Sodic Soil Amelioration using Lime and Gypsum - Five Years of Results at Gunning Gap.

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Key Points

- The application of lime and gypsum to a sodic soil has produced improvements in soil structure observable to visitors of the trial site.
- Improvement in soil structure have been associated with variable responses in grain yield and quality across years, apparently in response to varying available soil moisture over the last 5 crop years (2000 to 2004).
- Yield increases with soil amelioration are associated with years where crop growing conditions were conducive to high yield and/or reasonable levels of sub soil moisture were available to the crop (years 2001 and 2002).
- In contrast, barley yield declines of 40% - 80% and quality downgrades have occurred in the last two very dry years (2003 and 2004). This is thought to be due to the soil amelioration treatments promoting additional early season vegetative growth but being followed by severe spring conditions leading to the crop "haying off".
- The trial has sown no economic benefit of soil amelioration in 5 years.

Background

Long-term soil amelioration trials have been established at the Gunning Gap CWFS Regional Site. These trials aim to demonstrate the production and associated economic benefits from ameliorating soil sodicity over the long term. This report details results of the past 5 years at the Gunning Gap sodic soil site.

Methods

Location: Gunning Gap, 35km north west of Forbes, NSW. *Co-operator:* Mark Judson, "Beremana" *Trial History:*
Lime and Gypsum
Date spread: 16 May 2000 (initial treatments applied: commencement of trial)
20 March 2002 (3.5 t/ha lime on the Albrecht treatment plots)
Source: Bagged agricultural lime and gypsum
Sowing: 2000 2nd June, 45 kg/ha Janz, 85 kg/ha DAP
2001 17th May, 25 kg/ha Tilga, 85 kg/ha DAP
2002 29th June, 50 kg/ha Tilga, 85 kg/ha DAP
2003 19th July, 50 kg/ha Tilga, 75 kg/ha DAP
2004 25th June, 50 kg/ha Tilga, 70 kg/ha DAP

Trial Design and analysis:
This trial is based on a randomised block design with six treatments consisting of one nil treatment, four lime rates (Albrecht treatment 2 , 6 & 8 t/ha) and one gypsum treatment. The Albrecht treatments had 4t/ha of lime applied in May 2000 and then a further 3.5 t/ha of lime applied in March 2002 (as per the recommendations of an Albrecht soil laboratory). All treatments are replicated twice. The co-operating farmer sowed

the plots with a direct drill combine in all years. The plots were harvested with a plot header. The data has been statistically analysed using AOV or spatial analysis where applicable.

The Albrecht plots are based on the Albrecht soil management recommendations from the USA. *"The recommendations will utilize the proven principles of the Albrecht system of soil fertility management. The aim is to correct and raise the overall soil fertility to improve and maintain yields and/or crop quality. If we have previously made recommendations for the same soil location, and it has been properly identified as such, then these previous analyses and recommendations are taken into account also.'"* Information taken from http://www.kinseyag.com/

Results

Table 1: Rainfall at "Beremana" sodic soil amelioration trial site (2000 to 2004)

Location	Rainfall (i mm) Month												Annual	Fallow	Growing season	Water limited yield potential[A]
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	(Jan -Mar)	(Apr to Oct)	t/ha
2000	0	22	60	43	62	21	20	**70**	**16**	**87**	**70**	**3**	**474**	**82**	**319**	3.8
2001	0	41	24	54	14	**53**	**55**	**19**	**34**	**47**	**35**	**1**	**377**	**65**	**276**	2.9
2002	0	112	11	12	38	**4**	**8**	**0**	**45**	**0**	**0**	**23**	**253**	**123**	**107**	0.9
2003	0	29	18	8	2.2	**21.7**	**47**	**60**	**7**	**27**	**24**	**11**	**255**	**47**	**173**	0.9
2004	6	30	19	2	31	**46**	**16**	**30**	**31**	**4**	22	**90**	**327**	**55**	160	0.6

[A]Water limited yield potential (t/ha) = ((Nov to Feb) X 30% + (Mar) X 50%)mm + (Growing season rainfall -130)mm) X 15(kg grain/mm) /1000
WLYP if less than 200mm GSR = GSR - (90-(0.3 * (200-GSR)))*20

