Project LIE 00008

Working together to deliver multiple benefit messages to growers through a whole systems approach to soil management

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Introduction

Soil acidity has long been recognized as a serious limitation to agricultural production in Western Australia. As a consequence, there has been considerable investment from both the government and private sector in establishing lime trials and demonstrations to show the value of managing soil acidity appropriately.

The Department of Agriculture and Food WA has been a key player in establishing many trials that have been aimed to service both field based research and subsequent extension opportunities. Unlike other agronomic trials, lime trials remain valuable (if relocatable) for many years post their establishment phase.

Obtaining the best extension value from lime trials is always a challenge compared to other field based agronomy. The reasons are complex, but some key issues are:

- The time lag, some trials can take several years to respond and/or 'become visual' can complicate 'extension' opportunities
- Establishment of many lime trials happened when grower interest was far less than it is today, hence there may have been a lack of 'receptiveness' to view and absorb information, and this has now changed
- Tenure of funding and focus on lime is not always aligned optimally, hence valuable lime trials are 'abandoned' before they become important and suitable to promote to growers
- Suboptimal rates of lime initially applied to 'ameliorate' acidity adequately, for example when surface acidity is resolved, but subsoil acidity is still limiting.

Ongoing extension of the importance of lime in farming systems is now more topical for farmers and the diversity of industry people that growers work with. GRDC has supported a new approach to enhance extension opportunities- by 'reusing' some old lime trials.

Since this project commenced, Aglime has successfully located many old lime trials across south west of WA. Many have been soil sampled; others will be sampled during the next sampling season.

Forward

With the widespread recognition of extent and severity of soil acidity as a limitation to agriculture in WA, there have been many projects involved in the establishment and subsequent monitoring of the trials and demonstrations of using lime. One of the key extension tools used in the mid 1990's was the establishment of large scale (farmer equipment) demonstration sites to provide a valuable resource for research and serve as a reference point to assess the benefits of liming across WA. Many of these early trials are being relocated, soil sampled, and used for extension purposes now - which is testament to the foresight of those involved in establishing them.

Many people contributed to the establishment and conduct of lime field trials and demonstrations, particularly the Western Australian Soil Acidity Research and Demonstration team:

- Chris Gazey
- Amanda Miller
- Dave Gartner
- Sandy Pate
- Geoff Anderson

Other DAFWA staff also assisted with the process:

- Mike Bolland
- Nancye Gannaway
- Vicki Bolt
- Dan Hester
- Jason Brady
- Andrea Hills
- Jasmine Cheetham
- Colin Holt
- Adrian Cox
- Meg Howe
- Tony Clark
- Kylie Jensen
- Jenny Crisp
- Brendan McAuliffe
- Don Cummings
- Darren Morris
- Eliza Dowling
- Graham Mussell
- Amanda Just
- Tim Wiley

For early data relating to some the trials reported in this document, the reader is directed to:

Penny, S. and Gazey, G (2002) Western Australia Soil Acidity. Demonstration Site Results 1996-2001. Department of Agriculture **Misc Publication 24/2001. ISSN 1326-4168**

Acknowledgements

The 'Time to Lime' project was a major coordinated research and extension initiative during which time, many of the trials reported upon were initiated, and many organisations contributed:

- Grains Research and Development Corporation
- Department of Agriculture, Government of Western Australia
- National Landcare Program
- Land and Water Resources Research and Development Corporation
- National Heritage Trust
- CSIRO Australia
- Centre for Legumes in Mediterranean Agriculture
- The University of Western Australia
- Australia Fertiliser Services Association

I acknowledge GRDC project LIE00008, “Working together to deliver multiple benefit messages to growers through a whole systems approach to soil management” for financial support, and the staff at Liebe Group Inc for their management support.

Special thanks to Chris Gazey (Senior Research Officer, DAFWA Northam) and David Gartner for the detailed records kept from the trial establishment phase, and their subsequent assistance in locating this series of field trials.

Methodology

Aglime of Australia has been engaged as the sub-contractor involved in relocating, and resampling these old lime trials. The data reported, and the individual comments made on each trial are delivered in good faith, but should not necessarily be used in isolation in delivering widespread extension messages.

This document contains the five trial reports, and represents the summary of data collected during the project and has been reported against the initial treatments as described by DAFWA (the trial initiator). In some cases, there have been subsequent treatments (ie additional lime) applied to the original trial design. DAFWA is still looking at the full array of additional treatments (for example, combinations of additional lime and tillage options). All pH measurements reported in this document have been measured in the standard 1:5 soil: 0.01M $CaCl_2$.

