Improve productivity of canola by deep ripping on acidic yellow deep sand in the Western Australian grainbelt

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Key messages

- Canola plant growth and grain yield were increased significantly as a result of deep ripping in acidic yellow deep sand.
- Consider alleviating subsoil compaction to improve soil productivity and crop yield while ameliorating acidic yellow sand with lime.
- On compacted and acidic yellow sand the combination of lime with appropriate deep tillage will potentially minimise multiple soil constraints and offer better return on investment in the longer term.

Aims

Soil acidity and compaction are the two major subsoil constraints to crop production on yellow deep sands in the Western Australian grainbelt. A recent study shows more than 11 million hectares (~70%) of Western Australian agricultural area is affected by subsoil acidity, costing average returns for individual growers about $140/ha/year due to lost production and in total about $1.6 billion each year. About 12 million hectares (~75%) of Western Australian agricultural area is affected by subsoil compaction, costing the average grower about $55/ha/year in lost production and in total about $880 million each year (Petersen, 2016). These constraints stunt crop root growth and function to the extent that water and nutrient levels can be insufficient to sustain crop production**.** This has been particularly evident in lower rainfall areas (less than 300mm) of the eastern grainbelt.

The aim of this study was to improve knowledge of subsoil constraints and develop better ways of managing acidic yellow sandy soils to improve productivity.

Method

The trial site was selected in April 2015 at South Burracoppin about 50 km south-east of Merredin (Lat. -31.505˚; Long. 118.652˚). The soil at the trial site is classified as a Yellow Sandy Earth (Schocknecht and Prathan 2013) with acidic subsoil and compaction below 15cm depth (Figure 1). There were considerable variations in chemical properties among the soil profile at different depths. The topsoil (0-20cm) is moderately acidic (pH 5.4-6.2 $CaCl_2$), non-saline (EC 3.5-4.4/m), with low total cation exchange capacity (CEC 1.0-3.0meq/100g) and low soil organic carbon (0.3-0.8%). The subsoil (20-80cm) is acidic (pH <4.5 $CaCl_2$), potentially aluminium toxic (Al_{Ca}> 5mg/kg), non-saline (EC <4.8mS/m), with very low P (<2.0mg/kg), K (<20mg/kg), CEC (<1.0meq/100g) and organic carbon (<0.2%).

Twelve treatments were laid out in a complete randomise block design with four replicates. The treatments consisted of four tillage treatments (control, Grizzly® tandem disc plough, deep ripping and deep ripping plus Grizzly disc plough) and three rates of lime (0, 2.5 and 5.0t/ha) with a neutralising value of 90%. The experimental site had been chemically fallowed during the 2015 winter and 2.0t/ha lime was spread onto the surface across the whole paddock. In early August 2015, lime (limesand) was spread onto the surface at the selected rates of a series of 36m long and 2.5m wide plots (90m^2). The deep ripping (40cm) and disc ploughing (15cm) treatments were applied the day after lime was spread. Canola (cv Bonito) was sown at 4kg/ha on 7 April 2016 following standard agronomic practices. The total annual rainfall at the trial area was recorded 414mm and seasonal rainfall was above average (345mm; March to September 2016). On 16 November 2016, 222 days after seeding (DAS) the centre 2.0m of the each plot was harvested using a plot harvester.

Results

Canola germination, counted at 28 DAS was not affected by the tillage and lime treatments (Table 1). Plant density was quite high (63-73 plants/m^2) across all treatments, mainly due to the relatively high seed rate (4kg/ha), 144mm rainfall in March-April and favourable soil moisture for germination.

Deep ripping (40cm) reduced soil penetration resistance significantly at the compacted layer between 15 and 35cm (Figure 1) and increased the depth to which canola roots penetrated. For example, canola roots were present to a depth of 50 to 60cm in the ripped profile, while in the un-ripped profile roots were present only to a depth of 20 to 30cm (Table 1). This was also reflected in the visual assessment, plant height and shoot dry matter of the all deep ripping treatments, irrespective of lime incorporation (Table 1). In addition, canola plant growth and early vigour (NDVI) was significantly higher (p<0.001) with deep ripping irrespective of lime rates, measured at different growing stages, using a handheld GreenSeeker (data not shown). At 98 DAS canola plant growth (phenology) was quite distinct with the un-ripped plots being more than four weeks behind the deep ripped plots.