Table 2: Perry laboratory[d] (USA) soil test summary of Albrecht treatment plots

Date / timing		Depth cm	OC %	pH water	P (Colwell) ppm	S[a] ppm	Zn[a] ppm	CEC meq/100g	Ca:Mg ratio	Na % of cations
May 2000	before lime	0-10	1.7	**6.1**	44	28	2.1	26.0	0.87	10.5
May 2001	after 4t/ha lime	0-10	1.5	**7.3**	26	12	1.3	18.1	1.87	15.8
[c]Suggest optimal level			4-6	**6.2**	50	15-20	>8	10-20	**5.7**	0.5-3

[a]method not described on soil test report

[c]Suggested optimal levels from Perry soil test report

Table 3: Incitec laboratory[d] soil test summary of Albrecht treatment plots

Date/timing		Depth cm	OC %	pH CaCl2	P (Colwell) ppm	S (MCP) ppm	Zn (DTPA) ppm	CEC meq/100g	Ca:Mg ratio	Na % of cations
May 2000	before lime	0-10	0.9	**5.7**	**14**	11	0.3 No	18.3	0.83	12.8
May 2001	after 4t/ha + 3.5t/ha lime	0-10	No test	**7.6**	30	13	test No	19.7	1.76	**7.9**
		10-20	No test	**7.8**	15	9.7	test	30.9	1.05	13.9
[b]Suggested optimal level			>2	**6-7**	**>45**	>20	>1.2	_	**>2**	**<2**

[b]suggested optimal levels from Incitec soil interpretation manual
[d]the Perry and Incitec laboratories use different methods for soil analysis of some nutrients.
Therefore it is not possible to directly compare results between the two different labs for all nutrients.

Table 4: Yield data summary of sodic soil amelioration trial - 2000 to 2003

Rate & Product	2000 Wheat		2001 Barley		2002 Barley		2003 Barley	
t/ha	Yield (t/ha)	% of Nil	Yield (t/ha)	% of Nil	Yield (t/ha)	% of Nil	Yield (t/ha)	% of Nil
nil	1.28	100	2.58 a	100	0.20 a	100	0.33 d	100
2 Lime	1.22	95	3.17 be	123	0.38 c	186	0.14b	41
Albrecht[1]	1.34	105	3.22 be	125	0.33 b	162	0.08 a	23
6 Lime	1.20	94	3.20 be	124	0.36 be	179	0.07 a	20
8 Lime	1.28	100	3.03 b	117	0.35 be	170	0.08 a	23
4 Gypsum	1.40	109	3.34 c	129	0.45 d	220	0.21 c	62
lsd 5%	0.45	35	0.29	11	0.03	13	0.05	15
significant[2]	No		Yes		Yes		Yes	

[1] 4 t/ha of lime applied 16th May 2000 and 3.5 t/ha lime applied 20th March 2002 (as per Albrecht recommendation).
[2] Results in the same column with different letters beside them are significantly different.

Table 5: Sodic soil amelioration trial results 2004

Rate & Product	2000 Wheat				
t/ha	Yield (t/ha)	%of Nil	Retention (%)	Protein (%)	Screenings (%)
nil	0.68 b	100	63.1c	14.6 a	13.5a
2 Lime	0.46 a	67	36.4 b	17.1 be	23.2 ab
Albrecht[1]	0.42 a	62	13.4 a	18.2 c	34.7 be
6 Lime	0.39 a	57	12.4 a	18.7 d	38.6 c
8 Lime	0.40 **a**	59	12.1 a	18.4 cd	36.5 be
4 Gypsum	0.61b	90	44.8 be	16.5 b	20.0 a
Isd 5%	0.11	16	22.3	1.5	13.3
significant[2]	Yes		Yes	Yes	Yes

[1] 4 t/ha of lime applied 16lh May 2000 and 3.5 t/ha lime applied 20th March 2002 (as per Albrecht recommendation).

" Results in the same column with different letters beside them are significantly different.

Table 6: Economic analysis of sodic soil amelioration trial results 2000 to 2004

Product & Rate Applied (t/ha)	*Economic Analysis* Totals - 2000 to 2004		
	Extra Income ($/ha)	Lime/Gyp Costs ($/ha)	Net Benefit ($/ha)
Nil			
2.0 - Lime	$95	$100	-$5
Albrecht plot[1]	$97	$375	-$278
6.0 - Lime	$73	$300	-$227
8.0 - Lime	$52	$400	-$348
4.0 - Gypsum	$212	$240	-$28

Net benefit = $/ha benefit above Nil treatment after taking into account extra income and costs.

