GRAIN YIELD INCREASES FROM OVERCOMING SUBSOIL COMPACTION AND ACIDITY

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AIM

1. To assess the effectiveness of surface and deep placed lime to overcome subsoil acidity
2. To assess role of deep ripping in overcoming compaction and tramline farming to prevent compaction.

BACKGROUND

The site was established in 2005 on a poor performing acid yellow sandy earth with subsoil acidity and a compacted hardpan. Treatments at the site included combinations of deep ripping with and without surface applied or deep banded lime. Deep placement of lime was achieved by delivering limesand from a modified airseeder bin into the subsoil via delivery boots attached to the tynes of an Agrowplow shallow leading tyne (SLT) deep ripper. This setup was able to simultaneously deep rip to 30cm and place a total of 2.5 t/ha of limesand at depth distributed at 10, 20 and 30cm. A further treatment placed a total of 5t lime/ha in two passes at 10, 20 and 30cm in the first pass and at 30, 40 and 50cm in the second pass. Tyne spacing on the deep ripper was 45cm.

TRIAL DETAILS

Property	Brian & Tracy McAlpine, Maya
Plot size & replication	1.8m x 60m x 4 replicates
Soil type	Acid yellow sandy earth
Sowing date	28/05/08
Seeding rate	60 kg/ha Wyalkatchem wheat
Fertiliser	28/05/08: 70 kg/ha Agflow Post emergent: 50 L/ha Flexi-N
Paddock rotation	2005 = Wheat, 2006 = Pasture, 2007 = Pasture
Herbicides	Pre-seeding: 35 g/ha Logran; 1.5 L/ha Treflan Post-emergent: 300 mL/ha Tigrex + 300 mL/ha MCPA
Growing Season Rainfall	210mm (May-Oct, Buntine)

RESULTS

Root growth was assessed on 31 July 2008, about two months after sowing using soil pits in selected treatments. The most obvious and biggest effect on root growth was from deep ripping with preferential root growth down the deep rip lines (table 1). Where there was no ripping root growth was considerably reduced beyond a depth of 15cm, with roots either absent below this depth or at very low density. This 15-30cm depth corresponds to the peak in soil strength as a result of compaction (figure 1) and also with strongly acid subsoil with a pH_{Ca} = 4.1 (figure 2).

Table 1: Proportion of observations containing roots on soil pit face overlain by a 10x10 cm grid for Wyalkatchem wheat measured 31/7/08 (64 days after sowing). Observations were made in the rip line (Rip), on the edge of the rip line and in between (No Rip) the deep ripping lines.

Depth (cm)	**Proportion of observations containing roots (%)**		
	No Rip	Edge of Rip	Rip
0-10	100	100	100
10-20	92	100	100
20-30	54	92	100
30-40	14	38	90

Soil strength was also measured for all 2005 treatments using a cone penetrometer to measure soil penetration resistance (figure 1). For the unripped control plots soil compaction, with a penetration resistance > 2.0 mega pascals (MPa), was measured at a depth of 10-30cm (figure 1). The deep ripped soil had very low soil penetration resistance ~0.5 MPa. This is lower than the soil penetration resistance in a remnant vegetation area nearby with undisturbed soil. Soil penetration resistance directly under a tramline was very high (>2.0MPa) from 8-55cm (figure 1), highlighting the extent of compaction possible with repeated wheeling of agricultural machinery. Restricting traffic to tramlines has prevented re-compaction of deep ripped soil and maintained the deep ripping benefit.

