Can subsoil constraints be combated economically?

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Purpose: To determine which ameliorant practice is the most effective and economic in remediating subsoil acidity at depth.

Location: West Wubin

Soil Type: Yellow Tammin sand

Soil Test Results: See Table 1

Rotation: 2012 wheat, 2013 wheat, 2014 fallow

Growing Season Rainfall (April- October 2015): 288mm

BACKGROUND SUMMARY

It is estimated that more than 14.25 million hectares in the Western Australian Wheatbelt is acidic or at risk to become acidic (Gazey et al, 2014) making acidity one of the major limiting production factors to modern day faming systems. In monetary terms this is estimated to cost the agricultural industry $498 million equating to 9% of WA's annual crop (Herbert, 2009).

Soil acidity is a natural process however; modern farming systems accelerate the process through production (Gazey, P, 2015). Two of the main contributing factors to soil acidification in broadacre cropping systems is the use of ammonium based fertilisers and the export of alkaline products in the form of crop (Gazey & Ryan, 2015).

Aluminium toxicity is one of the major subsoil constraints that are clearly linked to soil acidity. Elevated levels of aluminium in the soil lead to root pruning resulting in decreased crop growth and yield. Generally aluminium toxicity will be an issue if your soil pH is ≤ 4.3 (Gazey & Ryan, Oct 2015). As a consequence, lime has been one of the major inputs in broadacre farming over the last 20 years, with 100% of Liebe members liming in 2012 (Hollamby, 2012).

This trial was designed by a project committee of Liebe members in an effort to determine the most effective liming strategy to undertake to maximise the return on investment in the Liebe region. The trial is located west of Wubin on a poor performing paddock that has the potential to improve once subsoil constraints have been addressed. The trial site was chosen for its uniform soil type and its obvious soil acidity issues. A target pH of 5.5 to a depth of 300mm was identified and entered into the Liebe Group's Lime Calculator along with the baseline soil pH results. The lime calculator generated a recommendation for lime rates required to achieve the given target pH of 5.5. Dolomite has a lower neutralising value than limesand therefore; more product is required to reach the target pH of 5.5, see trial details.

Incorporation techniques under investigation are spading and deep offset discs. Rotary spaders are the most effective type of cultivation for incorporating lime (Davies et al, 2015). Spaders mix and invert the soil to a depth of 25-30cm ensuring good incorporation of liming products through the profile (Davies, 2010). This mixing action is not even throughout the profile however, it does increase contact between the lime and the acidic soil giving a rapid response rate (Gazey et al, 2014).

Large offset discs (Tiny Grizzly discs) are an effective cultivation method that mixes well to a working depth of 30-35cm however, some layering occurs due to the angle of the discs

(Davies et al, 2015). This can result in the lime becoming concentrated in the soil throw between the furrows (Parker, 2015).

An automated weather station and moisture probes have been installed at the site to monitor the impacts of spading against the control treatments, giving further insight into cultivation methods and their effect on water use efficiency (WUE).

TRIAL DESIGN

Plot size: 11.65m x 14m

Repetitions: 4

Crop type and varieties used: Wheat cv. Calingiri

Seeding rates and dates: 01/05/2015: 62 kg/ha

Fertilizer rates and dates:
01/02/2015: 35kg/ha DAPSZC
16/07/2015: 40 kg/ha urea
15/08/2015: 20 L/ha UAN

Herbicide & fungicide rates and dates:
01/05/2015: 2 L/ha Glyphosate 450, 2 L/ha Trifluralin 480, 0.3% SP 700 Surfactant, 200 mL/ha LV Ester 680, 200 mL/ha Chlorpyrifos 500EC
16/07/2015: 850 mL/ha Diflufenican & Bromoxynil, 400 mL/ha MCPA 570, 150 mL/ha Tebuconazole 430

Other applications/ treatment rates and dates:

Lime History
2009: 1 t/ha lime
2014: 1.5 t/ha lime
2015: 3.2 t/ha Lime only plots, 3.4 t/ha Dolomite only plots, 1.65 t/ha each Lime & Dolomite plots

Incorporation
23/02/2015: Tiny Grizzly (36 inch discs)
05/03/2015: Spader

Treatment #	Treatment /Incorporation	Treatment /product	Rate t/ha
1	Untreated	Untreated	0
2	Spaded	Untreated	0
3	Grizzly	Untreated	0
4	Untreated	Lime	3.2
5	Spaded	Lime	3.2
6	Grizzly	Lime	3.2
7	Untreated	Dolomite	3.4
8	Spaded	Dolomite	3.4
9	Grizzly	Dolomite	3.4

