‘Tillage rotation’ to rehabilitate compacted subsoil and increase yield and profit.

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The spread of compacted soils

Subsoil compaction is widely spread in most agricultural soils in Australia (Figure 1). Contrary to what many people think, sandy soils are the worst affected. More than a century of cultivating at the same depth and at different soil moisture contents has left most southern Australian soils compacted. Compaction reduces yield and economic viability for many farming businesses. In this article we are using the term subsoil to mean that part of the soil profile below the cultivated layer but within the "potential" root zone of agricultural plants, and in particular between 5 cm and 20 cm.

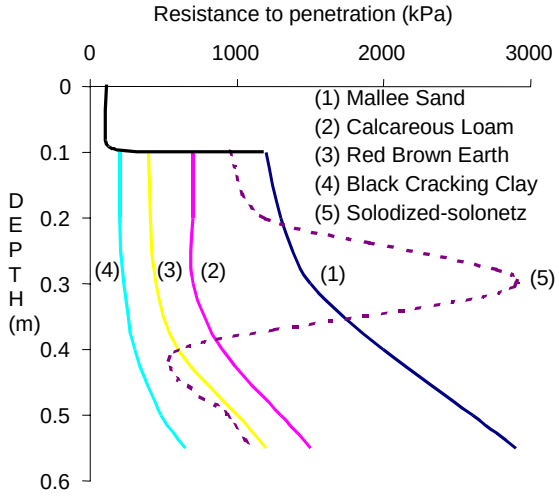


Figure 1. A penetration measurement survey of compaction by the late Dr E.L Greacen in 1983. Measurements were done at near field capacity (very wet)

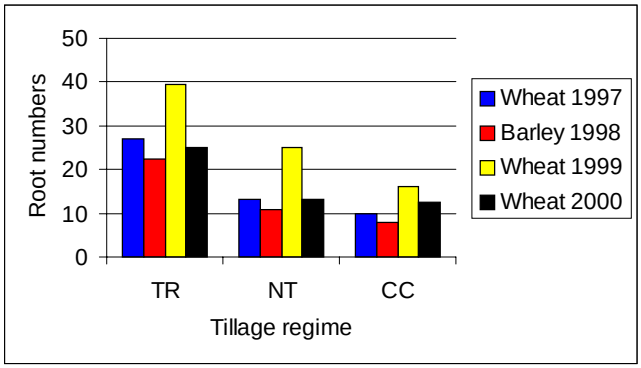
Development of cost effective tillage regime to rehabilitate compaction

South Australian Research Development Institute (SARDI) Senior Research Scientist Mr David Malinda has developed a novel tillage system to treat compacted subsoil. Field trials have been conducted to compare this system, called ‘Tillage Rotation’ (TR) with no-till (NT) and conventional cultivation (CC). TR uses narrow leading edge points with horizontal wings designed for deep tillage. The points place seed at normal depth in a direct drill operation with a depth of cut biting deeper each year to avoid a consistent uniform depth of working. NT uses narrow points for direct drilling with a 7 cm depth of cut. CC uses wide shears with two cultivations plus seeding. The three tillage regimes were tested in three crop rotations; wheat-barley-wheat-wheat-wheat (WBWWW), wheat-pasture-pasture-wheat-peas (WPPWPe), and wheat-peas-canola-wheat-peas (WPeCaWPe).

Removing the impediment of compaction will increase water infiltration. This is critical, particularly in low rainfall years, as the topsoil dries quickly, and the only water available to plants is that stored deep in the soil profile. Plants with roots that extend deep into the subsoil will cope better than those with roots that are concentrated in the topsoil.

Impact of compaction removal on yield and profit

Soil compaction can decrease farm productivity and product quality. Recent work at Halbury in South Australia has measured the effect on grain yield and quality of tillage at different depths to ameliorate compaction. TR, using super seeder points, broke up the compacted layer just below the normal cultivation depth and improved soil structure in the 10-15 cm layer below the surface. As a result, there were consistent and substantial increases in water infiltration (15 to 18 fold) and root growth below 30 cm. Grain yields were usually the highest in TR, especially in the very dry conditions (decile 1) of 2002, where yield increased by 50% over CC (Table 1). TR also recorded the highest gross margin of $50 per ha/yr over CC, averaged



Effect of tillage regime on root number that penetrated deeper than 300mm. Roots were measure at the end of tillering

over 6 years (Table 1).

