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.

96LG9 – Matt Cugley Newdegate

Key Messages

- During the first few years of this trial being monitored, there were significant changes in soil pH due to the application of lime, and these changes resulted in significant grain response

- The 'top up' application (1.5t/ha, across all initial lime rates of 0, 1 and 2t/ha)) of lime applied in 2006 (10 years post trial establishment) has had dramatic impact on current soil pH. Unfortunately, grain yields have not been monitored post the top up lime application.

- The 2016 pH measurements provide clear evidence inadequate lime has been applied to counter inherent and ongoing soil acidification. From a starting surface pH of 4.8 over a subsurface of 4.6 (in 1996), the highest rate of lime applied has been 2t (1996) and a further 1.5t (2006) is simply insufficient to lift soil pH above the DAFWA stated targets (5.5 over 4.8).

- Despite soil pH being under target, this trial provides a clear demonstration of the best soil pH profile being associated with the highest rate of lime application. Collecting grain yields would be valuable

Aim

The key aim of this trial is to document and understand the change in soil pH down to a depth of 30cm.

Background

96LG9 is situated on a sandy gravel soil with a pre-demonstration topsoil pH of 4.5, and a subsoil pH of 4.6. Limestone with a neutralising value of 86% was spread in 1996 at three rates (0 t/ha, 1 t/ha, 2 t/ha). By 1999, soil pH had increased by 0.6 pH units at 1 t/ha of lime and by 1.0 pH unit when 2 t/ha of lime was added.

Trial Details

Property:	Matt Cugley, Newdegate
Plot size & replication:	50m wide, 200 m long, area per plot 0.50 ha. 3 treatments by 3 replicates
Soil type:	Sandy gravel
Soil pH ($CaCl_2$):	Initially 4.5 (0-10cm) over 4.6 (10-20cm)

Subsequent lime application across the trial

In 2006, each plot (originally 50m wide by 200m long) was split in two. The western half of each plot received 1.5t/ha, the eastern side of each plot received no additional lime. This data is reported, showing the massive impact of the additional lime application across all the three initial lime treatments.

The cooperating farmers have now also applied another 2t/ha of lime (source unknown) in February 2016 (ie. Post soil sampling reported in this document). There was no other application of lime during the 1996-2016 periods across the trial site.

Selection of initial soil parameters at the beginning of this trial

Soil pH Analysis during establishment of trial in 1996

Plot Number	Lime (t/ha)	Sample Depth	Soil pH (Pre liming)	Soil pH (Mid Season 96)
1	2	0-10 cm	4.4	4.9
1	2	10-20 cm	4.6	4.6
1	2	20-30cm	Not Sampled	5.1
2	1	0-10 cm	4.6	5.2
2	1	10-20 cm	4.8	4.6
2	1	20-30cm	Not Sampled	5.1
3	0	0-10 cm	4.6	4.6
3	0	10-20 cm	4.7	4.7
3	0	20-30cm	Not Sampled	5.3
4	2	0-10 cm	4.6	5.5
4	2	10-20 cm	4.8	4.7
4	2	20-30cm	Not Sampled	5.1
5	1	0-10 cm	4.4	5.0
5	1	10-20 cm	4.6	4.5
5	1	20-30cm	Not Sampled	5.0
6	0	0-10 cm	4.5	4.4
6	0	10-20 cm	4.5	4.8
6	0	20-30cm	Not Sampled	5.1
7	2	0-10 cm	4.4	5.3
7	2	10-20 cm	4.5	4.6
7	2	20-30cm	Not Sampled	5.1
8	1	0-10 cm	4.5	5.1
8	1	10-20 cm	4.6	4.7
8	1	20-30cm	Not Sampled	5.1
9	0	0-10 cm	4.4	4.4
9	0	10-20 cm	4.5	4.5
9	0	20-30cm	Not Sampled	5.1

Pre Liming	**pH**
Average 0-10cm	4.5
Average10-20cm	4.6

LIME SOURCE	**NEUTRALISING VALUE**
Lime stone	86%

Lime 2 tonnes/ha	**Pre Liming**	**Mid Season 96**	**Change**
Average 0-10cm	4.5	5.2	0.7
Average 10-20cm	4.6	4.6	0
Average 20-30cm		5.1	NA

Lime 1 tonne/ha	**Pre Liming**	**Mid Season 96**	**Change**
Average 0-10cm	4.5	5.1	0.6
Average 10-20cm	4.7	4.6	-0.1
Average 20-30cm	NS	5.1	NA

1997 Soil pH:

		Lime rate (t/ha)		
Data	Depth	0	1	2
Average of pH	0-10 cm	4.8	5.5	6.0
	10-20 cm	4.7	5.0	5.0
	20-30 cm	5.1	5.3	5.2
StdDev of pH	0-10 cm	0.0	0.1	0.1
	10-20 cm	0.1	0.2	0.1
	20-30 cm	0.2	0.3	0.2

1998 Soil pH:

		Lime rate (t/ha)			
Data	Depth	0	1	2	lsd
Average of pH	0-10 cm	4.4	5.1	5.6	sig 0.44
	10-20 cm	4.5	4.5	4.6	ns 0.34
	20-30 cm	4.8	4.9	5.0	ns 0.36

