Increasing water extraction and production on Mallee sands through enhanced nutrient supply in the root zone

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Key messages

- **Deep ripping reduced soil penetration resistance and resulted in a grain yield increase of 0.85 t/ha.**
- **Deeper placement of nutrients had no effect on production above the physical impact of ripping.**
- **Spading nitrogen rich organic matter resulted in a yield increase of 0.6-1.0t/ha.**
- **Grain protein was significantly increased where available nitrogen was increased by either fertilisers or organic matter.**
- **Ground cover was rapidly established following a one pass spade and sow system; however, establishment counts were lower and more variable compared to normal no-till sowing methods.**

Why do the trial?

There are opportunities to increase production on Mallee sands by developing cost effective techniques to diagnose and overcome the primary constraints to poor crop water-use. Commonly recognised constraints that limit root growth and water extraction on sands include compaction (high penetration resistance), poor nutrient supply and low levels of biological cycling and crop establishment.

Opportunities for increasing crop production exist through a range of management strategies that can be broadly categorized as:

- Mitigation: lower cost, annual strategies that aim to minimise the impact of a particular soil constraint on crop water use.
- Amelioration: higher intervention, higher cost approaches that aim to have greater, longer-lasting impact, through changing the properties of the soil profile.

Two new long-term trials were established at Ouyen in the Victorian Mallee in 2017 as part of the GRDC project: *Increasing production on sandy soils in the low-medium rainfall areas of the southern region*. The trials at Ouyen are a collaboration between Moodie Agronomy and Mallee Sustainable Farming, CSIRO and UniSA. Both trials are aiming to improve productivity through enhanced nutrient supply in the root zone to increase rooting depth and water extraction.

How was it done?

The trials were located near Ouyen, Victoria on a sand 'dune', which is typical of an underperforming sandy soil in the region. The yellow coloured sand layer was approximately one metre thick and was characterised as having high penetration resistance (up to 4000 Megapascals (MPa)), and poor fertility in the subsurface layers (Table 1).

Two separate trial sites were established to investigate both mitigation and amelioration strategies to overcome constraints and improve root growth and water extraction in the sub-surface layers. The mitigation approach was to build up subsoil fertility with deeper placement of fertiliser using pre-drilling or deep-ripping ahead of seeding. The amelioration trial aims to build longer-term subsoil fertility by incorporating organic material with a spader to 30 cm depth. The trial is particularly focused on evaluating farm grown sources of organic material such as vetch and oaten hay. The trial compares these farm-grown residues to a wider range of organic inputs to assess whether the quality/complexity of organic matter is important for multiple years of impact.

Fertiliser placement trial (mitigation)

The mitigation trial compared surface banding (7-8 cm deep) of nitrogen (N) and other nutrients to deeper nutrient placement using a pre-drilling (20 cm) or deep ripping (30 cm) operation ahead of seeding (Table 2). Nitrogen was applied as urea alone or urea plus a wider nutrient package (P, K, S, Zn, Cu, Mn). Furthermore, nutrients were applied at an annual (30 kg N/ha) or once in three-year (90 kg N/ha) rate. The trial design will allow us to quantify the impact of physical disruption, deeper placement of nutrients and the combination of these interventions (Table 2).

Table 1. Key soil properties at the Ouyen sites.

Depth (cm)	Total organic carbon (%)	pH ($CaCl_2$)	Clay (%)	Electrical conductivity (µ/cm)	Colwell P (mg/kg)
0-10	0.3	6.3	3.8	53.7	18
10-20	0.2	5.1	4.2	20.5	18
20-40	0.1	6.0	4.3	16.1	10
40-60	0.2	7.0	3.8	39.9	-
60-80	0.1	7.3	4.1	35.7	-
80-100	0.1	7.5	4.9	35.2	-

Table 2. Key factors in the mitigation trial, incorporating physical disturbance with pre-drilling or deep ripping, 2017 nitrogen rate, depth of N placement (banding) and the addition of a nutrient package (P, K, S, Zn, Cu, and Mn) applied with N fertiliser.

