly increased yielded but not statistically compared with Agpoint and the control (Primary Sales Knife Point) (Figure 3a).

Grain Weight -Agpoint winged and Super Seeder points produced heavier grains of 28.3 g and 29 g respectively compared with control and Keech (27 g each) (Figure 3b).

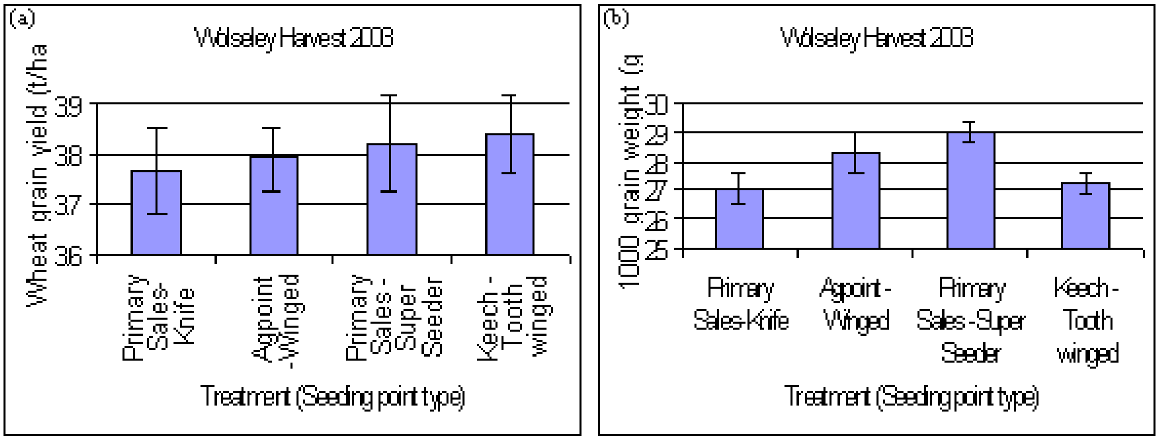

Figure 3. The effect of different seeding points and depth of cut on grain yield (a) and grain weight (b) at Halbury South Australia. Vertical bars are SE of means.

Kapunda Subsoil/Points Trial

Yield of lupins increased by 42% and 61% (Figure 4a), dry matter by 45% and 65%, grain weight by 4% and 5% for depth 15 cm and 18 cm respectively compared with control (5 cm). Taproot length and lateral root numbers followed a similar trend. The relationships between taproot and depth of cut and yield and tap roots and lateral roots roots were positive (Figure 4b, c, d).

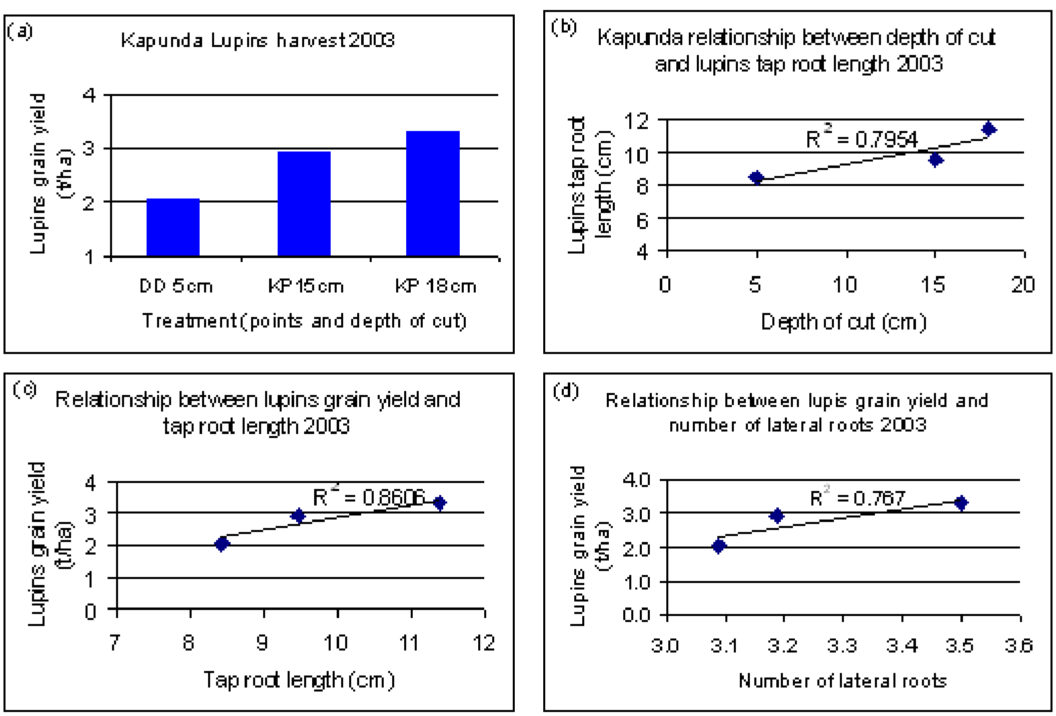

Figure 4. The effect of different depth of cut on lupins grain yield (a), the relationship between depth of cut and length of taproot (b)tap root and grain yield © and lateral roots and lupins grain yield (d).

Conclusions

Removing subsoil compaction by progressive tillage will save fuel and increase water and roots in the subsoil. The increased roots deeper in the profile increase water use efficiency and farm profit.

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