For simplicity only the initial lime treatments and if any subsequent lime has been applied are reported at this juncture.

It is extremely important to clarify that none of the trials reported on, have been under 'scientific management' for many years. Typically the trials reported upon were established, and under a regime of careful management and monitoring typically associated with DAFWA field based research for various times frames (typically for between 3 and 8 years). Since that time, they have all simply remained 'as a zone treated as the rest of the paddock 'within the normal farm management regime imposed by the cooperating farmer. In some cases, farms have been sold. Despite concerted attempts, complete understanding of any additional inputs imposed on the trials sites is not known.

Disclaimer

Aglime of Australia, neither DAFWA nor the cooperating farmer has full documentation of all inputs on these sites over that time frame since their establishment. On this basis therefore utmost care must be taken in drawing any isolated conclusions from the data. For instance additional lime, or fertilizer or herbicides could have been dumped on sections of the trial, and this could have influenced soil condition as reported in this document.

Aglime of Australia strongly emphasizes this is preliminary data, and in effect represents 'a photograph in time' in relation to the longevity of time elapsed since the establishment of these field experiments. This is very important, considering the large time lapse involved since trials were established and managed as per the requirements of the researcher involved. In some experiments, known additional treatments have been imposed, albeit typically 2 to 10 years post the initial establishment. Drawing conclusions from either the initial or subsequent treatment applied, and direct attribution of any differences today must be carefully considered.

Aglime of Australia strongly advocates contacting Chris Gazey (Senior Research Officer at DAFWA)
Email: chris.gazey@agric.wa.gov.au Mobile 0429 107 976 prior to making any statements about any of the preliminary data reported in this document.

96MO5 – Mal King Bindi Bindi

Key Messages

- During the early years following trial establishment, there was no grain yield response measured
- In 2004/2005, some 8 years post initial lime treatment, strong visual responses to lime became apparent
- The 'top up' application (1.5t/ha, across all initial lime rates of 0, 1 and 2t/ha)) of lime applied in 2005 (9 years post trial establishment) has had dramatic impact on current soil pH, and the soil pH profiles now reflect lime applied
- Only the highest rate of lime treatment (initial 2t/ha) followed by the 1.5t/ha in 2005 have a soil pH profile above the DAFWA recommendations (5.5 in the surface, over 4.8 at depth)

Aim
The key aim was to compare the rate of lime movement down the soil profile and the change in pH down to a depth of 30cm;

Background
96MO5 is a sand over gravel duplex soil with pre-demonstration topsoil pH of 4.6, and an average subsoil pH of 4.2. In 1996, limesand with a neutralising value of 88% and a particle fineness of 99% was spread at three different rates (0 t/ha, 1 t/ha, and 2 t/ha).

Trial Details

Property:	Mal King Bindi Bindi
Plot size & replication:	50m wide, 200 m long, area per plot 0.5 ha. 3 treatments by 3 replicates
Soil type:	Sand over gravel duplex
Soil pH ($CaCl_2$):	Initially 4.6 (0-10cm) over 4.2 (10-20cm)

Subsequent lime application across the trial
There has been a diverse array of sub treatments applied at 96MO5 since the trial was established in 1996.

For the purpose of simplicity, and to enable comparisons with other trials being assessed in this series, only two additional treatments are reported upon (nil extra lime and the 1.5t/ha extra lime applied in 2005).

Selection of initial soil parameters at the beginning of this trial

Plot Number	Lime (t/ha)	Sample Depth	Soil pH (Pre liming)	Soil pH (Mid Season 96)
1	2	0-10 cm	4.5	5.7
1	2	10-20 cm	4.2	4.1
1	2	20-30cm	Not Sampled	4.8
2	1	0-10 cm	4.4	5.2
2	1	10-20 cm	4.0	4.0
2	1	20-30cm	Not Sampled	4.3
3	0	0-10 cm	4.3	4.3
3	0	10-20 cm	4.2	4.1
3	0	20-30cm	Not Sampled	4.4
4	2	0-10 cm	4.5	6.1
4	2	10-20 cm	4.0	4.3
4	2	20-30cm	Not Sampled	4.6
5	1	0-10 cm	4.6	5.1
5	1	10-20 cm	4.2	4.1
5	1	20-30cm	Not Sampled	4.7
6	0	0-10 cm	4.7	4.6
6	0	10-20 cm	4.2	3.9
6	0	20-30cm	Not Sampled	4.1
7	2	0-10 cm	4.9	5.1
7	2	10-20 cm	4.4	4.1
7	2	20-30cm	Not Sampled	4.4
8	1	0-10 cm	4.6	4.8
8	1	10-20 cm	4.1	4.1
8	1	20-30cm	Not Sampled	3.9
9	0	0-10 cm	4.5	4.6
9	0	10-20 cm	4.2	4.3
9	0	20-30cm	Not Sampled	4.3

