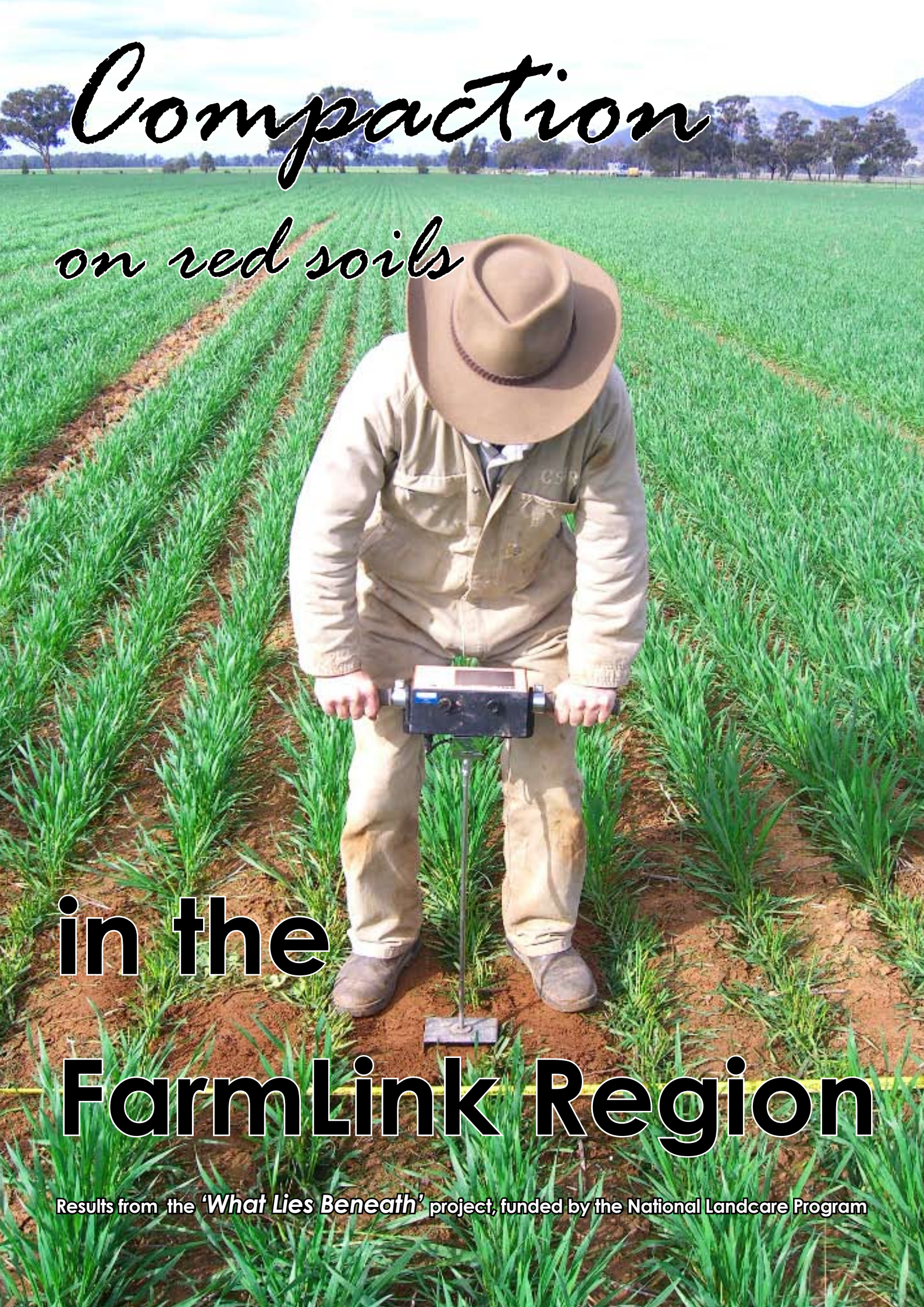
Compaction on red soils in the FarmLink Region



Results from the *'What Lies Beneath'* project, funded by the National Landcare Program

The project...

Controlled traffic farming has not been widely adopted in the FarmLink region of southern NSW, with uncertainty about the extent of compaction problems on red soils being a driving factor.