Table 1. Effect of tillage and crop rotation on grain yield (t ha^{-1}) and profit ($\$ha^{-1}$)

	Rotation1 WBWWW)			**Rotation 2 (WPeCaWPe)**			**Rotation3 (WPPWPe)**		
	TR	**NT**	**CC**	**TR**	**NT**	**CC**	**TR**	**NT**	**CC**
1997 Wheat	2.7	2.4	2.4	2.7	2.4	2.4	2.7	2.4	2.4
1998 Barley	4.4	4.7	4.6						
1998 Peas				1.9	2.0	1.8			
1998 Pasture									
1999 Wheat	4.3	4.0	3.7						
1999 Canola				1.9	1.4	1.7			
1999 Pasture									
2000 Wheat	3.4	3.1	2.8	5.4	4.9	5.1	5.6	5.1	5.0
2001 Wheat	2.7	2.6	2.3						
2001 Peas				2.2	2.3	2.0	2.1	1.9	2.0
2002 Wheat	1.2	1.0	0.8	2.2	2.0	1.9	2.0	2.0	1.8
2003 Wheat	4.2	4.2	3.7						
2003 Peas				1.6	1.5	1.1			
2003 Pasture							9.6	8.2	8.2
Summary of Gross Margin for Halbury Subsoil trial (means of 6 years)									
$	367	341	309	354	291	306	291	253	250

The farmers joy with removed compaction

TR was also tested in collaboration with a farmer at Kapunda (South Australia) on a heavy clay soil (red sodosol) using farm equipment. Soil at this site was compacted between 7 and 18cm. Initially, the whole site was cultivated with a disc coulter to a depth of 5cm. Three treatments were assessed in this trial. The control was cultivated a second time with a double disc coulter to a depth of 5 cm. Treatments 2 and 3 involved the use of knifepoints with varying depths of cut over three consecutive years. The depths were 10cm, 15cm and 17cm (treatment 1) and 17cm, 18cm and 18cm (treatment 2). In each year, all treatments were sown with a double disc coulter to 5cm.

Crop yields increased significantly with the removal of compaction. In year one, when wheat was grown, the control yielded 2.34t/ha, with increased yields of 2.77t/ha and 3.39t/ha achieved in treatments two and three (both tillage rotation), respectively. In 2003, when lupins were grown, the control yielded 2.06t/ha, with yields of 2.92t/ha and 3.31t/ha achieved in treatments two and three.

Summary

High machinery loads and working when soil moisture is not optimal can cause topsoil and subsoil compaction.

Compaction, particularly hard pans, can reduce infiltration up to 18 fold and reduce roots below 30 cm by more than 200%. Hard pans can easily be rehabilitated using progressive tillage resulting in:

- a significant increase in roots
- a significant increase in infiltration
- a significant increase in grain yield and quality

The success of TR may, however, be limited in some situations. Compaction management decisions need to take into account variations in soil type, horse power requirements for working at greater depths, moisture available at seeding, and machine/tyne breakout pressure.

Therefore “If it is not broken, don’t fix it”. In other words if we cannot identify a problem, there is no need to go to extensive lengths to solve it! The first stage is to determine where subsoils are damaged, the economic extent of the problem, and whether there are cost effective means to remove any compaction.

An important point regarding the remediation of non-drained waterlogged soils is that deep loosening on such soils can create a large reservoir of water at depth; creating even greater problems than may have been present initially, and perhaps even putting these soils out of production.

Symptoms of compaction include:
Seasonal water logging after rain
Points unable to penetrate the soil
Restricted plant growth and development (poor germination, yellowish vegetation, root deformation).

ACKNOWLEDGMENTS

We thank GRDC for financial support to conduct the trials, Ashley Robinson (Halbury), and Bary Vogt (Kapunda) on whose land we conducted the trials, and Primary Sales Australia, Keech and Agpoint for assistance with tillage equipment.