ANALYSIS

Pre Liming	pH
Average 0-10cm	4.6
Average10-20cm	4.2

LIME SOURCE	NEUTRALISING VALUE	PARTICLE SIZE
Limesand	88%	99%

Lime 2 tonnes/ha	Pre Liming	Mid Season 96	Change
Average 0-10cm	4.6	5.6	1.0
Average 10-20cm	4.2	4.2	0.0
Average 20-30cm	Not Sampled	4.6	N/A

Lime 1 tonne/ha	Pre Liming	Mid Season 96	Change
Average 0-10cm	4.5	5.0	0.5
Average 10-20cm	4.1	4.1	0.0
Average 20-30cm	Not Sampled	4.3	N/A

No Lime	Pre Liming	Mid Season 96	Change
Average 0-10cm	4.5	4.5	0.0
Average 10-20cm	4.2	4.1	-0.1
Average 20-30cm	Not Sampled	4.2	N/A

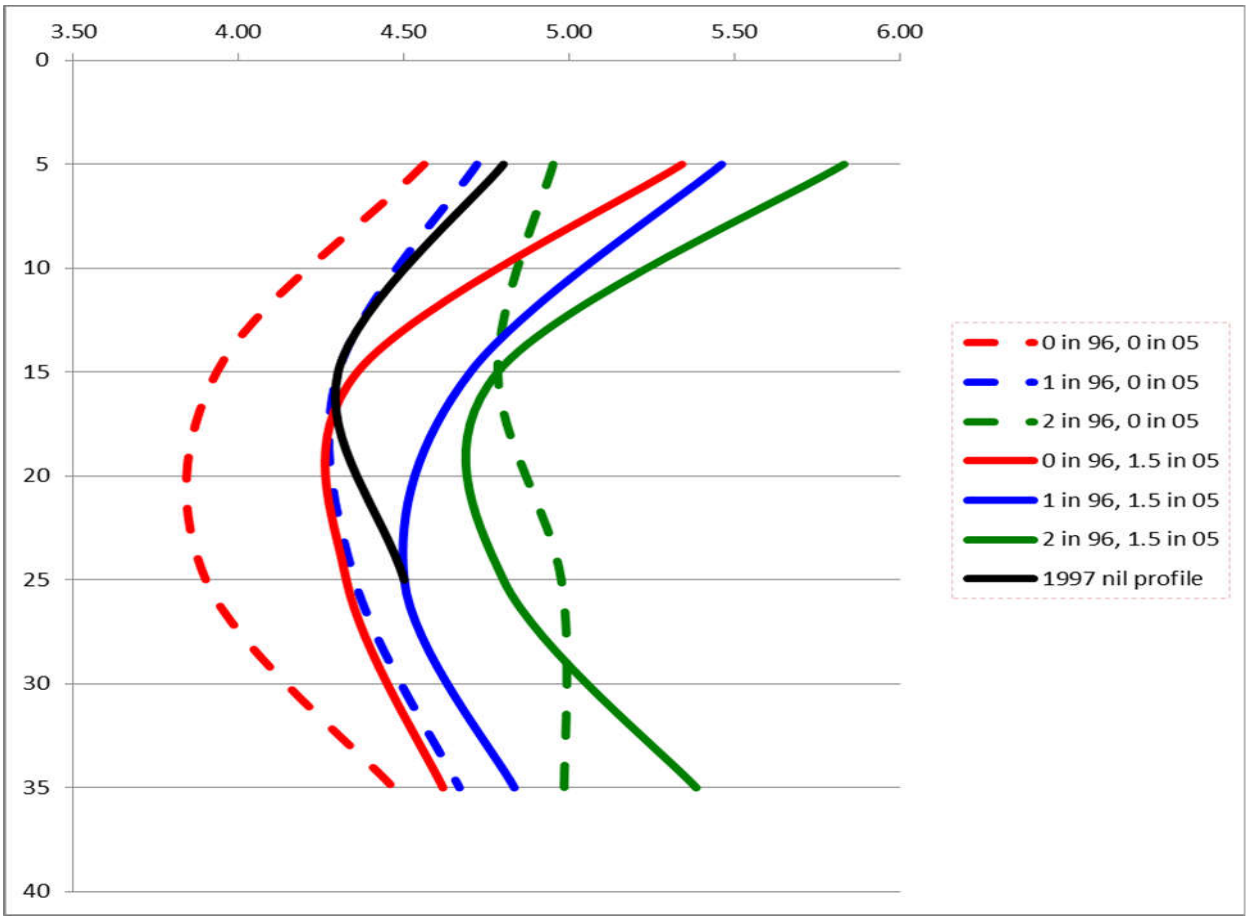
96MO05 Mal King Bindi Bindi. Lime applied in 1996, pH results for some early years of the trial

