Ripping Mallee soils, what are the production benefits?

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Abstract
Historical soil compaction due to random and extensive machinery traffic within paddocks is known to limit crop production. Physically ameliorating the soil via deep ripping is used to alleviate such compaction and when combined with controlled traffic farming (CTF) benefits may be prolonged. Previous deep ripping work has demonstrated improved water infiltration and root access to nutrients and water deeper in the profile across various soils. Research trials were established in 2018 at Woomelang and Kooloonong to determine the effect of deep ripping, with and without inclusion plates on Mallee soils. Yield improvements of 0.5 t/ha were recorded at Kooloonong, on a deep sand after ripping without inclusion plates to a depth of around 40 cm. However, no significant yield response was recorded at Woomelang on either a sand over sandy loam dune or sandy loam over clay loam swale where ripping was applied to an average depth of 20 cm. This indicates that the immediate value of deep ripping is highly dependent on soil type, ripping depth and stored soil water. Multi-year studies are required to assess the long-term value of deep ripping.

Key Words
Compaction, low rainfall zone, soil strength, wheat

Introduction
The Mallee region of Victoria receives an average of 200-300 mm growing season rainfall (April-October, GSR) with dryland cropping the predominant land-use. Farms typically operate under low input systems on highly variable dune swale landscapes and lower lying heavier plains. Soil types vary in texture from sand/sandy loams in the northern Mallee to heavier soils in the south (Sodosols and Vertosols). Mallee subsoils can be highly alkaline and sodic, with high levels of chloride and/or boron which can inhibit root growth and access to soil water (Nuttall, Armstrong & Connor 2003).

The adoption of soil conservation practices and new varieties have provided significant yield improvements. However, soil compaction has been identified as a potential limitation to grain production on light textured cropping soils in southern Australia. Forming as layers and typically found at depths of 10-60cm, such compaction reduces water infiltration and restricts root growth, thereby reducing access to stored nutrients and subsoil water. One remediation option is to mechanically break up compacted layers by deep ripping.

Improvements in grain yields of 11% from shallow ripping (30-40 cm) and up to 44% from deep ripping (50-70 cm) have been observed on deep sands and loamy sands from the low rainfall zone in Western Australia (Davies et al. 2017). These positive yield responses have been reported to last for three seasons on loamy sands and sandy clay loams (Hamza & Anderson 2003). Deep ripping is often performed prior to adopting a CTF system which helps to prolong the yield benefits (anecdotally reported up to 10 years on light soil types) due to reduced traffic. Further yield improvements from deep ripping sandy soils have been observed from topsoil slotting, a technique where inclusion plates funnel the topsoil and any surface applied ameliorants (e.g. chicken manure) into the furrow made by the deep ripper (Blackwell et al. 2016). In the current study, the utility of deep ripping in the Victorian Mallee was tested on soil types ranging from sandy loam over clay loams to deep sands, with the benefits of inclusion plates also being tested.

Method
Site description
Two trials were established on commercial paddocks near Woomelang (35º37'21"S 142º37'50"E) and Kooloonong (34º47'50"S 143º03'54"E), Victoria. At the Woomelang site, CTF on a 9 metre wide system

was established in 2009 and transitioned to a 10 metre system in 2013 and a 12 metre system in 2018. The trial was split over two different soils types; a brown sandy loam over clay loam on the swale and a light brown sand over sandy loam on the dune. The GSR was 125mm in 2018 (av. GSR 217 mm) with 23 mm plant available water (PAW) at sowing on the swale and 133mm PAW on the dune to depths of one metre (Fig. 1). Wheat (*cv*. Scout) was sown on 25 May into lentil stubble. Ripping depth was determined by dividing the plot into nine subplots and pushing a ruler down different rip lines. For the Kooloonong site, a CTF system was established in 2012 on a 12 metre system. The trial was undertaken across a dune ranging from deep sand to loamy sand. The GSR was 65 mm for 2018 (av. GSR 200 mm) with 84 mm of PAW to one metre at sowing (Fig. 1). Wheat (*cv*. Scepter) was sown on 7 May 2018 into lupin stubble. Ripping depth here was determined by a combination of visual observations of the tines in the ground and random measurements with a ruler.