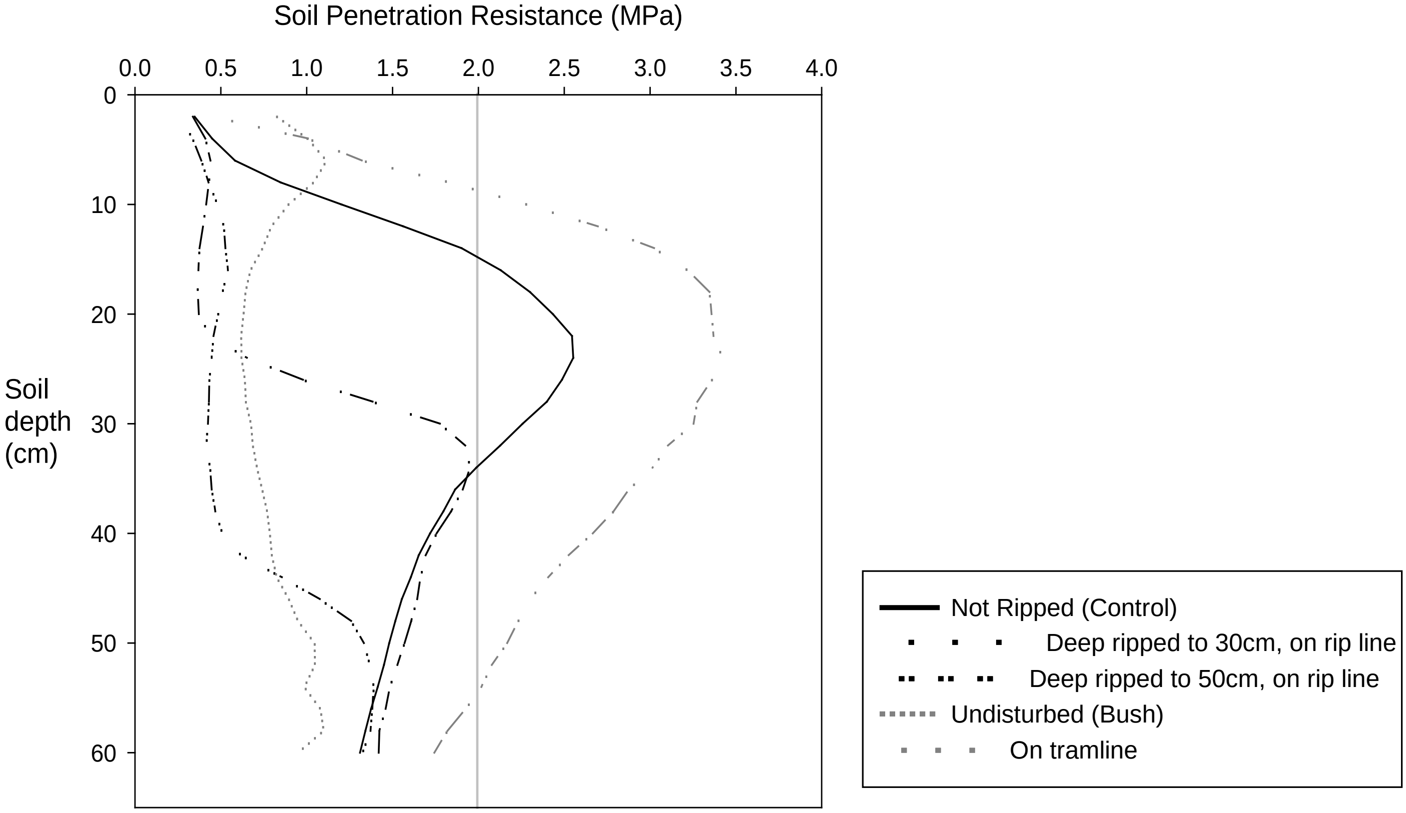

Figure 1: Soil penetration resistance for soils deep ripped to 30cm or 50cm in 2005 compared with unripped control, on top of a tramline (wheel track), and in a nearby undisturbed soil in remnant vegetation (bush) area, measured 31/7/08 with the soil at field capacity.