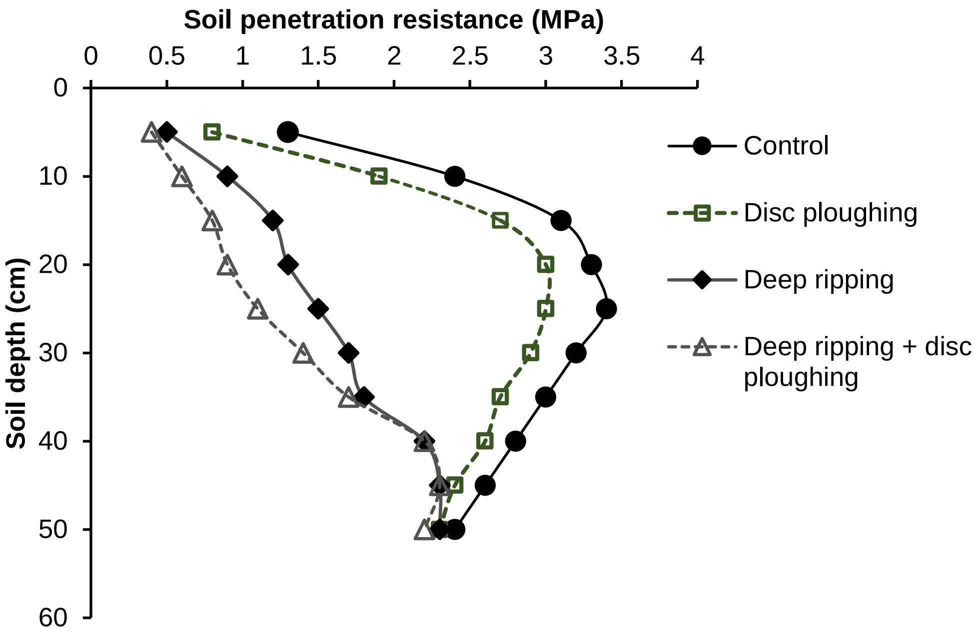

Figure 1: The effect of tillage treatments on soil penetration resistance, measured at field capacity in March 2016.

Table 1: Effect of various treatments on canola plant density (28 DAS) and growth measurements 98 DAS on acidic yellow deep sands.

Tillage treatments	Lime rate (t/ha)	Plant density (plants/m^2)	Visual assessment (0-10)	Root length (cm)	Plant height (cm)	Shoot dry matter (t/ha)
1. Control	0	63	3.0	31	36	1.06
2. Disc ploughing		69	3.5	27	36	1.13
3. Deep ripping		64	6.0	46	59	2.35
4. Deep ripping + disc ploughing		69	6.0	49	58	2.35
5. Control	2.5	66	4.0	28	36	1.13
6. Disc ploughing		70	4.0	45	48	1.71
7. Deep ripping		68	7.0	65	63	2.48
8. Deep ripping + disc ploughing		73	7.0	59	60	2.71
9. Control	5.0	66	4.0	38	36	1.19
10. Disc ploughing		68	4.5	47	45	1.48
11. Deep ripping		65	7.0	60	57	2.40
12. Deep ripping + disc ploughing		72	8.0	71	67	2.73
Lsd (p≤0.05)		ns	1.0***	12***	12***	0.75***

n.s Not significant at the 0.05 probability level
*** Significant at the 0.001 probability level

Canola grain yield, grain size and oil content were highly significant (p<0.001) between the treatments (Table 2). Highest grain yield was observed in the deep ripping +/- lime incorporations. Canola grain yield was increased by 250 to 570 kg/ha on deep ripping +/- lime incorporations compared to those not ripped (Table 2). Grain size and oil contents were significantly (p<0.001) higher for the deep ripping treatments, irrespective of lime incorporation (Table 2). Lime had no significant impact on canola grain yield, grain size and oil content.

Table 2: Canola grain yield, grain size and oil content grown on acidic yellow deep sands under various treatments, harvested 222 DAS.

