Deep incorporation of lime into acidic subsoils

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Purpose:	To assess amelioration of subsoil acidity using a range of tillage methods for incorporating surface applied lime into acidic subsoils and the impacts of tillage and lime on crop productivity.
Location:	Peter Negus, "Cooligee", Dandaragan Rd, Dandaragan
Soil Type:	Deep yellow sand
Soil Test Results:	Indicative soil pH ($CaCl_2$): 0-10cm = 5.3; 10-20cm = 4.3; 20-30cm = 3.9

BACKGROUND SUMMARY

Subsoil acidity is a major constraint to crop and pasture root growth and productivity. Recent soil pH surveys In the West Midlands showed that 57% of 0-10 cm samples were below the target pH of 5.5 while in the subsurface layers 40% of 10-20 cm samples and 50% of 20-30 cm samples were below the subsoil pH target of 4.8 (Gazey et. al. 2013). Typically it can take 3-5 years for surface applied lime to significantly increase the pH of the 10-20 cm layer and even longer to increase the pH of the 20-30 cm layer. Given the extremely low soil pH in many subsoils mechanical incorporation of surface applied lime using strategic tillage is seen as a way of more rapidly correcting subsoil acidity.

TRIAL DESIGN

Plot size: 20m x 4m

Design: Randomised complete block strip-plot design

Repetitions: 4

Machinery use: A range of tillage treatments to incorporate surface applied lime including: Scarifier; Offset discs; One-way plough; Deep ripper; Rotary spader; Mouldboard plough. In addition a combined treatment of deep ripping followed by spading was also included.

Crop type and varieties used: Baudin barley

Seeding rates and dates: 90 kg/ha 13 July 2013 (first seeded on 22 May 2013 then sprayed out re-seeded 13 July due to extensive white cockatoo damage)

Fertilizer rates and dates: Gusto 100 kg/ha at seeding + 90 L/ha UAN top up post seeding; 40 L/ha Flexi-N and 150 mL/ha Prosaro on 22 August 2013.

TRIAL LAYOUT

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Tillage	0 t/ha Lime	5 t/ha Lime	3 t/ha Lime	
Rip+Spade	1	2	3	4m wide
Control	4	5	6	
Spader	7	8	9	
Mouldboard	10	11	12	
Offsets	13	14	15	
Deep rip	16	17	18	
Scarifier	19	20	21	
One-way	22	23	24	
	20m	20m	20m	
				10 mts
	3 t/ha Lime	0 t/ha Lime	5 t/ha Lime	
Spader	25	26	27	
One-way	28	29	30	
Deep rip	31	32	33	
Control	34	35	36	
Rip+Spade	37	38	39	
Scarifier	40	41	42	
Offsets	43	44	45	
Mouldboard	46	47	48	
				10 mts
	5 t/ha Lime	3 t/ha Lime	0 t/ha Lime	
Control	49	50	51	
Scarifier	52	53	54	
Deep rip	55	56	57	
Mouldboard	58	59	60	
Spader	61	62	63	
One-way	64	65	66	
Rip+Spade	67	68	69	
Offsets	70	71	72	
				10 mts
	3 t/ha Lime	0 t/ha Lime	5 t/ha Lime	
Deep rip	73	74	75	
Offsets	76	77	78	
Control	79	80	81	
Rip+Spade	82	83	84	
One-way	85	86	87	
Spader	88	89	90	
Mouldboard	91	92	93	
Scarifier	94	95	96	
		15 metres from fence		

RESULTS

The site was initially sown on the 22 May 2013 but due to extensive white cockatoo damage the remaining plants were sprayed out and the site re-seeded on 13 July 2013. Small seedlings in loose tilled soil can easily be pulled out by white cockatoos.