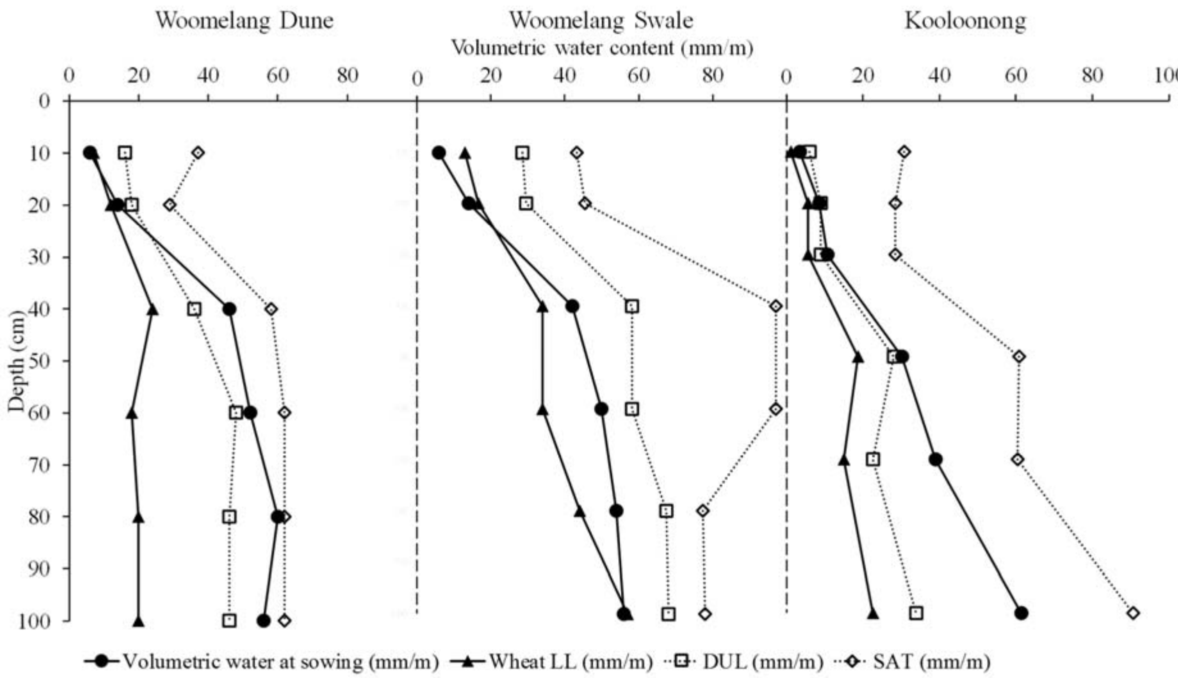

Figure 1. Soil water at sowing for the sand over sandy loam on the dune (left), sandy loam over clay loam on the swale (middle) at Woomelang and deep sand over loamy sand at Kooloonong (right). The volumetric water content at sowing is compared with the wheat crops lower limit (Wheat LL), drained upper limit (DUL) and saturation point (SAT) for the different soil types (APSoil, 2005 & 2014).

Experimental Design

The trials were established as complete randomised block designs (plot size 12m × 50m). At Woomelang, there were six replicates of four treatments; (1) control (CTF), (2) deep ripping, (3) deep ripping with inclusion plates (4) conventional practice (scarifying topsoil). At Kooloonong there were four replicates of seven treatments, designed as a multi-year experiment (2018 was year one) to also look at the effect of re-compacting the soil after deep ripping. The first three treatments were equivalent to Woomelang with the addition of (4) control (CTF) + traffic, (5) deep ripping + traffic, (6) deep ripping with inclusion plates + traffic, (7) deep ripping with inclusion plates + annual traffic.