Description	Physical disturbance	2017 nitrogen rate (kg N/ha)	Fertiliser placement			Nutrient package (P, K, S, Zn, Cu, Mn)
			7.5 cm	20 cm	30 cm	
Control	Nil	30	✔			+/-
Pre drill control	Pre Drill	30	✔			+/-
Pre drill N (annual)	Pre Drill	30		✔		+/-
Pre drill N (1 in 3)	Pre Drill	90		✔		+/-
Deep rip control	Deep Rip	30	✔			+/-
Deep rip N (annual)	Deep Rip	30			✔	+/-
Deep rip N (1 in 3)	Deep Rip	90			✔	+/-

Table 3. Treatments included in the amelioration trial.

Treatment	Application rate (t/ha)	C:N ratio	*N applied (kg/ha)
Spaded Vetch Hay	6	16:1	156
Spaded Oaten Hay	5.9	72:1	35
Spaded Vetch + Oat Hay	3.3 + 2.7	25:1	102
Spaded Chicken Litter Compost	6.8	16:1	218
Spaded Compost	15.8	10:1	252
Urea	0.34	N/A	156
Spaded control	Nil	N/A	-
Non-spaded control	Nil	N/A	-

**An additional 50 kg N/ha was applied to all treatments through fertiliser.*

Soils

Management 2017

Both the mitigation and amelioration trials were sown to Spartacus barley on 29 May 2017. The site had a full profile of moisture at sowing due to 100 mm of rainfall falling in the month preceding sowing. The site received 363 mm (decile 6) for the year with 195 mm (decile 3) falling during the growing season (April-October). In-crop rainfall was very patchy with most of this rainfall received during the months of April, May and August.

All treatments in both trials received a total fertiliser N input of 50 kg/ha except for the 1 in 3-year treatments in the fertiliser placement trial where 110 kg N/ha was applied in 2017. In addition to the nitrogen treatments outlined above, both trials received DAP S Z (16:17:0:8; 0.5%Zn) @ 62.5 kg/ha at seeding and 47 kg/ha of ammonium sulphate applied on 25 July during tillering. Urea was also applied to the spaded organic matter trial to supply 10 kg N/ha at seeding and a further 20 kg N/ha during tillering on 25 July. Foliar trace elements (Cu, Zn, Mn) were applied during tillering. Weeds were controlled using 0.6 L/ha of Intervix and 0.5 L/ha of MCPA LVE 570.

What happened?

Fertiliser placement trial (Mitigation)

Deep ripping had a positive impact on penetration resistance, significantly reducing resistance in the 15–40 cm soil layer compared to the control (Figure 1). However, disturbing the soil using the pre-drilling approach had little impact on reducing penetration resistance.

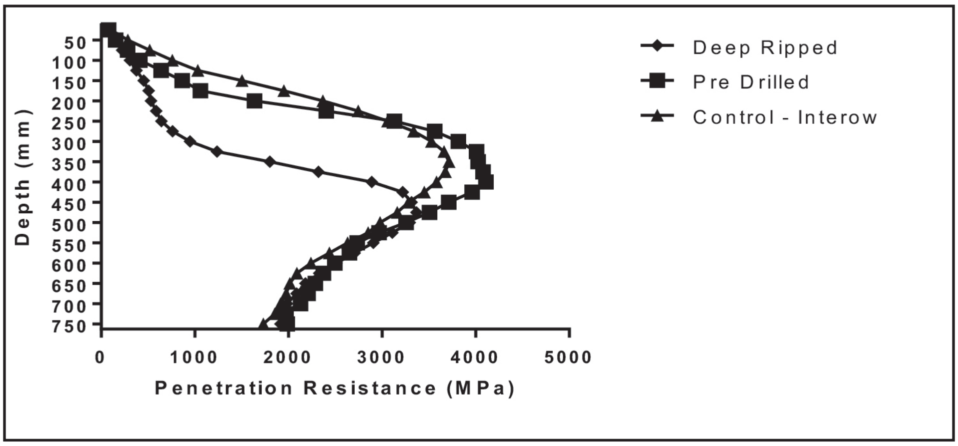

Figure 1. Impact of pre-sowing soil disturbance using pre-drilling (20 cm) or deep ripping (30 cm) on soil penetration resistance.