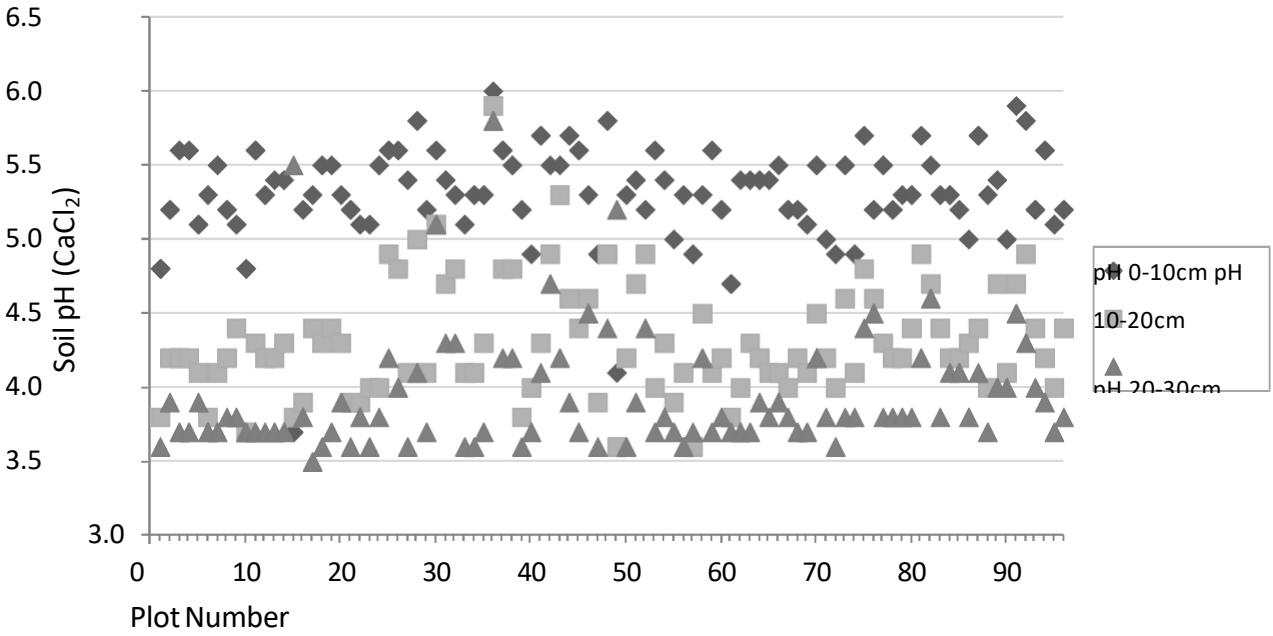

Figure 1. Soil pH ($CaCl_2$) measures on trial plots for the 0-10, 10-20 and 20-30 cm layers prior to application of lime and tillage treatments.

Soil pH was measured for each of the 96 plots at the site prior to lime application and incorporation (Fig. 1). Subsoil acidity was common throughout the site. From the plot pH measures 75% of the 10-20 cm samples and 94% of the 20-30 cm samples had a pH less than 4.5 furthermore 69% of 20-30 cm samples had a pH below 4.0 (Fig. 1).

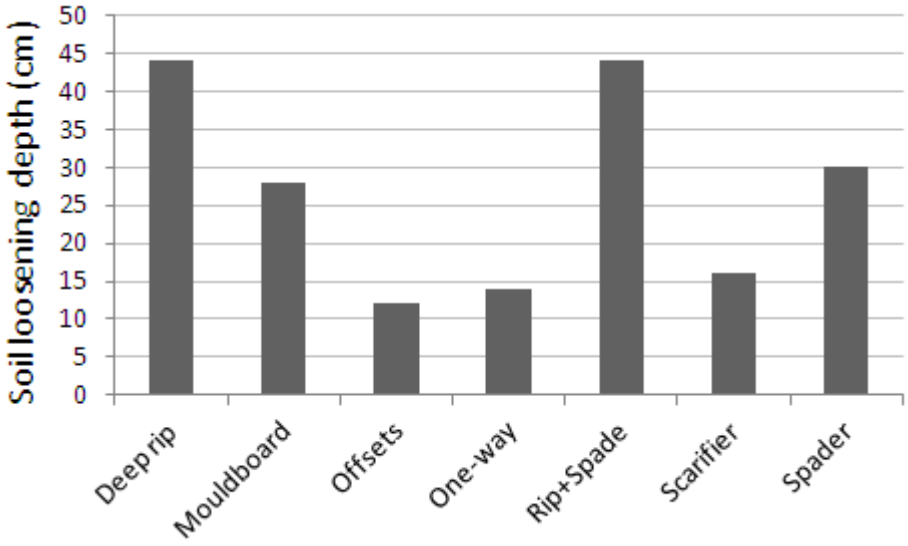

Figure 3. Maximum average soil loosening depth (cm) for a range of tillage implements.