The deep ripping treatments were imposed using a 3.4 metre wide, 9-tine AGROWPLOW deep ripper (no lead-in tines) prior to sowing on the 28 March 2018 (Woomelang) and 6 April 2018 (Kooloonong) under dry conditions. A depth of greater than 30 cm was targeted for the deep ripping. The deep ripped plots were rolled at Woomelang. The re-compaction treatment at Kooloonong was imposed by multiple passes of an 18-ton tractor over the entire plot. Assessments included; plant establishment, crop biomass at flowering and grain yield (determined from quadrat cuts).

Results

Woomelang

The average depth of disturbance by the tines was 20 cm for both soil types. The shallow penetration is potentially due to a combination of high soil strength (Table 1) related to the dry soil conditions and/or insufficient draft. Jarvis et al. (2001) has reported that moist soil (but not saturated) throughout the soil profile will aid in achieving the targeted ripping depth along with soil type and tractor/implement used. Despite this, at 20 cm, the hard pan was partially broken, evident by the massive clods on the surface (Fig. 2).

Table 1. Bulk densities (g/cm^3) from the control plots prior to ripping at the Woomelang dune/swale and Kooloonong.

Soil Depth (cm)	Woomelang Dune	Woomelang Swale	Kooloonong
0-10	1.59	1.17	1.50
10-20	1.57	1.36	1.71
20-40	1.76	1.31	1.70
40-60	1.71	1.30	1.71
60-80	1.74	1.39	1.71
80-100	1.74	1.54	1.71

Figure 2. Soil clods from the dune (left) and swale (right) after ripping at Woomelang.

Across the four treatments there were no significant differences in plant establishment, biomass at flowering, grain yield or its components (Table 2). Soil type significantly (P <0.001) affected both harvest biomass and grain yield. The sand over sandy loam (dune) had significantly higher biomass (5.8 t/ha) and yield (2.8 t/ha) compared to the sandy loam over clay loam (swale) of 4.5 t/ha and 1.7t/ha respectively. The small effect of ripping may be related to the low yield potential due to limited available water in the top 30 cm of the soil profile (Fig. 1) as well as reduced ripping depth, which may have been insufficient to reduce the high bulk density (>1.7 g/cm3) below 20cm, and continued to restricting root growth.

Table 2. The effect of ripping on wheat establishment and growth on a sandy dune and loamy swale at Woomelang in 2018. Parentheses indicate percentage change compared to the control.

Treatment Description	Establishment (plants/m^2)	Biomass (t/ha)	Yield (t/ha)	Harvest Index	Kernel size (mg/kernel)
DUNE					
1. Control	152	5.8	2.7	44.6	41.2
2. Deep ripping	128 (-16)	5.3 (-9)	2.7 (0)	44.4 (0)	42.4 (3)
3. Deep ripping + inclusion	137 (-10)	6.0 (3)	3.0 (11)	44.8 (0)	41.1 (0)
4. Conventional practice	153 (1)	6.0 (3)	2.7 (0)	42.9 (-4)	42.8 (4)
LSD (P=0.05)	NS	NS	NS	NS	NS
SWALE					
1. Control	154	4.8	1.6	36.6	38.9
2. Deep ripping	141 (-8)	4.2 (-13)	1.6 (0)	36.4 (-1)	39.5 (2)
3. Deep ripping + inclusion	142 (-8)	4.2 (-13)	1.6 (0)	37.7 (3)	39.7 (2)
4. Conventional practice	155 (1)	4.9 (2)	1.8 (13)	35.9 (-2)	39.3 (1)
LSD (P=0.05)	NS	NS	NS	NS	NS

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Kooloonong

At Kooloonong the average depth of deep ripping was 42 cm, which is likely to have effectively loosened part of the compacted subsoil. Significant differences were observed for plant establishment with lower plant numbers on the deep ripped with and without inclusion plates (Table 3). For the treatments that were re-trafficked after ripping, plant establishment was equivalent to the undisturbed plots. For grain yield, there was a significant positive response to soil amelioration, where deep ripping without inclusion plates and no additional traffic increased yield relative to the control by 0.5t/ha.