In 2007, FarmLink successfully applied for the funding of a one-year project through the National Landcare Program of the Department of Agriculture, Fisheries and Forestry. The project, 'What Lies Beneath', was established in collaboration with CSIRO to determine the impacts of compaction from machinery and livestock on red soils of the FarmLink region.

With the aid of local growers, two paddock-scale trial sites were established at Greenethorpe (near Grenfell) and Tootool (near The Rock) during the 2007 season. The selected trial paddocks had a compacted subsurface layer, or 'hard pan', typical of many cropping paddocks in the mixed farming zone.

Treatments:

Each paddock had the following treatments imposed:

- deep ripping (comparing deep ripped with unripped)
- controlled traffic (comparing wheel tracks & between wheel tracks)
- summer grazing by sheep (comparing grazed vs non-grazed areas)

Measurements:

Comprehensive soil and plant measurements were undertaken by CSIRO at 3 stages during the project:

- post ripping/sowing (August '07) - to determine early responses to deep ripping
- post harvest/pre-grazing (December '07) - to determine the residual effects of deep ripping and impact of wheel tracks
- post grazing (April '08) - to determine the residual effects of deep ripping and impact of summer grazing

Photo: F. Gummer

A Yeomans Plow was used to deep rip to a depth of 35cm at Greenethorpe and 25cm at Tootool. Other less disruptive methods of cultivation may be more suitable in some situations to break up compacted layers.

Photo: K. Condon

Both paddocks were sown and sprayed using controlled traffic with +/- 2cm GPS autosteer. Wheel tracks were 1st year at Greenethorpe and 2nd year at Tootool.

Photo: CSIRO

Sections of both paddocks were grazed lightly (but at realistic stocking rates considering the low stubble loads) over summer to determine the effects of stock on surface compaction.

Location of trial sites in the FarmLink Region:

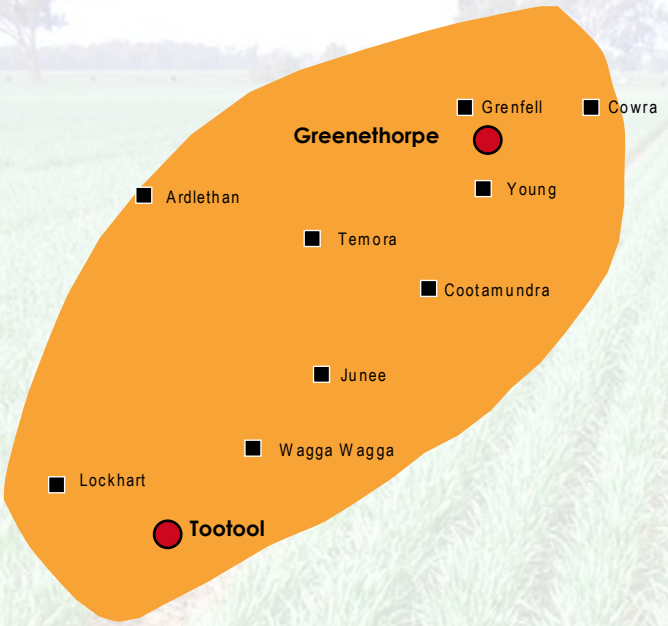


Photo: K. Condon

Soil core from Tootool - compaction in both paddocks was greatest at 10-20cm depth (penetrometer resistance > 3 MPa)

FarmLink gratefully acknowledges the National Landcare Program for their funding, and to the following people and organisations for their involvement:

- John Kirkegaard, CSIRO
- Tony Swan, CSIRO
- Warwick & Di Holding (Pontara Grain), Tootool
- Rob & Mandy Taylor, Greenethorpe
- GPS-Ag

Project Co-ordinator: Katrina Durham
Project Officer: Felicity Gummer
Project Communications: Kirrily Condon (author)

General observations:

- Deep ripping was able to remove the compacted layer ('hard pan'), decreasing soil strength and bulk density and increasing air filled pore space. However this came at the expense of grain yield in a very dry season.
- Re-compaction occurred during the season under the wheel tracks. Between wheel tracks, reductions in bulk density were still evident 12 months after ripping. The wheel track effect is consistent with other research which shows that controlled traffic farming is necessary to maintain the benefits of compaction removal.
- Light grazing of stubble over summer resulted in small but significant increases in surface bulk density, but had little impact on water infiltration and storage. Greater responses would be expected under higher stocking rates and wetter soil conditions.