Discussion

Seasonal conditions

The rainfall and water limited yield data presented in Table 1 highlights the tough seasonal conditions experience in the Gunning Gap district over the last 3 years. Crop yields in these years have also been adversely affected by late sowing breaks. Long term rainfall records indicate that the last 3 years have been amongst the driest on record (data not shown).

Soil Test Comments

Prior to the commencement of the trial, a uniform bulk soil sample from the site was divided and sent to two separate soil laboratories for analysis: Incitec Analysis Systems and Perry laboratories (USA). The Perry laboratory performed soil analyses and provided recommendations based on the Albrecht system. The Incitec laboratory utilised the industry 'standard' analysis procedures and interpretation techniques.

The Peny Lab Albrecht interpretation (Table 2) stated that very low Ca and excess Mg were the major limiting factors, with a total lime deficiency of 10.8 t/ha. It was recommended that lime be applied at a rate of 4 t/ha in the first year and then re-tested to fine tune further lime applications. The lab also recommended the application of 3 kg/ha of Zinc (Zn) sulphate. The Zn Sulphate was not applied and no Zn deficiency symptoms appeared in the crop at any stage. Extensive Zn trials in the Forbes district have never shown a response to Zn fertiliser with wheat (Motley *etal* 2004).

The Albrecht treatments were re-tested in the second year (i.e. 2001) following the application of lime in 2000, as was recommended. Soil samples were again sent to the Perry soil laboratory for another full Albrecht analysis and interpretation. The second interpretation following the 4t/ha lime application stated excessive Mg and Na, and very low Ca were still the major limiting factors, with a total lime

deficiency of 3.5t/ha. In March 2002, 3.5 t/ha of lime was added to the plots previously treated with 4 t/ha lime. This made for a total lime application rate of 7.5 t/ha on the Albrecht treatment plots. A fourth soil test was conducted in May 2003 on the Albrecht plots with top soil and subsoil samples sent to the Incitec Pivot soil laboratory. The results from this test suggested that the lime was having the desired effect of reducing exchangeable Na (i.e. sodicity) and increasing the Ca:Mg ratio (Table 3). However, these test results highlighted that the subsoil was still very sodic(13.9%exch.Na).

Yield and economic response

No significant yield or quality effect from soil amelioration treatments were seen in the first year (Table 4). It is thought that the application of lime and gypsum in May 2000, only 2 weeks before sowing, was responsible for the lack of response in that year, with treatments needing more time to react in the soil.

The lime and gypsum treatments provided significant yield increases in both 2001 and 2002 (Table 4). The gypsum treatment appeared to be the best treatment in these early years of the trial. The gypsum treatment was the highest yielding in 2001 and 2002. The effects of the lime and gypsum on the soil have been readily observed by visitors to the trial site.

In 2003 and 2004 the lime treatments resulted in severe yield declines, very high grain protein, high screenings and low retention in barley (Table 4 and 5). High grain protein levels in excess of 19% in 2003 (data not shown) and 18% in 2004 (Table 5) in the lime treated plots suggests that moisture stress was severe during the grain fill period. This effect is more pronounce with high rates of lime. During this time, the soil amelioration effect of gypsum appears to have gradually declined, becoming more like the Nil treatment, both in terms of visual crop growth and grain yield and quality.

Visual observations of the plots suggest that the lime and gypsum treatments encouraged better plant root and foliage growth during the winter and early spring. Severe conditions in early spring appeared to make the crop in these plots more susceptible to moisture stress and "haying off. There has been no visual evidence of increased disease or induced nutritional problems in any of the lime or gypsum treatments.

An economic analysis of the yield responses associated with soil amelioration treatments over the last 5 years indicates that none of the lime or gypsums treatments have been profitable (Table 6). However it should be noted that, the results of the economic analysis has been greatly influenced by the extremely low yields achieved in 2002, 2003 and 2004. Low rainfall and water limited yield potentials have generally resulted in poor profitability from crop production in the Gunning Gap area during this time. This is particularly true for systems that have high levels of capital expenditure on soil amelioration.

These trials will be continued in 2005. The co-operating fanner plans to sow the trial site to barley undersown with lucerne. The treatments with be extensively soil tested in 2005 to investigate more closely the effects of the soil amelioration.

References

Motley, K., Harbison, D., Thompson, R.B., Rice, A. and Roberts, K. (2004). Sulfonylurea herbicides and Zn/P fertiliser interactions in wheat in CW NSW. CWFS Research Compendium 2003-2004. pp 55-64.

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