Effect of Lime Incorporation on Soil Nutrient Availability

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Key Messages

- Cultivation with a one-way plough changed soil pH($CaCl_2$) in surface 20cm.
- Incorporating lime at the same time as cultivation had no immediate yield benefit in this trial
- Grain yield lost due to omitting P fertiliser was least in the cultivation + lime treatments, and greatest in the no-till control treatments

Aim

To determine whether a profit can be achieved from incorporating lime in the year it is applied.

Background

Recent work has shown that i) the majority of soils in the WA agricultural zone are below critical levels for soil pH [pH($CaCl_2$) 5.5 0-10cm and pH($CaCl_2$) 4.8 10-20cm], ii) soil pH below 5.5 has a negative effect on soil phosphorus availability and iii) cultivation can increase the availability of soil nutrients. Incorporation of lime with disc ploughs provides an option for rapid amelioration of soil acidity, although cost is a barrier to adoption. If the availability of soil nutrients is improved with ploughing, it is feasible that growers could shift investment from fertilisers to lime and incorporation.

Trial Details

Property	G & H Pearse Pty Ltd, west Wubin
Plot size & replication	20m x 1.54m x 3 replications
Soil type	Deep yellow sand
EC (dS/m)	0-10cm: 0.047 10-20cm: 0.016 20-30cm: 0.016 30-40cm: 0.011
Sowing date	22/05/13
Seeding rate	80 kg/ha Mace wheat
Paddock rotation	2010: canola, 2011: wheat, 2012: lupin
Herbicides	21/05/13: 1.5 L/ha Roundup 22/05/13: 118 g/ha Sakura, 2 L/ha SpraySeed 18/06/13: 300 mL/ha Axial, 0.5% Adigor 02/07/13: 1 L/ha Velocity, 0.5% Hasten
Growing Season Rainfall	228mm

Table 1: Soil Chemical Analysis April 2013

Soil depth (cm)	Organic Carbon (%)	Ammonium Nitrogen (mg/kg)	Nitrate Nitrogen (mg/kg)	Phosphorus Colwell (mg/kg)	PBI	Potassium Colwell (mg/kg)	Sulphur (mg/kg)	pH ($CaCl_2$)	Aluminium ($CaCl_2$)
0-10	0.58	4	18	18	9	37	5	5.2	0.5
10-20	0.21	3	5	19	9	30	3	4.4	4.2
20-30	0.10	2	3	20	12	29	4	4.3	6.4
30-40	0.11	2	2	10	11	31	5	4.5	4.2
40-60	0.07	1	2	<2	11	40	6	4.8	0.6
60-80	0.06	1	1	<2	12	42	6	5.5	< 0.2
80-100	0.16	1	1	7	12	39	7	5.7	7.5

PBI - Phosphorous Buffering Index

Trial Design

The trial was located at the 2013 Liebe Group Main Trial Site. It was a strip plot design: the layout was divided into strips of main treatments and sub treatments were applied to each main treatment.

Main treatments:
1. No-till control
2. Cultivation*
3. Lime sand @ 3 t/ha + cultivation*

* Cultivation was deep ripping to 30 cm + one-way plough

Sub treatments:
1. All nutrients (All)
2. All minus N fertiliser (All-N)
3. All minus P fertiliser (All-P)
4. All minus K fertiliser (All-K)
5. All minus S fertiliser (All-S)
6. Nil fertiliser (Nil)

Nutrient treatments

Phosphorus: 20 kg P/ha drilled as Double Phos (18% P)
Nitrogen: 10 kg N/ha drilled + 10 kg N/ha topdressed at sowing, + 20 kg N/ha topdressed 4 weeks after sowing as urea (46% N)
Potassium: 100 kg K/ha topdressed at sowing as Muriate of Potash (50% K)
Sulphur: 20 kg S/ha topdressed at sowing as Gypsum (17% S)

Results

Soil pH

The cultivation and lime treatments only changed soil pH in the top 20cm of soil (Figure 1). Cultivation decreased soil pH in 0-10cm by 0.8 and increased soil pH in 10-20cm by 0.2 compared to control. Lime + cultivation decreased soil pH in 0-10cm by 0.4 and increased soil pH in 10-20cm by 0.3 compared to control.

Dye staining of pit faces revealed that the one-way plough did not mix the lime evenly through the surface 20cm (not shown here). The lime was mostly located in concentrated bands where the plough had inverted the topsoil.