Future directions:

- This project has formed the 'stepping stone' to a new five-year GRDC funded 'Water Use Efficiency' project, in which many of the issues will be explored in more detail. These include:
  - refining critical levels of compaction in red soils that restrict water infiltration and plant growth
  - assessing the impact of summer grazing under wetter conditions, heavier stubble loads and therefore higher stocking rates (would protection from heavier stubble loads offset higher stock numbers?)
  - assessing the pros and cons of summer grazing - do feed value and weed control benefits offset reduced water storage from grazing?

Responses... post sowing

- ► Compaction at both sites was greatest (above 3MPa) between 10 and 20cm. A soil is considered to be compacted when soil strength (penetrometer resistance) is above 2MPa.
- ► Deep ripping prior to sowing removed most or all of the compacted layer.
- ► Wheel tracks from sowing and spraying during the season re-compacted the soil, but not back to the original level.

- Measurements taken 2-3 months after deep ripping showed that **compaction** had been removed* to a depth of approximately 35cm and 25cm in the rip line at Greenethorpe and Tootool respectively. Shattering also removed compaction between the rip lines to a depth of approximately 25cm and 12cm respectively. Closer tyne spacing or deeper penetration by the ripper, if possible, would have achieved a more complete breakout between the rip lines at Tootool.
- Measurements taken on the wheel tracks showed that machinery for sowing and spraying **re-compacted** the soil after deep ripping, although not back to the original compaction levels. Confining wheels to the same tracks for each pass minimised the area of the paddock that was re-compacted.
- Deep ripping also resulted in greater **pore space** ('air pockets') in the soil down to a depth of 36cm (Greenethorpe) and 24cm (Tootool). Below these depths, air filled pore space remained above the 10% critical limit at Tootool, but dropped to levels where the soil was becoming anaerobic to plant roots at Greenethorpe.
- Despite removing the compacted layer, the rough seedbed left by the ripper resulted in poorer (and uneven) **plant establishment**, with 20% lower plant density at Greenethorpe and 10% lower at Tootool compared with the unripped area. Dry conditions prevented the trials from being ripped earlier which would have given more time for the soil to settle, potentially reducing establishment problems.

** penetrometer resistance less than 2MPa*

Photo: K. Condon

Deep soil cores were taken to measure bulk density and soil moisture after deep ripping. Results showed that ripping reduced bulk density to a depth of 36cm at Greenethorpe and 24cm at Tootool. Volumetric moisture was lower in the ripped areas.

Photo: K. Condon

Soil strength was measured using a penetrometer to determine the impact of deep ripping. Results showed deep ripping removed the compaction layer at both sites, although wheel tracks re-compacted the soil during the season.

Responses... post harvest

- ► Soil strength was still lower in the ripped areas seven months after deep ripping (except under wheel tracks).
- ► Deep ripping had significantly improved infiltration rates under simulation of a 'heavy' rainfall event, but not under 'normal' rainfall.
- ► Despite improvements to soil characteristics, deep ripped areas yielded less; Wheel tracks had no impact on yield. It is likely the extremely dry spring conditions were the limiting factor.

- Measurements taken 7 months after deep ripping showed that **bulk density** (measure of soil structure) still remained lower, and **pore space** higher, in the ripped areas, although these benefits had been negated under the wheel tracks.
- Under simulation of a heavy rainfall event, **infiltration rates** were significantly better in the ripped areas. However under the wheel tracks, infiltration rates were much lower, potentially resulting in run-off in heavy rain.
- Under simulation of a 'normal' rainfall event, there were no differences in **infiltration rates** between treatments (not surprising given the apparatus primarily measures the surface soil), with infiltration averaging 25mm/hr at Greenethorpe and 18mm/hr at Tootool. It is possible the natural permeability of red soils means rainfall is still able to infiltrate the soil even when compacted.
- Poor plant establishment in the ripped areas resulted in less **dry matter** and fewer **tillers** at maturity at Tootool, but not at Greenethorpe. Both sites, however, **yielded** less in the ripped area, probably due to a combination of poor seedling establishment and greater moisture loss from cultivation in a very dry season. Wheel tracks had no impact on plant growth or yield at either site despite the negative impacts on soil characteristics. It is possible the original level of compaction may not have been sufficient to cause significant reductions in plant growth under the dry conditions.

