Yield responses to deep ripping of wheat on yellow deep sand in Western Australian grainbelt

Shahab Pathan, David Hall, Glen Riethmuller and Greg Shea, Department of Primary Industries and Regional Development, WA; **Tony Murfit,** Warakirri Cropping, South Burracoppin, WA

Key messages

- Crop growth and grain yield were increased consecutively for 2 years as a result of deep ripping in yellow deep sand with multiple constraints.
- Consider alleviating subsoil compaction to improve soil productivity and crop yield while ameliorating acidic yellow sand with limesand.
- On compacted and acidic yellow sand the combination of limesand with appropriate deep tillage will potentially minimise multiple soil constraints.

Aims

The aim of this study was to improve knowledge of subsoil constraints and develop better ways of managing soils with multiple constraints to improve productivity.

Soil acidity and compaction are the two major subsoil constraints to crop production on yellow deep sand 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 for Western Australia 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; van Gool, 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.

Method

The field 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 Pathan, 2013) with multiple constraints which include non-wetting, subsoil compaction and acidity. Soils are highly compacted with soil resistance more than 3.0MPa within 15-25cm. There were considerable variations in chemical properties among the soil profile at different depths. Selected soil properties are given at Table 1.The top 20cm is moderately acidic, non-saline, with low cation exchange capacity (CEC), organic carbon (OC) and sulfur (Table 1). The subsoil, 20-80cm, is acidic, potentially aluminium toxicity, non-saline, with very low soil OC and essential plant nutrients (Table 1).

Table 1: Selected soil properties of the trial site at South Burracoppin.

Soil depth (cm)	**Soil Resistance** (MPa)	**pH** (CaCl2)	**EC** (mS/m)	**OC** (%)	**CEC** (meq/100g)	**N** (mg/kg)	**P** (mg/kg)	**K** (mg/kg)	**S** (mg/kg)	**Al** (mg/kg)
0-10	2.5	6.0	5.1	0.8	3.6	17	14	33	8	0.2
10-20	3.3	4.9	2.7	0.5	1.7	8	8	24	10	1.0
20-30	3.2	4.5	2.7	0.3	1.2	6	5	22	19	3.0
30-50	2.8	4.5	3.0	0.3	1.1	6	4	23	31	5.0
50-80	2.4	4.5	3.4	0.2	1.3	6	4	26	37	5.0

Twelve treatments were laid out in a complete randomise block design with four replicates. The treatments consisted of four tillage treatments; Control (no tillage), Disc plough (1.9m wide G16 Grizzly® tandem offset disc with 40.6 x 66.0cm), Deep ripping (four Agrowplow® tines spaced 445mm apart with five leading tines 100mm shallower and 223mm off line) and Deep ripping plus Disc plough and three rates of limesand 0, 2.5 and 5.0t/ha with a neutralising value of 90%. The experimental site had been chemically fallowed during the 2015 winter. In early August 2015, limesand was spread onto the surface at the selected rates of a series of 36m long and 2.5m wide plots. The deep ripping to 40cm deep and disc ploughing to 15cm treatments were applied the day after limesand was spread. Canola (Bonito) was grown in 2016 and results were presented at the Grains Research Updates 2017 (Pathan et al. 2017). In 2017, wheat, cv Calingiri, was dry sown at 50kg/ha on 23 April following standard agronomic practices. The total annual rainfall at the trial area was 315 mm although growing season rainfall was below average with 182 mm May to October 2017. On 29

November 2017, 220 days after seeding (DAS) the centre 1.8m of the each plot was harvested using a plot harvester. A summary of the trial site major operational activities are given at Table 2.

Table 2: Trial site major activities since July 2015.

Activities	2015	2016	2017
Lime sands (90% nv)	31 July		
Tillage	2 August		
Crop	Chemical fallow	Canola	Wheat
Variety		Bonito	Calingiri
Seeding date		7 April	23 April (dry sown)
Seeding rate (kg/ha)		4	50
Plant biomass cut		14-July	6-September
Crop harvested		16-November	29-November
Growing season rainfall (mm)		264 (April-Sept)	182 (May-Oct)
Annual rainfall (mm)	400	414	315

Results

Wheat germination, counted at 39 DAS varied from 52 to 69 plant/m^2 among the treatments (Table 3). This was mainly due to very low rainfall 2.2mm during sowing and unfavourable soil moisture for germination. The wheat was sown on 23 April and first seasonal rainfall 25mm was observed on 11 May 2017. Wheat plant growth and early vigour as measured by NDVI, using a handheld GreenSeeker, was significantly higher ($p<0.001$) on the deep ripped plots, irrespective of limesand incorporation at different growing stages (Figure 1). This was also reflected in the visual assessment, drone NDVI images and shoot dry matter of the all deep ripping treatments (Table 3). For example, shoot dry matter increased by around 25% as a result of deep ripping, irrespective of limesand application compared to the control with no deep ripping (Table 3) This was mainly due to deep ripping reducing the soil penetration resistance significantly at the compacted layer between 15 and 35cm, and increasing the depth of roots and nutrients available for plants (Pathan et al. 2017). In addition, wheat plant tissue nitrogen (N), potassium (K) and sulfur (S) concentrations were significantly higher for plants grown on deep ripped plots compared to not ripped plots, irrespective of lime application (data not shown).