10	Untreated	Lime +Dolomite	1.65 (Ratio 1:1)
11	Spaded	Lime + Dolomite	1.65 (Ratio 1:1)
12	Grizzly	Lime + Dolomite	1.65 (Ratio 1:1)

Osborne Road

Rep 4	Rep 3	Rep 2	Rep 1
5 412	7 301	6 212	1 101
4 411	12 302	4 211	2 102
6 410	4 303	10 210	3 103
3 409	6 304	7 209	4 104
1 408	3 305	11 208	5 105
10 407	8 306	12 207	6 106
11 406	5 307	8 206	7 107
2 405	9 308	3 205	8 108
7 404	10 309	2 204	9 109
9 403	2 310	5 203	10 110
12 402	1 311	9 202	11 111
8 401	11 312	1 201	12 112

Sander

EASTERN FENCE LINE

14m

5m

11.65m

61.6m

RESULTS/STATISTICS

Limesand was applied to the paddock on two occasions prior to the trial being implemented in 2009 (1 t/ha) and 2011 (1.5 t/ha). From the baseline soil results in Table 1 it can be observed that this lime has not moved through the profile and is still sitting in the 0-5cm layer of topsoil.

Table 1: Baseline results for selected soil properties (0-40cm) collected prior to treatments being imposed at the trial site February 2015

Depth (cm)	EC (dS/m)	pH ($CaCl_2$)	Organic Carbon (%)	NH_4 (mg/kg)	$N0_3$ (mg/kg)	Phosphorus Cowell (mg/kg)	Potassium Cowell (mg/kg)	Sulphur (mg/kg)	Aluminum (meq/100g)
0-5	0.104	5.9	0.79	3	23	38	42	15.4	0.12
5-10	0.048	4.6	0.71	1	13	36	24	9.7	0.24
10-20	0.029	4.2	0.36	1	7	16	22	11.6	0.42
20-30	0.025	4.4	0.28	1	5	6	17	19.4	0.34
30-40	0.025	4.7	0.16	2	4	3	18	24.7	0.24

In the first year since the trial was implemented the lime treatments showed no significant results. Both Spader and Grizzly treatments had significantly higher hectolitre weight than the Control (no till) treatment.

Table 2: Effect of lime treatments on yield and quality at west Wubin in 2015

Treatment Number	Lime Treatment	Yield (t/ha)	Protein (%)	Screenings (%)	Hectolitre (kg/hl)	Grade
1	Control	2.0	10.2	1.6	78.2	ANW1
4	Limesand	2.2	10.3	1.7	77.7	ANW1
7	Dolomite	2.0	10.4	1.6	78.7	ANW1
10	Lime & Dolomite	2.0	10.3	1.6	77.8	ANW1
LSD		*0.31*	*0.23*	*0.45*	*0.85*	
CV (%)		*18.3*	*2.7*	*34.6*	*1.3*	
P value		*0.43*	*0.34*	*0.61*	*0.11*	

Table 3: Effect of tillage treatments on yield and quality at west Wubin, 2015

Treatment Number	Tillage Type	Yield (t/ha)	Protein (%)	Screenings (%)	Hectolitre (kg/hl)	Grade
1	No Till	2.0	10.1^a	1.7	76.96^b	ANW1
2	Spader	2.0	10.3^a	1.6	78.73^a	ANW1
3	Grizzly	2.2	10.6^b	1.4	78.63^a	ANW1
LSD		*0.27*	*0.20*	*0.39*	*0.73*	
CV (%)		*18.3*	*2.7*	*34.6*	*1.3*	
P value		*0.501*	*<0.001*	*0.18*	*<0.001*	

Table 4: Interaction of cultivation and lime on yield and quality results for Calingiri wheat at west Wubin, 2015

	Lime Treatment	Tillage Type	Yield (t/ha)	Protein (%)	Screenings (%)	Hectolitre (kg/hl)	Grade
1	Control	No Till	1.8	10.0	2.1	77.0	ANW1
2	Control	Spader	1.8	10.2	1.6	79.2	ANW1
3	Control	Grizzly	2.4	10.5	1.3	78.3	ANW1
4	Limesand	No Till	2.2	10.1	1.5	76.8	ANW1
5	Limesand	Spader	2.2	10.2	1.3	78.5	ANW1
6	Limesand	Grizzly	2.2	10.4	1.4	77.9	ANW1
7	Dolomite	No Till	2.3	10.1	1.4	77.0	ANW1
8	Dolomite	Spader	1.9	10.4	2.2	79.5	ANW1
9	Dolomite	Grizzly	1.9	10.7	1.4	79.5	ANW1
10	Lime & Dolomite	No Till	1.8	10.1	2.0	77.0	ANW1
11	Lime & Dolomite	Spader	2.1	10.2	1.4	77.7	ANW1
12	Lime & Dolomite	Grizzly	2.1	10.7	1.5	78.7	ANW1
LSD			*0.55*	*0.40*	*0.78*	*1.47*	
CV (%)			*18.3*	*2.7*	*34.6*	*1.3*	
P value			*0.16*	*0.94*	*0.17*	*0.38*	

