Effects of deep ripping on soil compaction and crop performance in Mallee sands.

Authors: Brian Dzoma¹, Nigel Wilhelm² and Kym Zeppel¹
¹SARDI Loxton Research Centre, ²SARDI Waite Research Precinct

Peer Review: Sjaan Davey (SARDI - Waite) and Brett Masters (Rural Solutions – Port Lincoln).
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Key Messages

• For sands with subsoil compaction that goes to depth, ripping deeper is better to maximise shoot biomass production and grain yield
• Optimal ripping depth x tine spacing combination was 60 cm x 60 cm on a deep grey sand.

Background

Sandy soils dominate the landscape across the low rainfall region of south-eastern Australia, and anecdotal evidence suggests that compaction is widespread on these soils. Soil compaction is one of the major problems facing modern farming systems on sandy soils mainly because of the use of heavy machinery and intensive cropping. Soil compaction adversely affects soil physical fertility, particularly storage and supply of water and nutrients, through increasing soil bulk density, decreasing porosity, increasing soil strength, decreasing soil water infiltration, and water holding capacity.

Deep ripping or deep cultivation, is an expensive yet important option for addressing soil compaction, destroying hard pans and ameliorating hard setting soils. Mallee sands tend to form hard layers just below the soil surface which limit water infiltration and root penetration, hence in low rainfall South Australian (SA) Mallee farming systems deep ripping has been used to shatter these dense subsurface soil. Deep ripping alone has been shown to increase crop production on sands, but often the effects are not sustained long term (Adcock et al., 2007). In a summary of deep ripping trials on Eyre Peninsula from 2006-2008, Paterson and Sheppard (2008) concluded that (i) sandy soils were more responsive to deep ripping than finer textured soils, and (ii) responses did not persist past 2 years.

Thus the challenge for growers is quantifying the contribution of deep ripping to crop productivity, refining how best to do it, and if used in combination with chemical, biological and other physical soil ameliorants, can these benefits be improved or prolonged. How crops utilise available moisture and nitrogen after ameliorating soil compaction in these environments is poorly understood. If this gap can be closed, crop productivity and farm profitability could be improved through more efficient use of nitrogen in these moisture limited environments.

About the trial

Two replicated field trials were conducted in 2018. One on a deep red sandy soil (Loxton) and a second on a grey sand with clay underneath (Peebinga). Trial 1 (Table 1), was conducted in the southern Mallee, to evaluate the impact of deep ripping at different tine spacing and depth. The main objective of this trial was to identify an optimum depth of ripping where productivity gains can be maximised, and to evaluate whether narrow tine spacing improves the longevity of the operations.

Trial 2 (Table 1), was conducted in the northern Mallee as a crop phase experiment with 3 different crop types. The aim was to assess the impact of deep ripping on crop performance and to determine which crop
types (wheat, barley and field peas) respond better to deep ripping in the 1st, 2nd and 3rd year after amelioration. One tine spacing (50 cm) was used for trial 2.

Table 1: Treatment details

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Trial 1: Peebinga</th>
<th>Trial 2: Loxton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depths</td>
<td>5 depths (0, 20, 40, 60, 70 cm)</td>
<td>Ripped (50 cm) vs compacted (control)</td>
</tr>
<tr>
<td>Tine spacings</td>
<td>2 Tine spacings (Narrow = 30 cm and wide = 60 cm)</td>
<td>1 tine spacing (50 cm)</td>
</tr>
<tr>
<td>Total # plots</td>
<td>Total # plots = 40</td>
<td>Total # plots = 24</td>
</tr>
<tr>
<td>Sowing rate</td>
<td>Sowing rate: 60 kg/ha (Scope barley)</td>
<td>Sowing rate, kg/ha: Mace wheat (60), Scope barley (80), Gunyah peas (100)</td>
</tr>
<tr>
<td>Fert inputs</td>
<td>Fert inputs: 20 P kg/ha and 100 N kg/ha</td>
<td></td>
</tr>
<tr>
<td>Experimental design</td>
<td>Randomised complete block design x 4 reps</td>
<td>Randomised complete block design x 4 reps</td>
</tr>
</tbody>
</table>

Deep ripping treatments were imposed using a straight tine ripper on 11 May and 21 May 2018 at Loxton and Peebinga respectively. Penetration resistance readings were taken on 7 August at both sites using a Rimik CP40 (II) cone penetrometer to determine the depth of compaction. In season assessments of crop density, early and late shoot dry matter (DM), grain yield and quality were carried out to help quantify the effect of ameliorating compacted sands through deep ripping.