		Treat Description		
Data	Depth (cm)	0 t/ha Limesand	1 t/ha Limesand	2 t/ha Limesand
pH_1997	0-10	4.9	5.9	6.0
	10-20	4.3	4.3	4.3
	20-30	4.5	4.4	4.5
pH_1998	0-10	4.9	5.9	6.5
	10-20	4.0	4.2	4.2
	20-30	4.2	4.3	4.4
pH_1999	0-10	4.6	5.6	6.1
	10-20	4.1	4.3	4.3
	20-30	4.3	4.4	4.5
pH_2000	0-10	4.7	5.1	5.8
	10-20	4.1	4.2	4.3
	20-30	4.2	4.2	4.5
pH_2004	0-10	4.4	5.0	5.6
	10-20	3.9	4.4	4.3
	20-30	4.0	4.2	4.3
Aluminium ppm_2004	0-10	1.7	1.0	0.8
	10-20	9.0	2.9	3.3
	20-30	6.7	3.9	3.4

Soil pH at 0, 1 and 2t//ha of lime applied in 1996 (with or without top up of 1.5t/ha in 2005, 9 years post trial establishment)

Initial lime	pH (0-10 cm)	pH (10-20 cm)	pH (20-30 cm)	pH (30-40 cm)
0	4.6	3.9	3.9	4.5
1	4.7	4.3	4.4	4.7
2	5.0	4.8	5.0	5.0
Extra 1.5t/ha				
0	5.3	4.4	4.3	4.6
1	5.5	4.7	4.5	4.8
2	5.8	4.8	4.8	5.4
lsd	0.3	0.4	0.5	0.5
sig	*	*	*	NS

Figure 6. 2016 Soil pH at 0, 1 and 2t/ha of lime applied in 1996 (with or without top up of 1.5t/ha in 2005, 9 years post trial establishment)



Comments

There are significant differences in soil pH at the surface, 10-20cm, and 20-30cm depths at this trial site. There are trends at the deepest depth (30-40cm) sampled, but they are not significant (Figure 6).

Without any lime application, the soil pH profile has acidified considerably since the trial was established.

The soil pH profile of the initial 1t/ha (without any subsequent lime application in the following 20 years) is very similar to the initial pH profile, with increased acidification at depth. This provides good evidence lime application is not a 'one off' task. To achieve optimal acidity management, ongoing liming is essential.

The 2016 soil pH profiles measured reflect the lime applications over the previous 20 years- the more lime applied, the better the soil pH. Only the highest rate of lime treatment (initial 2t/ha in 1996, and subsequent 1.5t top up in 2005) has a soil pH profile above the DAFWA recommendations (of 5.5 over 4.8). This suggests 3.5 t of lime has been adequate to ameliorate the initial acidity, and the excess has been able to counter the ongoing acidification. All other treatments involving less lime applications have not had the excess alkalinity to counter ongoing acidification.

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APPENDIX

GRDC has funded this cooperative program involving Liebe, MIG, WMG and South DIRT group and Aglime of Australia to have soil acidity better managed across the state. Given the project title "Working together to deliver multiple benefit messages to growers through a whole systems approach to soil management", raising awareness about the importance of understanding soil acidity, and it limitations to profitable agriculture is a critical focus of all project partners.

To achieve this regime, in addition to sampling the 'old long term lime trials', Aglime has been instrumental in trying to encourage growers to recognize the importance of actually making soil pH measurements in their own trial and demonstration programs.

In addition to the soil sampling milestone requirements, Aglime has focused on ways to enhance growers, and the various staff from many organizations they are working with to gain a better understanding of the variation in soil type, and the importance of adequate pH measurement, before and post the application of various lime and tillage treatments.