Table 5: Crop establishment at west Wubin, 2015

Treatment	**Crop establishment (plant/m^2)**		
	Grizzly	**No Till**	**Spader**
Dolomite	7	26	8
Lime Sand	8	18	9
Lime/Dolomite	9	25	10
Control	8	22	8

FINANCIAL ANALYSIS OF RESULTS

The Control/Grizzly treatment has given the greatest gross return at $688/ha, returning a net margin of $468/ha. The lowest average net margin was from the dolomite/spader treatment returning $230/ha in the first year (Table 6).

The treatment with the highest rate of return was the dolomite/no till at 661% while the lowest was the control/no till treatment at 0% (Table 6).

Table 6: Economic analysis of different soil ameliorant treatments at west Wubin, 2015

Treatment Number	Lime Treatment	Tillage Type	Average Gross Return ($/ha)	Average Variable Cost ($/ha)	Average Net Margin ($/ha)	Average Return on Treatment Investment (%)
7	Dolomite	No till	659	203	456	661
4	Lime Sand	No till	632	217	415	459
3	Control	Grizzly	688	220	468	451
10	Lime/Dolomite	No till	519	227	292	247
2	Control	Spader	529	255	274	129
6	Lime Sand	Grizzly	648	302	346	117
12	Lime/Dolomite	Grizzly	614	312	302	79
9	Dolomite	Grizzly	539	288	251	73
5	Lime Sand	Spader	645	337	308	59
11	Lime/Dolomite	Spader	613	347	266	31
8	Dolomite	Spader	553	323	230	28
1	Control	No till	511	135	377	0

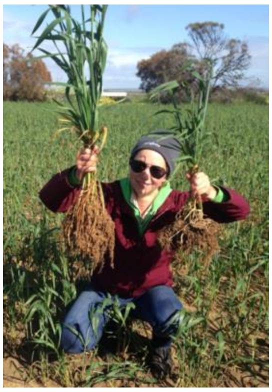
Note: Grain prices based on AWB prices for the Kwinana Zone on the 19 November 2015, ANW1 $288.
Costs taken into account; fertiliser, chemical, cultivation, lime ($7/t), dolomite ($26/t) and cartage. Cultivation cost based on an average contractor rate of $85/ha (Grizzly) $120/ha (Spader). Cartage cost based on contractor rate of $10/t dolomite (Watheroo) and $21/t limesand (Greenhead). Spreading of lime treatments based on contractor rate of $8/ha. Cost of spraying, seeding and harvest not taken into account. Cost of lime applied prior to trial being implemented not taken into account. ROI % based on treatment 1 (control/no till) set at 0%.

OBSERVATION/ DISCUSSION/ MEASUREMENTS

Prior to treatments being imposed aluminium toxicity was visually identified as a constraint by digging up plants and examining the roots. It was evident from the roots sideways growth that root pruning was occurring, affecting plant growth by limiting access to nutrients and water. Compaction was thought not to be an issue as it was possible to push a 1cm rod to a depth of 140cm by hand.

When the Grizzly treatments were being implemented it was difficult to have an even depth throughout the plot due to plot size. The discs were only achieving maximum depth (30-35cm) in the centre of the plot however; the average depth achieved within the plot was 25-30cm.

At seeding it was difficult to establish an even seed bed which led to uneven germination in both the Spaded treatments and the Grizzly treatments. This resulted in these treatments having lower plant establishment numbers over the no till (Control).



Throughout the season it was visually evident that the incorporation treatments had major effects on crop growth and health. The Grizzly and spaded treatments had better vigour and larger head sizes when compared to the control treatments. This is likely due to the lower plant numbers, leading to less competition for water and nutrients in the cultivated plots. Although this didn't translate to significant yield increases in the first year, the second year of the trial is expected to show more as the seeding bed will have settled allowing for an even germination.

Figure 1: Wheat grown at west Wubin 2015, Grizzly treatment (Left side) and No till treatment (Right side)

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PEER REVIEW/REVIEW

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Soil acidity management strategies throughout Western Australia are available for download from:
http://www.liebegroup.org.au/working-together-to-deliever-multiple-benefit-messages-to-growers-through-a-whole-systems-approach-to-soil-management/

Free for download Liebe Lime Calculator: http://www.liebegroup.org.au/lime-profit-calculator/

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