A soil penetrometer was used to assess the loosening depth (Fig. 2) of the tillage treatments and soil strength (Table 1). The loosening depth gives an indication of the likely lime incorporation depth although deep ripping is unlikely to incorporate lime to the full loosening depth. Rotary spading and mouldboard ploughing are capable of incorporating some lime into the 20-30 cm layer, while one-way ploughing, scarifying and offset discs can incorporate lime to into the 10-20 cm layer with loosening depths of 12-15 cm (Fig. 2). Soil strength data indicates that the site had moderate to strong compaction in the 20-40 cm layers (Table 1). Deep ripping effectively removed compaction to

a depth of 40 cm while rotary spading and mouldboard ploughing removed compaction to a depth of just over 25 cm (Fig. 2, Table 1).

Table 1. Soil penetration resistance at 10, 20, 30 and 40 cm for untilled control and a range of tillage treatments.

Tillage treatment	Soil Penetration Resistance (MPa)			
	@10 cm	@20 cm	@30 cm	@40 cm
Untreated	1.0	1.9	2.2	2.7
Deep rip	0.3	0.3	0.6	2.0
Mouldboard	0.4	0.7	2.5	2.9
Offsets	0.7	1.7	2.6	2.7
One-way	0.6	2.1	3.2	2.9
Rip+Spade	0.3	0.4	0.9	2.2
Scarifier	0.8	1.9	2.7	2.6
Spader	0.4	0.5	2.2	2.5

Barley establishment at the site ranged from around 150-180 plants/m^2 and there was no significant impact of lime or tillage on crop establishment (data not shown). If anything there was a small trend towards higher establishment in some of the tillage treatments but the difference was not large. There is mild water repellence at the site but in 2013 this was not severe enough to cause large differences in crop establishment.

Barley grain yields at the site were high with yields across all treatments ranging from 4.5-5.3 t/ha (Fig. 3). In 2013 neither lime application or cultivation had any significant impact on final grain yield (Fig. 3). Visually the plots that had been spaded or mouldboard ploughed appeared to have greater biomass and were more even than the untreated control or scarified plots but this did not translate into higher yields. There may be a number of possible factors contributing to the lack of yield response in the 2013 season including:

- Good (soft) finish to the season allowed those plots which did not have lime added to still yield to potential
- It was observed that powdery mildew was worse on the bulkier deep cultivated plots and this may have negated the benefits of cultivation
- Variability in soil pH has been observed across the site associated with trees that were once present, these areas and old tree root systems can act as pathways for roots and may negate some of the lime benefit.