Photo: D. Holding

Short term infiltration rates were measured using a disc permeameter to simulate responses under a 'heavy' rainfall event. Infiltration was higher in the ripped areas, but much poorer under wheel tracks.

Photo: CSIRO

Steady state infiltration rates were measured using a drip infiltrometer to simulate responses under a 'normal' rainfall event. There were no differences in infiltration rates between treatments.

Responses... post grazing (stubble)

- ► Light grazing resulted in small but significant increases in bulk density at the soil surface.
- ► Despite this, grazing had no significant impact on infiltration rates or stored soil water. The result may have been different with higher stocking rates on wetter soils.
- ► Residual effects of deep ripping 12 months prior were still apparent at Greenethorpe with surface bulk density and soil strength lower in the ripped areas.

- Measurements taken after stock were removed showed that despite low stocking rates (low stubble loads)*, grazing increased **surface bulk density** at both locations.
- However this effect did not significantly impact on **infiltration rates**, consequently grazing had no impact on **stored soil water**. Grazing earlier on wetter soil may have had a greater impact on water storage, although in this project, grazing was timed to intentionally avoid wet soils.
- Post grazing measurements also showed there were still residual effects from deep ripping 12 months later at Greenethorpe, with reduced **bulk density** and **soil strength** in the surface. Although this had no *significant* impact on infiltration rates, a *trend* towards increased infiltration rates in the deep ripped area resulted in greater water storage at depth. There was little evidence of residual effects from deep ripping at Tootool.

**1.1t/ha stubble at Greenethorpe (358 DSE days/ha) and 2.1t/ha stubble (384 DSE days/ha) at Tootool.*

Photo: CSIRO

Penetrometer used to measure soil strength at the surface (0-1cm) after grazing, which had increased at Greenethorpe.

Photo: CSIRO

Soil core used to measure bulk density at the surface (0-5cm) after grazing, which had increased at both locations. Note the heavily crusted soil which had formed in the ungrazed area at Tootool. A slight crust had also formed at Greenethorpe, although this tended to disappear when wet.

Photo: CSIRO

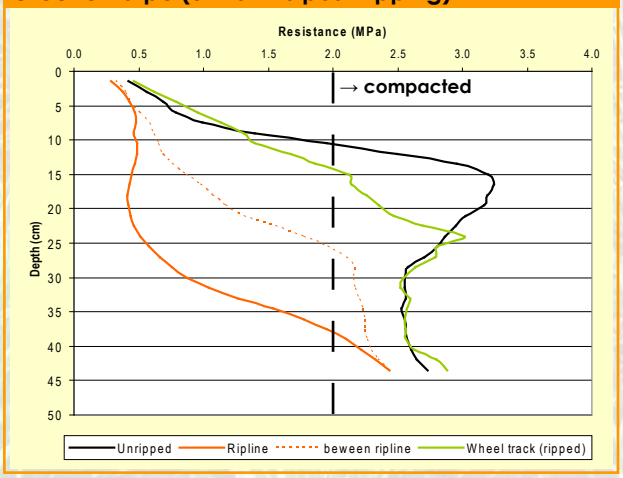
Soil structure after grazing at Greenethorpe.

Data summary...