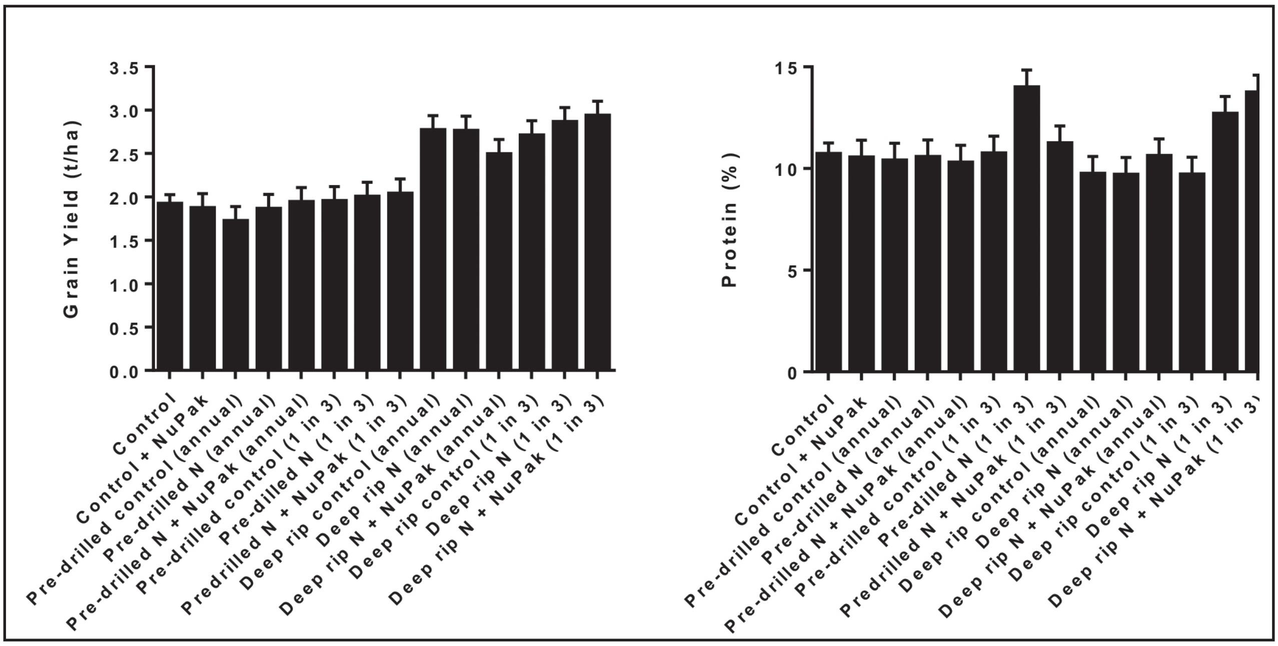

Figure 2. Grain yield and protein responses to fertiliser placement treatments. Data are average of 4 replicates, with error bars represent standard error.

Deep ripping resulted in a significant increase in yield of 0.85 t/ha (Figure 2). Pre-drilling did not alter yield, therefore there was a clear link that reducing the penetration resistance of the soil increased production.

Fertiliser treatments did not impact on yield, however applying urea at the 1 in 3-year rate (90 kg N/ha) resulted in a 3 % increase in protein compared to the annual rate (30 kg N/ha) (Figure 2). There was no impact of either the differing depth of fertiliser placement or the addition of the nutrient package on either grain yield or protein.