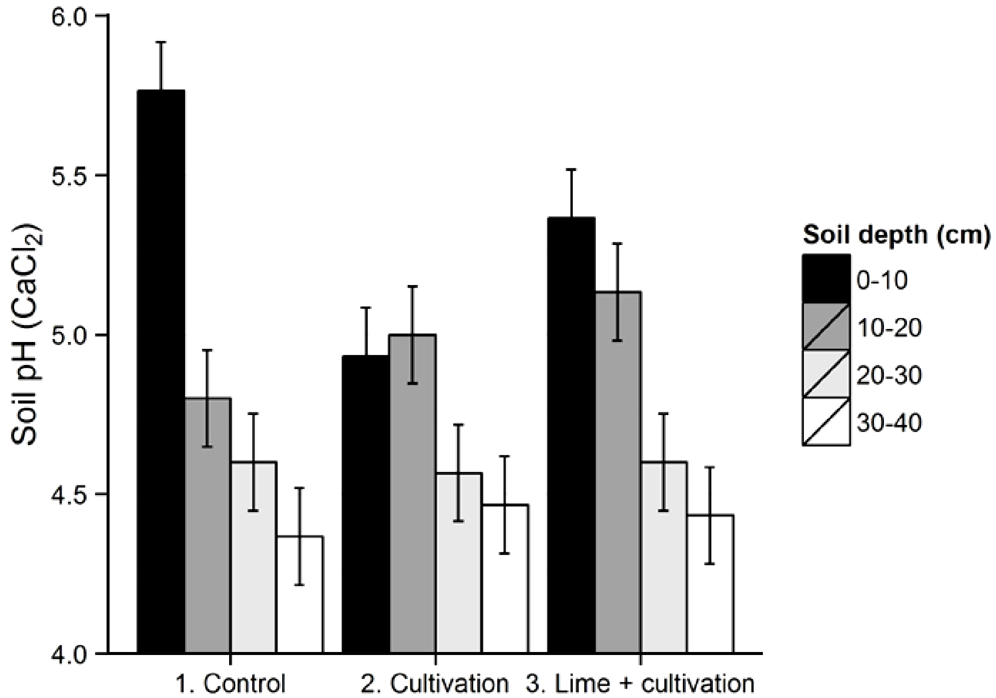

Figure 1: Soil pH profiles measured 8th August (17 weeks after lime application and cultivation).

Grain yield

Cultivation alone led to a statistically significant increase in grain yield, but this was not further enhanced by liming. The mean grain yields for the main treatments (nutrient treatments combined) were 1759, 2168 and 2101 kg/ha for the control, cultivation, and lime + cultivation treatments, respectively. The least significant difference for the main treatments was 169 kg/ha meaning that the cultivation treatments yielded significantly higher than the control, and there was no difference between the cultivation and lime + cultivation treatments.

Nutrient treatment had a significant effect on grain yield. A comparison of mean grain yield for the nutrient treatments (main treatments combined) to the All nutrient treatment showed that the yield difference was greatest in the Nil (-719 kg/ha), followed by All-P (-369 kg/ha), All-N (-325 kg/ha), All-S (154 kg/ha) and All-K (-106 kg/ha).

Cultivation had an effect on the yield lost by omitting P fertiliser. The yield loss of 619 kg/ha from omitting P fertiliser (All compared to All-P) in the control was significant (LSD = 386 kg/ha), while the yield losses due to omitting P fertiliser of 355 kg/ha in the cultivation and 132 kg/ha in the lime + cultivation were not significant. The yield losses from omitting N fertilizser were not statistically significant; 258 kg/ha in the control, 372 kg/ha in the cultivation and 342 kg/ha in the lime +cultivation.

Economic Analysis

Overall, the cultivation treatments were the most profitable (Table 2). The cultivation treatment with Nil nutrients applied had the highest net return of $348/ha. For all nutrient treatments, the net return in the cultivation treatments was higher than the control treatments, showing that the income benefit gained from cultivation was greater than the cost of the cultivation.