Soil samples for measurement of pH and extractable aluminium were also collected on 31 July 2008 for all 2005 treatments and both on and off deep rip lines, where applicable (figure 2). The subsoil at the site is strongly acidic with pH of 4.2 or less. It is also aluminium toxic with an extractable aluminium concentration of 6 mg/kg or more at 10-20cm and >15 mg/kg at 20-30cm (figure 2). Application of surface lime, even with post-application ripping, has had no significant effect on subsoil pH and extractable aluminium thus far. Deep placed lime has increased the subsoil pH and reduced the extractable aluminium levels. However, the distribution of lime is uneven through the profile and limed seam quite narrow making accurate soil sampling difficult.

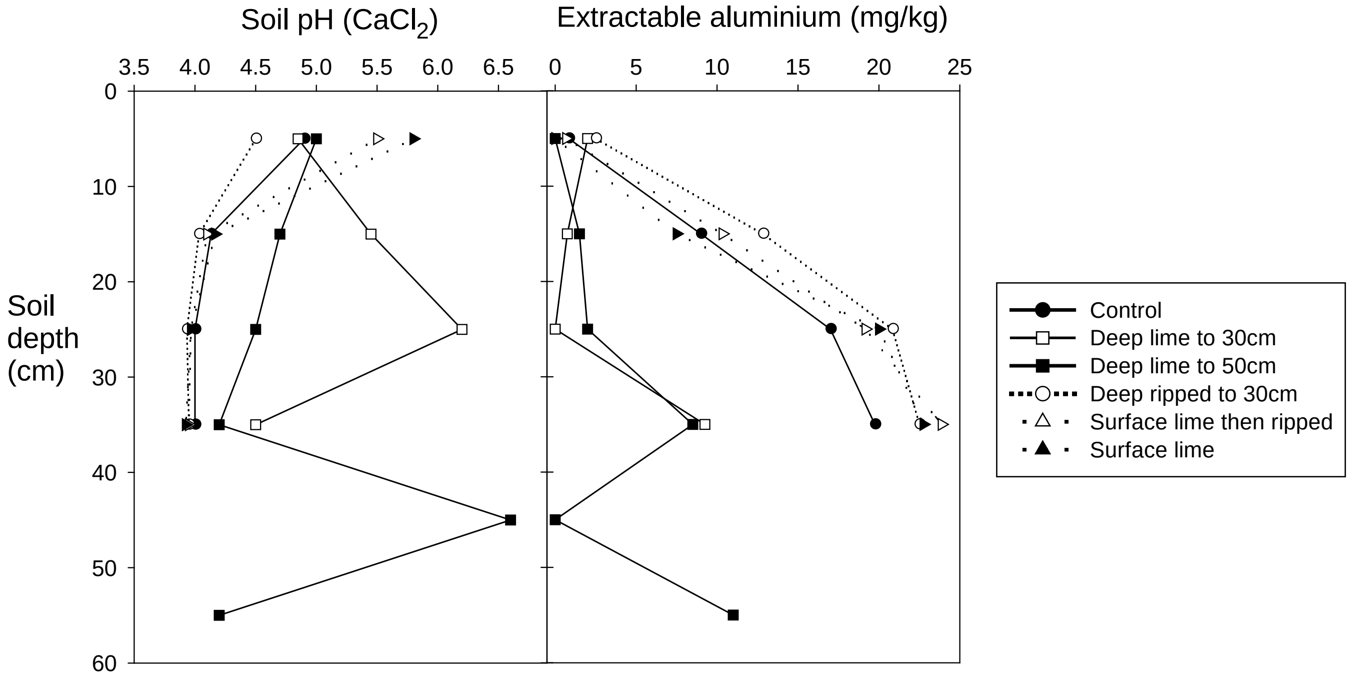

Figure 2: Soil pH ($CaCl_2$) and extractable aluminium from core samples taken 31/7/08 of selected treatments. Data from deep lime and deep ripped treatments were taken on the rip line.

Table 2: Grain yield, quality and returns from Wyalkatchem wheat, harvested 27/11/08 to various deep ripping and deep lime treatments applied in 2005.