Application of 1 t/ha and 2 t/ha of lime in 1996 significantly increased pH in the 0-10 cm soil depth by 0.7 and 1.1 pH units respectively compared to not using lime

1999 Soil pH:

		Lime rate (t/ha)			
Data	Depth	0	1	2	lsd
Average of pH	0-10 cm	4.4	5.0	5.4	sig 0.34
	10-20 cm	4.5	4.6	4.7	ns 0.35
	20-30 cm	4.8	5.1	5.1	ns 0.75

1 t/ha and 2 t/ha of lime applied in 1996 significantly increased soil pH in the 0-10 cm soil depth by 0.6 and 1 pH units respectively compared to not using lime

2016 Soil pH

Lime 1996	pH 0-10	pH 10-20cm	pH 20-30 cm
0	4.1	4.2	4.4
1t	4.3	4.4	4.6
2t	4.8	4.8	4.9
+1.5 t 2006			
0	4.7	4.6	4.5
1	5.1	4.7	4.9
2	5.2	5.2	5.1
Sig	*	*	NS
lsd	0.77	0.34	0.66

Figure 2a. 2016 Soil pH at 0, 1 and 2t//ha of lime applied in 1996 (with and without top up of 1.5t/ha in 2006, 10 years post trial establishment)

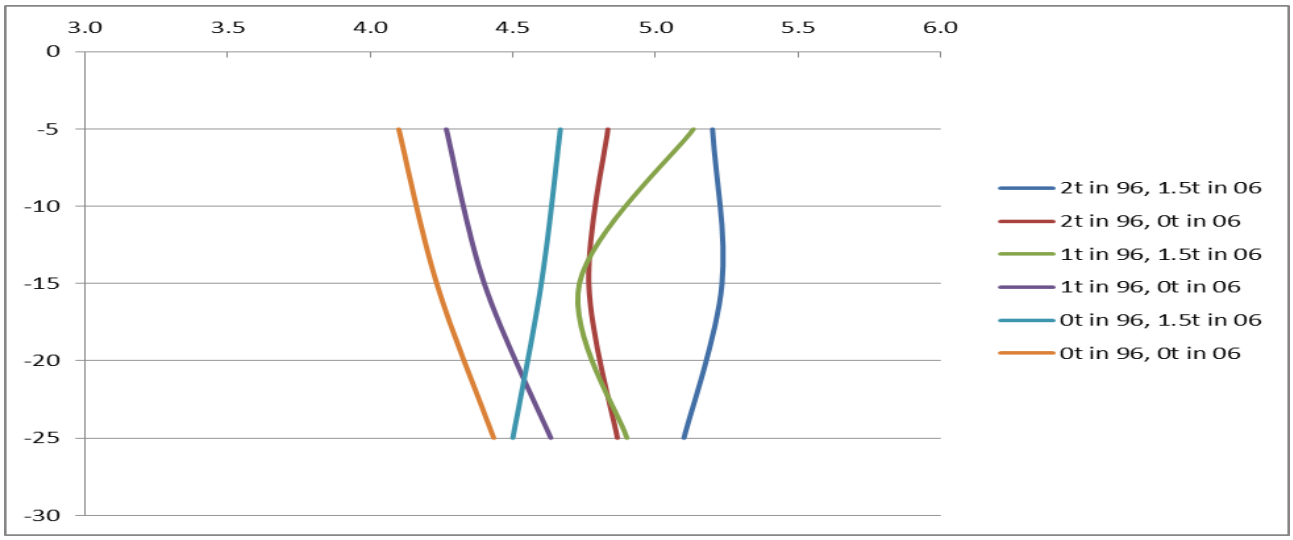


Figure 2b. 2016 Soil pH at 0, 1 and 2t//ha of lime applied in 1996 (no other lime applied)