Table 3. The effect of ripping over the 2018 growing season at Kooloonong.

Treatment Description	Establishment (plants/m²)	Biomass (t/ha)	Yield (t/ha)	Harvest Index	Kernel size (mg/kernel)
1. Control	163[ab]	3.2	1.1[cd]	40.2[bc]	43.9
2. Deep ripping	134[bc]	3.6	1.6[ab]	41.9[abc]	44.2
3. Deep ripping + inclusion	126[c]	3.7	1.5[abc]	46.2[ab]	44.5
4. Control + traffic	159[ab]	2.9	1.1[d]	37.3[c]	42.9
5. Deep ripping + traffic	172[a]	3.4	1.2[bcd]	41.5[bc]	42.6
6. Deep ripping + inclusion + traffic	153[abc]	3.9	1.6[ab]	43.3[abc]	44.7
7. Deep ripping + inclusion + annual traffic	150[abc]	3.3	1.8[a]	48.1[a]	43.5
LSD ($P<0.05$)	29.1	NS	0.4	6.5	NS

Conclusion

Responses to deep ripping in the Mallee in 2018 were variable, likely due to several contributing factors including soil type, soil water and depth of soil disturbance. These experiments demonstrated that yield benefits can be achieved by removal of soil compaction, but this is dependent on the interaction between soil type and depth of ripping. On sandy soils at Kooloonong, wheat yields increased by 0.5t/ha after deep ripping. In contrast, on the sand over sandy loam dune and a sandy loam over clay loam swale at Woomelang no yield advantages were observed. The addition of inclusion plates provided no additional benefit at either site. Whilst it appears soil compaction limits crop yield potentials on some sandy soils, questions remain as to whether deep ripping will be an economically feasible practice for soil compaction amelioration, with on-going monitoring required.

Acknowledgements

This work was funded by the 'Improving practices and adoption through strengthening D&E capability and delivery in the southern region' Regional Research Agronomists program (DAV00143) as part of the Grains Research & Development Corporation (GRDC) and Agriculture Victoria – Department of Jobs, Precincts and Regions (DJPR), Bilateral Research Agreement, in conjunction with the 'Application of CTF in the Low Rainfall Zone' project (ACT00004) funded by the GRDC and participating partners. The authors also wish to acknowledge the assistance of our growers, Darrell Boxall and Alistair Murdoch for their time and use of their land.

References

Blackwell, P, Isbister, B, Riethmuller, G, Barrett-Lennard, E, Hall, D, Lemon, J, Hagan, J & Ward, P 2016, 'Deeper ripping and topsoil slotting to overcome subsoil compaction and other constraints more economically: way to go!' *GRDC Update Paper,* GRDC Grains Update, 29 February – 1 March 2016, Perth, WA

Davies, S, Parker, W, Blackwell, P, Isbister, B, Betti, G, Gazey, C & Scanlan, C 2017, 'Soil Amelioration in Western Australia', *GRDC Update Paper*, Grains Research Updates, 27-28 February 2017, Adelaide SA, DAFWA and GRDC

Hamza, MA & Anderson WK 2003, 'Responses of soil properties and grain yields to deep ripping and gypsum application in a compacted loamy sand soil contrasted with a sandy clay loam soil in Western Australia', *Australian Journal of Agricultural Research,* vol. 54, no. 3, pp. 273-282

Jarvis, R, Perry, MW, Porritt, S & White, P 2000, 'Tillage' in WK Anderson & JR Garlinge (eds), *The wheat book: principles and practice,* Department of Agriculture and Food, Western Australia, Perth, Bulletin 4443, pp. 185-187.

Nuttall, J, Armstrong, R & Connor, D 2003, 'Evaluating physicochemical constraints of Calcarosols on wheat yield in the Victorian southern Mallee', *Australian Journal of Agricultural Research*, vol. 54, no. 5, pp. 487–497.