Results & Discussion

With total growing season rainfall of 116 mm (Peebinga) and 106 mm (Loxton), crop growth and productivity was heavily compromised at both sites. However, visual responses in crop establishment and biomass to ripping were evident at both sites.

Penetration resistance: Crop root growth usually begins to be impeded when penetration resistance exceeds 1500 kPa, with severe restriction in sands beyond 2500 kPa. Penetrometer readings in Figure 1 show that at the Loxton site, the deep ripped plots had greatly reduced soil compaction within the top 40 cm of soil. Comparatively, the unripped control had a compaction zone starting from as shallow as 20 cm going down to depth. At Peebinga, penetrometer data show that the compacted layer was shallower; starting from 18 cm (Figure 2). Ripping to 20 cm only addressed surface compaction, having no impact on sub-surface compaction below 20 cm. Soil compaction was greatly reduced when the plots were ripped to a depth greater than 60 cm.

Effect on crop performance

(a) Loxton. Deep ripping did not affect early shoot biomass for wheat, however there was a significant increase in barley and peas (Figure 1, Left). There was no significant increase with deep ripping in wheat or peas flowering shoot DM, however, barley flowering DM increased by 74% (Figure 1, Right).
Severe frost prevented any grain yield in field peas. Deep ripping did not improve grain yield for wheat, however there was a 100% increase in grain yield of barley where soil compaction was ameliorated (Figure 2).

Peebinga. Crop establishment was poor at this site because the top 10 cm of this sandy soil was water repellent. There was an average of only 45 plants/m², which, together with the below average season rainfall contributed immensely to low shoot DM and grain yield.

Across all ripping depths, deep ripping with narrow tine spacing at 30 cm, on average resulted in an overall significant increase in early and late shoot DM. However this did not seem to affect barley grain yield (Figure 3).
Figure 3: Effect of narrow vs wide tine spacing on early and late shoot DM of barley, and grain yield at Peebinga 2018.

Increased grain yield, as well as early and late shoot DM, were generally achieved by increasing the depth of ripping (Figure 6). These highly significant responses (p<0.001) were consistent across the 3 assessments and showing that large responses can be achieved by ripping beyond the 40 cm zone. Ripping to 20 cm with wide spaced tines, gave similar results to the control, indicating that the compacted layer was below 20 cm. However, narrow (20cm) performed better than the control, possibly indicating that shallow ripping had some benefit in treating the water repellent sand.

Figure 4: Effect of ripping depth on early and late shoot DM, and grain yield of barley at Peebinga in 2018.

Responses from the 9 individual treatments (Figure 7) exploring the best combination of ripping depth and tine spacing, show that ripping with a narrow spacing (30cm) to a depth of 70 cm resulted in the largest flowering shoot biomass production response (328% more than the control). The results also show that ripping to depths greater than 60 cm gave the largest grain yield responses ranging from 155% (wide, 60cm) to 211% (wide, 70cm) more than the control.
Implications for commercial practice
Slow and restricted root growth caused by subsoil compaction can often lead to reduced crop productivity and profitability and also result in on and off-farm including increased wind and water erosion, dryland salinity and waterway degradation. Thus, the challenge for growers is to quantify the contribution of deep ripping to improved crop productivity, refining the ripping methodology (e.g. ripper type, spacing, depth), and determining if these benefits are sustainable. Our trials show that ameliorating compacted sandy soils in low rainfall environments can lead to improved crop biomass and grain yield, and should subsequently lift farm productivity and profitability. In terms of grain yield, ripping narrow or wide gave similar outcomes, therefore wider tine spacings can be considered in order to use less machinery horsepower. Results of these trials show that when there is deep soil compaction then deeper ripping provides larger grain yield benefits, provided that no chemical constraints are present below the compaction zone. From the individual treatments investigated, ripping with wide tine spacings (60 cm), to a depth of 60 cm is the optimal combination to maximise productivity. Although there was a trend of higher yields from ripping deeper and with narrower tine spacings, these were not significantly different to the optimal combination.

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