Table 3: Effect of various treatments on wheat plant density (28 DAS) and growth measurements 130 DAS on acidic yellow deep sand.

Tillage treatments	Limesand (t/ha)	Plant density (plants/m^2)	Visual assessment (0-10)	NDVI (130 DAS)	Shoot dry matter (t/ha)
1. Control	0	65	5.0	0.46	0.92
2. Disc ploughing		63	4.4	0.45	0.99
3. Deep ripping		57	6.1	0.52	1.06
4. Deep ripping + disc ploughing		66	5.8	0.51	1.11
5. Control	2.5	62	5.2	0.43	1.03
6. Disc ploughing		69	5.1	0.46	1.07
7. Deep ripping		56	6.5	0.51	1.19
8. Deep ripping + disc ploughing		52	6.4	0.52	1.23
9. Control	5.0	60	5.4	0.46	0.99
10. Disc ploughing		60	4.9	0.48	1.00
11. Deep ripping		55	6.2	0.51	1.17
12. Deep ripping + disc ploughing		62	6.6	0.52	1.17
Lsd ($p \le 0.05$)		9*	1.0***	0.05**	0.14***

* Significant at the 0.05 probability level
** Significant at the 0.01 probability level
*** Significant at the 0.001 probability level

Wheat grain yield was highly significant (p<0.001) between the treatments and highest grain yield was observed in the deep ripping + disc plough, with 5.0t/ha limesand incorporation (Figure 2). The wheat grain yield increased by 290 to 370 kg/ha on deep ripping +/- limesand incorporations compared to those not ripped (Figure 2). The wheat grain size, protein content and screenings were not affected by treatments (data not shown). During the 2016 growing season the canola grain yield increased by around 25% as a result of deep ripping (Pathan et al. 2017).

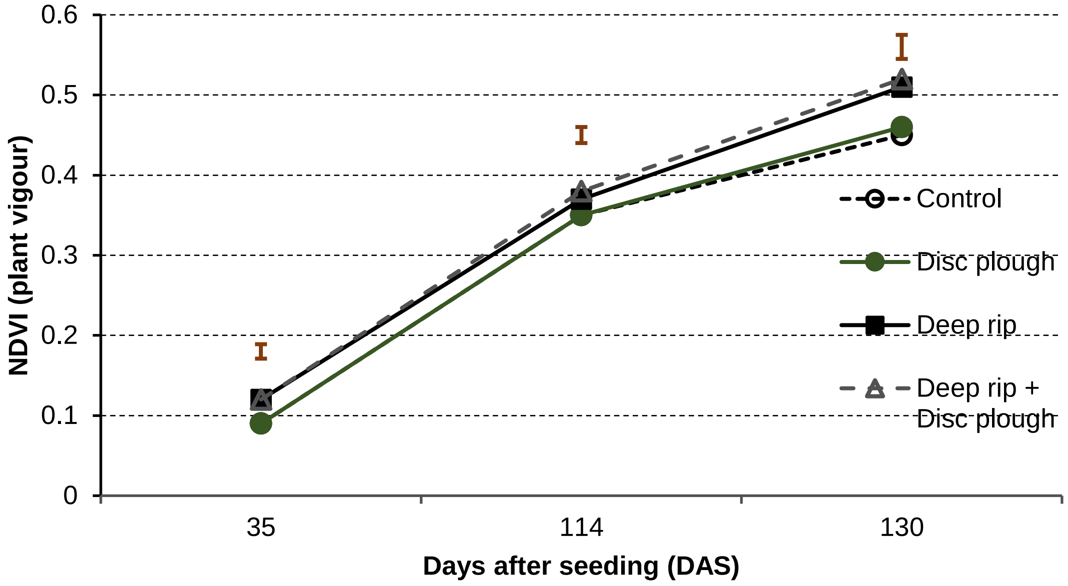

Figure 1: The effect of tillage treatments on wheat plant vigour (NDVI), measured at different growing stages in 2017.