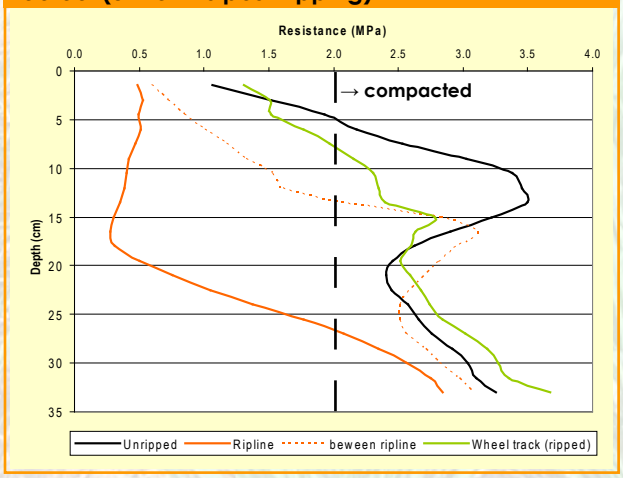
Measurement	Greenethorpe	Tootool
Effect of deep ripping (cf unripped) after 3 months on:		
Bulk density	lower (down to 36cm in ripline, 18cm between ripline)	lower (down to 24cm in ripline, 12-18cm between ripline)
Soil strength[1]	lower (below 2 MPa down to 36cm in ripline, 25cm between ripline)	lower (below 2 MPa down to 24cm in ripline, 12cm between ripline)
Air filled pore space	higher (down to 36cm in rip line)	higher (down to 24cm in ripline)
Plant establishment	lower (by 20%)	lower (by 10%)
Effect of deep ripping[2] (cf unripped) after 7 months on:		
Bulk density (0-5cm)	still lower (1.25 cf 1.32 g/cm^3)	still lower (1.25 cf 1.32 g/cm^3)
Air filled pore space	still slightly higher (52% cf 51%)	still slightly higher (53% cf 50%)
Steady state infiltration	NS (23.9 cf 27.1 mm/hr)	NS (16.9 cf 18.6 mm/hr)
Short term infiltration	higher (1200 cf 460 mm/hr)	higher (1057 cf 415 mm/hr)
Plant growth & yield	•NS difference at anthesis (tillers or dry matter) •NS difference at maturity (heads or dry matter) •lower yield[3] (85 cf 294 kg/ha)	•(no anthesis measurements) •lower head counts & dry matter at maturity •lower yield (1.39 cf 1.98 t/ha)
Effect of deep ripping (cf unripped) after 12 months on:		
Bulk density (0-5cm)	still lower (1.26 cf 1.19g/cm^3)	NS (1.31 cf 1.28g/cm^3)
Soil strength (0-1cm)	stiller lower (450 cf 336 kPa)	still lower (1086 cf 785 kPa)
Steady state infiltration	NS (19.5 to 23 mm/hr)	NS (13 to 13 mm/hr)
Short term infiltration	NS (218 to 338 mm/hr)	NS (91 to 127 mm/hr)
Stored water in April	increased (by 20mm)	NS (no change)
Effect of wheel tracks[4] on:		
Bulk density	increased (1.29 to 1.39 g/cm^3)	increased (1.29 to 1.50 g/cm^3)
Soil strength	increased	increased
Air filled pore space	decreased (52 to 48%)	decreased (51 to 44%)
Short term infiltration	decreased (830 to 62 mm/hr)	decreased (736 to 21 mm/hr)
Plant growth & yield	NS difference at maturity (heads, dry matter, yield)	NS difference at maturity (heads, dry matter, yield)
Effect of summer grazing on:		
Bulk density (0-5cm)	increased (1.19 to 1.26g/cm^3)	increased (1.27 to 1.32g/cm^3)
Soil strength (0-1cm)	increased (332 to 453 kPa)	NS (949 to 922 kPa)
Steady state infiltration	NS (23 to 19 mm/hr)	NS (12 to 14 mm/hr)
Short term infiltration	NS (356 to 200 mm/hr)	decreased (132 to 86 mm/hr)
Stored water in April	NS (no change)	increased[5] (by 30mm)

[1] compaction = soil strength (penetrometer resistance) above 2MPa
[2] data from between wheel tracks
[3] unripped areas affected by rhizoctonia, which due to dry season, conserved moisture and allowed better grain fill than unaffected ripped areas.
[4] average of wheel tracks in ripped and unripped areas
[5] data may have been influenced by heavy weed growth at Tootool
NS = not statistically significant

Soil strength response to ripping & wheel tracks at Greenethorpe (3 months post-ripping)



Soil strength response to ripping & wheel tracks at Tootool (3 months post-ripping)



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