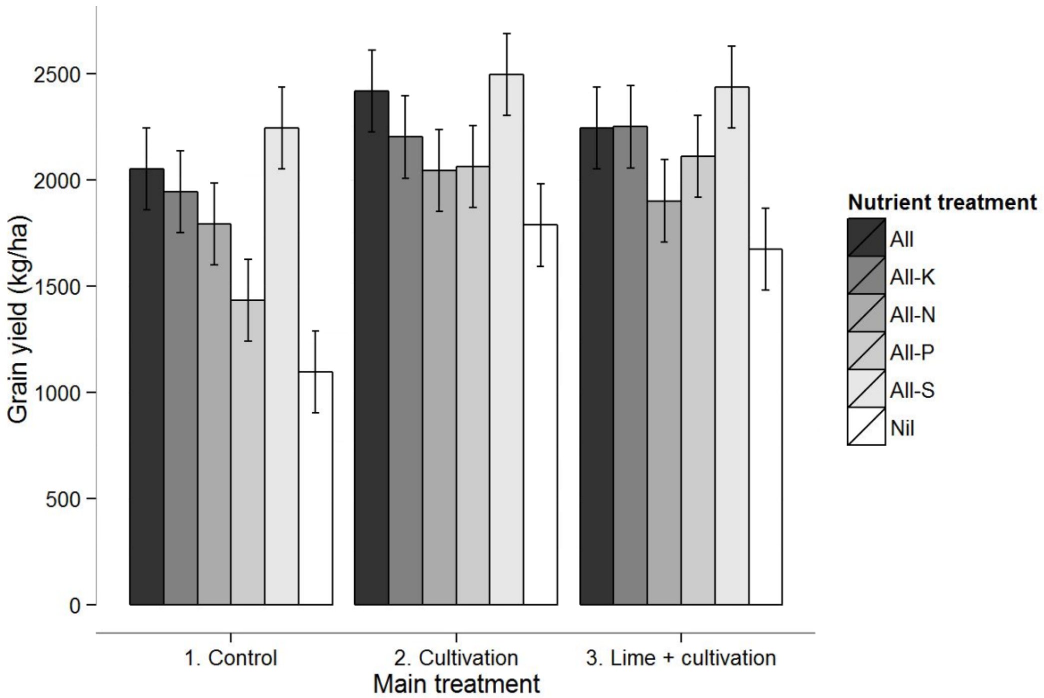

Figure 2: Effect of main treatment and nutrient treatment on grain yield. Error bars are least significant difference. Where error bars do not overlap a statistically significant difference was observed between treatments.

In this trial, incorporating lime was most profitable in the All-K treatment ($239/ha) followed by the Nil treatment ($218/ha). The All-K treatments were the most profitable for each of the main treatments because the yield benefit gained from 100 kg K/ha was not sufficient to cover the cost of the potassium fertiliser. Surface soil K levels were near adequate and subsurface soil K levels were high (Table 1) so in practice much lower rates may be profitable. The higher net return in in the All-K treatment compared to

the Nil treatment suggests that there is an economic benefit from applying fertiliser when incorporating lime.
It should be noted that the economic analysis may have been compromised because fertiliser rates were higher than used in practice. The fertiliser rates used in this trial were designed to examine the effect of the main treatments on soil nutrient supply, and consequently high fertiliser rates were required to meet the trial aims.

Table 2: Economic analysis of treatments applied. Net return is grain income minus cultivation, lime and fertiliser costs only. All costs and benefits were attributed to 2013.

Main treatment	Nutrient treatment	Grain yield (kg/ha)	Income ($/ha)	Cultivation / lime costs ($/ha)	Nutrient costs ($/ha)	Total input cost ($/ha)	Net return ($/ha)
Control	All	2050	451	0	244	244	207
	All-K	1942	427	0	106	106	322
	All-N	1792	394	0	219	219	175
	All-P	1431	315	0	169	169	146
	All-S	2243	493	0	239	239	254
	Nil	1094	241	0	0	0	241
Cultivation	All	2417	532	45	244	289	243
	All-K	2201	484	45	106	151	334
	All-N	2044	450	45	219	264	186
	All-P	2062	454	45	169	214	239
	All-S	2495	549	45	239	284	265
	Nil	1786	393	45	0	45	348
Lime + cultivation	All	2243	493	150	244	394	99
	All-K	2249	495	150	106	256	239
	All-N	1900	418	150	219	369	49
	All-P	2110	464	150	169	319	145
	All-S	2435	536	150	239	389	147
	Nil	1672	368	150	0	150	218

Based on $220/t for wheat, $25/ha for deep ripping, $20/ha for one-way plough, $35/t limesand topdressed, $45/t for gypsum topdressed and fertiliser prices at March 2013.

Comments

Cultivation did change the grain yield response to P fertiliser. The yield lost by omitting P fertiliser was greatest in the control and decreased in the cultivation and lime + cultivation treatments. These results suggest that it is feasible to reduce P fertiliser rates when incorporating lime to maximise profit.

The lack of response to lime at this site may be a result of poor incorporation and soil pH that was near to critical levels. In soils where soil pH is below 4.5 at 10-20cm, a yield benefit from lime may be observed due to the amelioration of aluminium toxicity.

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