A key focus of this approach has been to establish dialogue, and create 'small nodes' of activity related to trialing and demonstrating using lime to treat acidity across the WA wheatbelt. The rationale is to help growers understand the issues, and ultimately to help growers to help themselves.

One approach taken to achieve this objective has been to offer comprehensive soil sampling to growers involved in establishing and monitoring their own field trials. During the first two years of this project, Aglime has sampled for various collaborators (data not shown in this report). All data has been returned to the various project staff, who will report direct to the organisations they receive funding from, and cooperate with in their various programs. Aglime does have copies of all this raw data and the geo locations of the collection sites, and it can be made available to GRDC upon request.

Some of the relevant examples across the WA wheatbelt include:

Brian Cusack- Narembeen
Travis Hollins- Nungarin
Dennis Martin- Badgingarra
Will Browne- Warradargee
Peter Negus- Dandaragan
Murray Preston- Geraldton
Tony Sasche- Bencubbin
Ben Hobley- Nyabing
Tony Murfit- South Burracoppin

We have tried to address this issue, albeit with a small number of growers in the state, and the 'end result' of considerable field sampling and literally hundreds of soil pH measurements from a single field trial is often only a simple graph, with small numbers of pH profiles reflecting various treatments over time.

Most growers and consultants understand the pH scale (logarithmic), and the fact a soil with a pH of 4.5 has ten times the acid concentration of a soil at pH 5.5. However, very few understand the impact of initial soil pH on the rate of lime reaction. Whilst the acid concentration is 10 fold for 1 pH unit, the rate of lime dissolution in the field is more typically 100 fold for a 1 pH unit change (i.e lime dissolves 100 times faster at pH 4.5 than it does at pH 5.5).

The implications of this chemical fact, in broadacre field trials looking at low (typically 1 or 2t/ha of lime) rates of lime is grossly underestimated, and inadequate interpretation of the effectiveness of lime in treating soil acidity is usual thereafter. If farmer trials are inadequately designed and replicated (and many are), and the starting pH of the plots nominally allocated as the control or nil lime plots simply by chance happens to be at

pH 4.8, and the starting pH of the plots receiving 2t/ha by chance start at pH 4.2, then a typical conclusion 12 months post lime trial establishment is that 'lime didn't work' in changing the soil pH.

If adequate numbers of soil cores and replications of the various treatments are made at the start of a lime trial, and again post treatment, then erroneous conclusions are less likely. However, like many issues, the time involved to collect enough soil samples, and the lack of willingness to part with the money required to make the appropriate number of pH measurements (CSBP lab in Perth charges $14 per sample for a pH measurement) generally means a compromise is made. This needs to be understood.

Another issue with farmer established lime trials that does impact on results obtained is the fact growers are using a variety of lime sources, and often of unknown quality. The concept of a 'bargain' source of lime which maybe advertised at a lower price per tonne would seem to appeal to many, despite the fact its neutralising value may be vastly inferior to another source of lime available at a marginally higher listed price.

Added to the complication of neutralising value is the issue of particle size. In the drying climate WA wheatbelt farmers operate in, the importance of particle size of lime sources is grossly underestimated by far too many.

It is an unequivocal fact, finer particles react quickest. The do not react more, simply faster. If soil acidity is limiting productivity (and again the facts are clear this is the case), getting lime to react as fast as possible is imperative.

Even in the case of some of the work reported in this document when high NV lime, of a very fine particle size has been used, there is still clearly unreacted lime at depth 15 years post treatment. Whilst there can be no argument, tillage of certain soil types can have negative (as well as positive) outcomes, the evidence presented in the photographs is not uncommon across many WA lime trials. Inadequate mixing of lime and acid soils is common, and restricting access to the economic benefits correct amelioration offers.

Whilst lime use has clearly increased dramatically over the past ten years, the vast majority of lime applied across rural WA has simply been top-dressed on the surface. In many circumstances, surface acidity is not the culprit in limiting yields. If surface soils have been limed, and the current pH of this layer is improved (say from 4.5 up to 5.4), then any subsequent lime applied to the surface (without mechanical mixing) will have little impact on the soil pH in the deeper layers, which are still acid, and are still limiting access to water and nutrients at depth, and ultimately yield.

Farmers now better understand the need to use lime in managing acidity, however incorporation technology/process, the array of machinery options and the impact of the diversity of soil types across the state represent some considerable challenges that needs far better resourcing.