2005 Treatment	Yield (t/ha)	Protein (%)	Screenings (%)	Hectolitre Weight (kg/hL)	Grade	Gross Return[1]	Variable Costs[2]	Gross Margin
Control	2.46	10.9	2.4	81	APW2	612	95	516
2.5 t/ha surface lime	1.85	11.6	3.7	77	APW2	457	114	343
2.5 t/ha surface lime then ripped to 30cm	2.35	11.5	3.1	79	APW2	588	123	465
Deep ripped to 30cm	2.58	11.5	2.5	80	APW2	645	104	541
2.5 t/ha deep lime to 30cm	2.73	11.6	2.8	80	APW2	683	123	560
Deep ripped to 50cm	2.77	10.9	2.4	80	APW2	689	113	575
5 t/ha deep lime to 50cm	3.34	10.7	1.6	82	APW2	825	150	675
LSD (0.05)	0.65	0.7	1.1	2				

[1]Based on EPR on 31/12/08 for APW $338/tonne (AWB Western Pool No. 1) less estimated wheat selling costs.
[2]Includes fertiliser and herbicide costs based on 2008 prices and also includes estimated 2005 liming costs (estimated using Optlime v2008-1.4, contact Chris Gazey DAFWA, Ph: (08) 9690 2000) amortised over 5 years.

The only significant yield response in 2008 was for the deep ripping and deep liming to 50cm treatment which yielded 36% (880 kg/ha) more than the untreated control (table 2). The deep lime to 50cm treatment had lower protein than some of the other deep ripping and lime treatments due to dilution of the grain protein as a consequence of the higher grain yield (table 2). Screenings were lowest and hectolitre weight the highest for the deep lime to 50cm treatment (table 2) despite the higher yield indicative of the improved access to subsoil moisture the crop had with this treatment. Estimates of 2005 liming costs, both surface applied and deep banded were determined and amortised over five-years. This is a conservative estimate given that surface applied lime has been shown to provide a benefit for 12 or more years (Davies *et al.* 2008). These costs were added to the other variable costs. On this basis the combination of deep ripping and deep lime to 50cm to overcome the subsoil acidity and compaction constraints is highly profitable with an estimated gross margin benefit of $159/ha more than the control. Surface applied lime with and without deep ripping is yet to show any benefit at this site which highlights how difficult it can be to ameliorate severe subsoil acidity with surface lime applications.

COMMENTS

- The 2008 result is very similar to that achieved in 2005, the year the experiment commenced, in which both the deep ripping to 50cm with lime and without lime yielding 3.3 t/ha compared to 2.5 t/ha for the control, a yield increase of 800 kg/ha (Gazey and Gartner 2006). This suggests that in reasonable seasons the benefits from this amelioration treatment are robust.

- Grain yield responses to deep ripping and lime at this site in 2008 were dependent on the depth of amelioration with the biggest response when the soil was deep ripped and limed to 50cm rather than 30cm. The unripped soil at the site is compacted to a depth of 30cm but strongly acidic to depth of 40cm or more, hence the need for deeper amelioration. This suggests that for some sites affected by subsoil acidity and compaction a greater depth of the profile needs to be ameliorated before large productivity responses are seen. This is both technically difficult and expensive. The shallow leading tyne ripper used in this trial has several tynes operating at shallower depths ahead of and in line with the main ripping tyne which can significantly reduce draft compared to a normal ripper (Hamza and Riethmuller 2005).

- Significant responses have been shown at other sites with surface lime treatments and deep ripping to 30cm so using test strips to test responsiveness of a soil to these more treatments is a good option. The best strategy remains to prevent subsoil acidity with regular liming and minimise compaction by using a controlled traffic (tramline) farming system where possible. Penetrometer results from this site demonstrated the benefits of tramline farming for preventing re-compaction of ripped soil and confining compaction to the tramline. These benefits from ameliorating both the compacted hardpan and subsoil acidity are likely to continue to be present into the future.

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