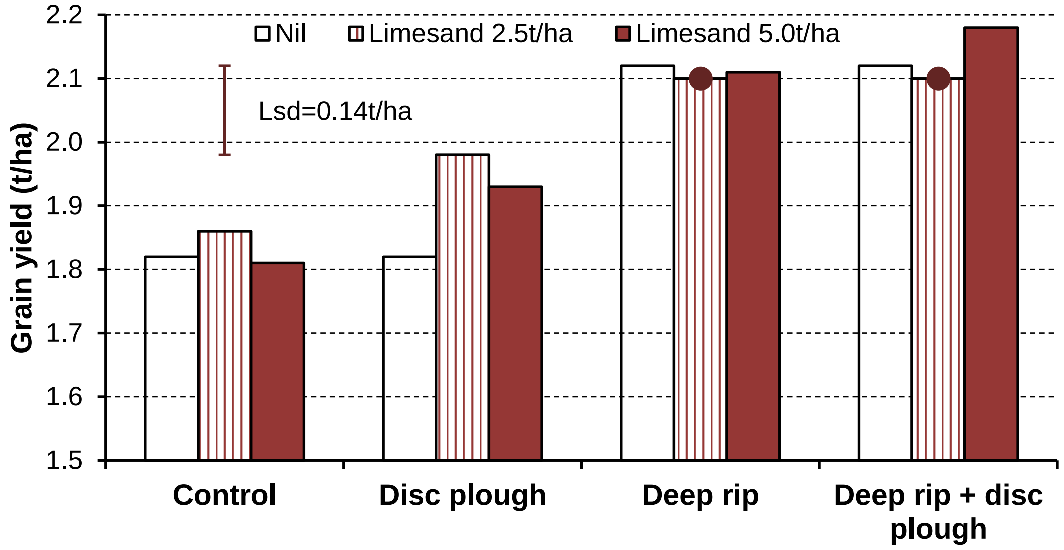

Figure 2: Effect of various treatments on wheat grain yield grown on multiple constraints yellow deep sand during 2017 growing season.

Conclusion

Improved plant growth and crop grain yield were observed in acidic yellow deep sand consecutively for 2 years as a result of deep ripping. Recent research has shown that there are potentially yield benefits from deep ripping of canola, lupins and barley across the Western Australian grainbelt (Pathan et al. 2017; Blackwell et al. 2016; 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 (Pathan et al. 2017).

Initial responses in this work are more related to deep ripping than limesand. It is known surface applied lime takes many years to ameliorate the subsoil acidity (Davies et al. 2015) and lime is required to manage subsoil acidity in the long term. Thus, alleviating subsoil compaction needs to be considered while ameliorating acidic yellow deep sand with limesand. 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 limesand with appropriate deep tillage will potentially minimise multiple soil constraints and offer better return on investment in the longer term. Some growers are modifying ‘one-way’ ploughs using fewer and larger discs to provide greater working depth with greater soil inversion. This sort of deep tillage enables better incorporation of the limesand particles and greater contact with the acidic soil.

Key words

Subsoil acidity, compaction, deep ripping, limesand, wheat

References

Blackwell P, Isbister B, Riethmuller G, Barrett-Lennard E, Hall D, Lemon J, Hagan J and Ward P. (2016). Deeper ripping and topsoil slotting to overcome subsoil compaction and other constraints more economically: way to go! 2016 GRDC Grains Research Update, Perth WA.

Davies S, Gazey C, Parker W, Blackwell P, Riethmuller G, Wilkins A, Negus P, Hollins T, Gartner D and Lefroy W. (2015). Lime incorporation into acidic subsoils – assessing cost, efficacy, value and novel approaches. 2015 Agribusiness Crop Updates, Perth WA.

Hall D and Shea G. (2016). Preliminary results from tillage and lime effects on acidic sands. 2016 GRDC Grains Research Update, Perth WA.

Pathan S, Hall D, Riethmuller G, Shea G and Murfit T. (2017). Improve productivity of canola by deep ripping on acidic yellow deep sand in the Western Australian grainbelt. GRDC Grains Research Update, Perth WA.

Petersen E. (2016). Economic analysis of the impacts and management of subsoil constraints. 2016 GRDC Grains Research Update, Perth WA.

Schoknecht N and Pathan S. (2013). Soil groups of Western Australia. Resource Management Technical Report 380, Department of Agriculture and Food, Western Australia.

van Gool, D. (2016). Identifying soil constraints that limit wheat yield in the South-West of Western Australia. DPIRD, Resource Management Technical Report 399

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⚘ Varieties displaying this symbol beside them are protected under the Plant Breeders Rights Act 1994.

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