Tillage treatments	Lime rate (t/ha)	Grain yield (t/ha)	Grain weight (g/1000 grain)	Oil content (%)
1. Control	0	1.75	3.44	46.1
2. Disc ploughing		1.69	3.54	46.2
3. Deep ripping		2.06	3.66	46.8
4. Disc ploughing + deep ripping		2.01	3.74	47.0
5. Control	2.5	1.65	3.57	45.4
6. Disc ploughing		1.96	3.59	46.3
7. Deep ripping		2.12	3.70	47.0
8. Disc ploughing + deep ripping		2.00	3.60	47.2
9. Control	5.0	1.62	3.52	46.0
10. Disc ploughing		1.92	3.55	46.0
11. Deep ripping		2.05	3.60	46.5
12. Disc ploughing + deep ripping		2.19	3.67	47.2
Lsd (p≤0.05)		0.24***	0.12***	0.73***

n.s Not significant at the 0.05 probability level
*** Significant at the 0.001 probability level

Nevertheless, grain yield responses to deep ripping were much less than plants shoot dry matter and plant growth performance (early vigour). For example, canola grain yield increased by around 25% as a result of deep ripping irrespective of lime application compared to the control with no deep ripping, whereas shoot dry matter was more than double (Figure 2). This may be due to the long growing season (222 days), above average annual rainfall (414mm), comparatively cool and high numbers of rainy days (128 days) in 2016, resulting in a soft finish. The canola plant is indeterminate and produces flowers and pods as long as it has the resources to continue. However, the higher grain yield compared to shoot dry matter was only observed in the non-rip treatments, irrespective of lime applications (Figure 2).

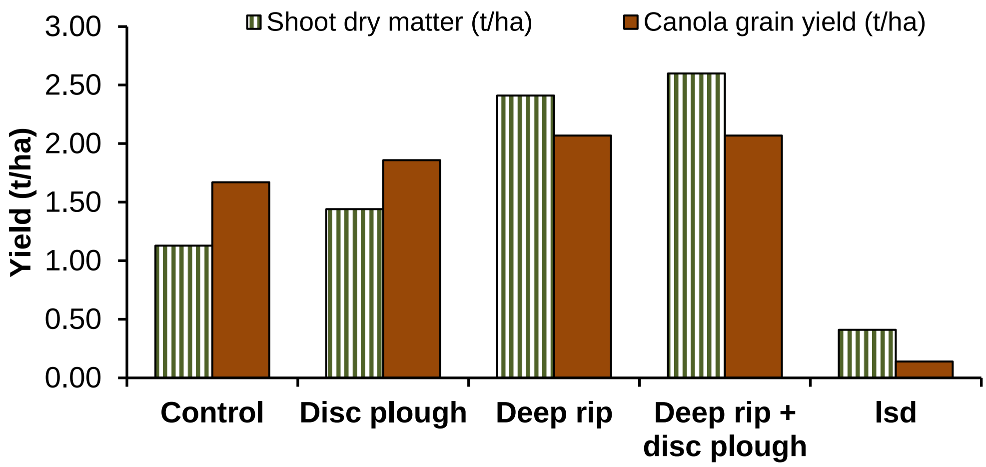

Figure 2: Comparison of canola plant shoot dry matter and grain yield grown on acidic yellow deep sands under various tillage treatments, irrespective of lime application.

Recent research has shown that there are potential yield benefits from deep ripping of canola, lupins and barley across the Western Australian grainbelt (Blackwell et al. 2016; Davies et al. 2015). Initial responses are more related to deep ripping than lime and this may be due to surface applied lime which may take many years to ameliorate the subsoil acidity (Davies et al. 2015). Deep tillage loosened the subsoil, significantly increased root length, shoot dry weight, and increased the proportion of roots in the 30-60cm soil layer. Some growers are modifying ‘one-way’ plough using fewer and larger discs to provide greater working depth with greater soil inversion. Deep tillage will enable better distribution of the lime particles and greater contact with the acidic soil.

Conclusion

Improved soil physical properties, plant growth and canola grain yield were evident in acidic yellow deep sand treated with deep ripping. Initial responses are more related to deep ripping than lime. This was also borne out in the preliminary work by Hall and Shea (2016).

Alleviating subsoil compaction needs to be considered while ameliorating acidic yellow deep sand with lime. Deep ripping loosened the compacted layer which presumably benefited crop growth performance, access to nutrients and water down the soil profile. In addition, deep incorporation of lime is likely to work better where subsoil acidity occurs in a compacted layer, typically between 15 and 35cm. Therefore, on compacted and acidic deep sand the combination of lime with appropriate deep tillage will potentially minimise multiple soil constraints and offer better return on investment in the long term.

Key words

Subsoil acidity, compaction, deep ripping, lime, canola

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