Spading and organic matter quality (amelioration)

Incorporating N rich organic matter such as vetch hay, chicken litter compost and compost significantly increased yields by up to 1 t/ha (Figure 3). All treatments increased yield relative to the non-spaded control, except for spaded oaten hay. Establishment was variable in the spaded treatments which were sown using a spade and sow system and establishment in the spaded treatments was 50-60 plants/m^2 while the non-spaded control established 110 plants/m^2. The higher establishment variability in the spaded treatments may have limited the ability to detect significant effects of spading against the control.

Grain protein was also significantly increased in the spaded vetch, urea and chicken litter compost treatments (Figure 3).

We were unable to find any evidence that the organic matter treatments resulted in “haying off”, which is often a concern of applying high fertility treatments. All organic matter treatments significantly improved harvest index (ratio of grain yield to biomass) by 5-8% relative to the control which had a harvest index of 38%.

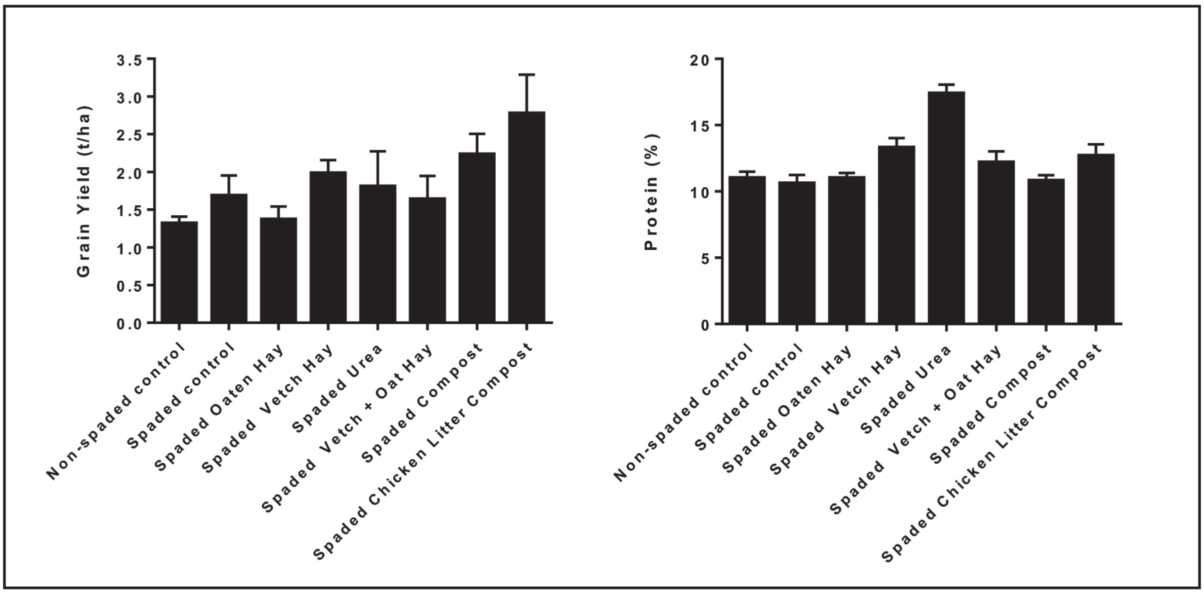

Figure 3. Grain yield and protein responses to spaded organic matter treatments. Error bars represent standard error.

What does this mean?

The first-year results have shown that there is potential to significantly improve production on Mallee sandy soils using both mitigation and amelioration approaches. In this first year of the trial, deep ripping alone resulted in a 0.85 t/ha increase in yield, while benefits of up to 1 t/ha were measured with higher cost treatments where N rich organic matter was incorporated using a spader. Both trials will continue for at least two more seasons (2018-19) to measure the longer-term benefits of the treatments, which is important to determine the most economic options for improving production on Mallee sands.

Acknowledgements

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