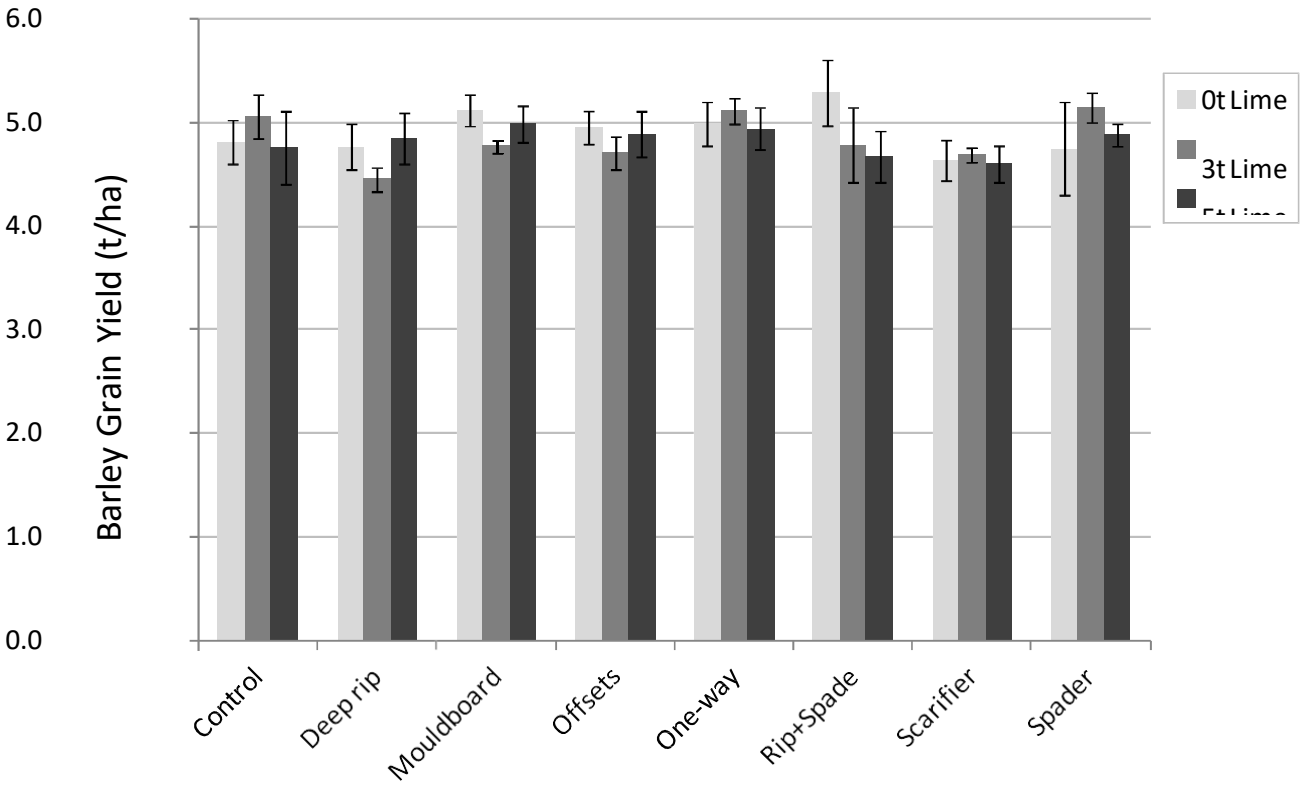

Figure 3. Grain yield of Baudin barley in response to lime application and soil incorporation methods.

DISCUSSION

Soil pH results after liming and tillage treatments were applied was found to be quite variable and more sampling needs to be done before pH results can be quoted. Soil loosening indicates that only the deep tillage techniques were likely to incorporate lime into the deeper 20-30 cm acidic layer. Observations of lime incorporation lime in small soil pits at the field using universal pH indicator indicated that:

- rotary spading had done a good job of incorporating lime,
- mouldboard ploughing had buried lime in a layer at depth and there appeared to be some additional movement of lime but lime distribution above the buried topsoil was poor
- deep ripping incorporated small amounts of limed topsoil if it falls behind the deep ripping tynes as they pass through the soil
- one way ploughing and offset discs incorporated lime evenly but only through the top 12-15cm , incorporation below 10 cm with the scarifier was minimal

This trial highlights the importance of measuring subsoil pH levels and applying sufficient rates of lime to prevent and correct subsoil acidification. Where tillage treatments are used to incorporate lime it is important to understand to what depth lime will be incorporated and which subsoil layers need correction. It is intended to monitor this trial for the next few years to further assess the benefits of correcting subsoil acidification. Yield response to lime incorporation can increase over time as the untreated soil continues to acidify further and as lime has more opportunity to react and neutralize the acidity that is present.

REFERENCE

Gazey C, Andrew J, and Griffin E (2013). ‘Soil acidity’. In: Report card on sustainable natural resource use in agriculture, Department of Agriculture and Food, Western Australia.

PEER REVIEW

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