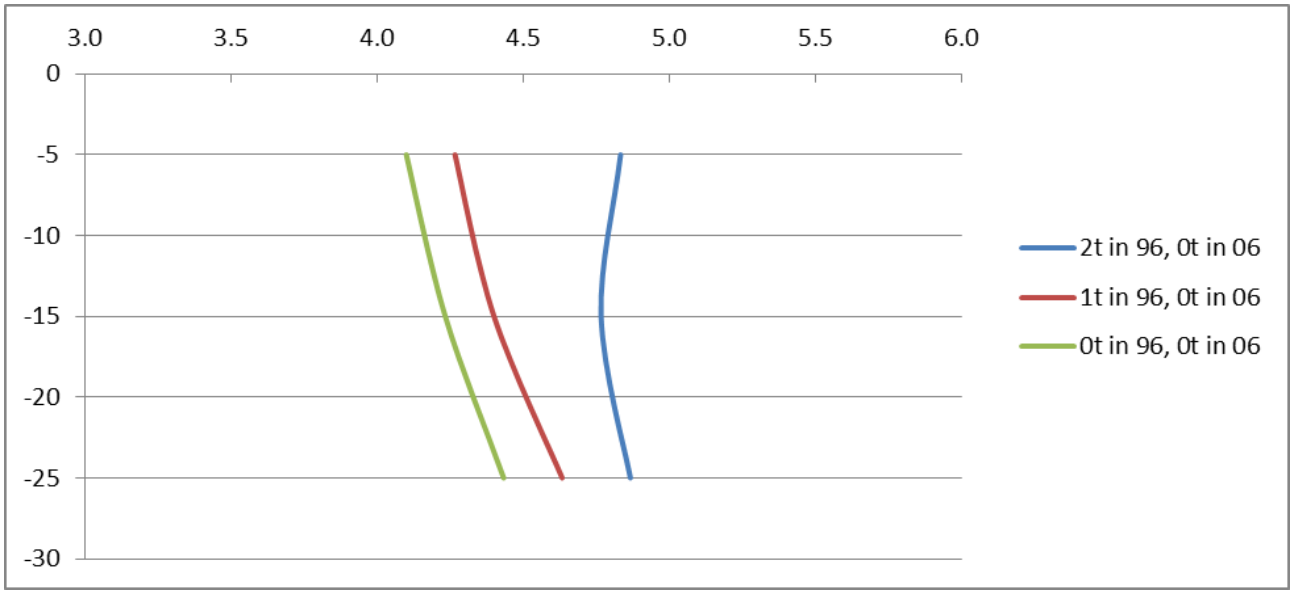
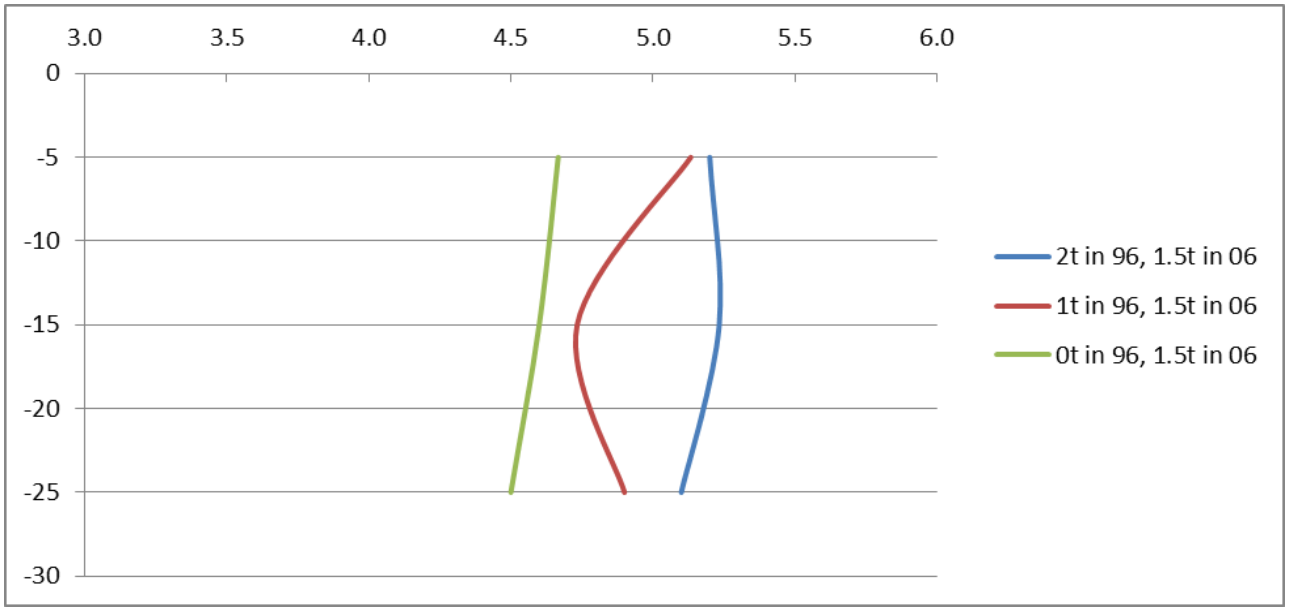


Figure 2c. 2016 Soil pH at 0, 1 and 2t//ha of lime applied in 1996 (plus 1.5t/ha in 2006)



Comments
There is clear separation of the soil pH within the different initial and subsequent liming treatments (Figure 2a, b, c). There are significant differences in the surface and 10-20 cm pH, and despite trends the pH at 20 to 30cm differences are not significant.

None of the profiles have a soil pH at or above the DAFWA suggested targets (5.5 in the surface soil, and 4.8 at depth), despite good separation (better soil pH profile, with the highest rate of lime applied). This is not unexpected, based upon long term DAFWA research, and predicted acidification rates in this agricultural zone. Even the highest rate of lime applied (2t in 1996, and 1.5t in 2006) is inadequate to ameliorate the soil pH from the initial 4.5 over 4.6, and to counter the ongoing acidification over the following 20 years.

In terms of annual lime input, the 3.5 t applied equates to 175kg/ha/yr, whilst DAFWA recommendations in this environment would be more typically in the 200 to 250kg/ha/yr range.

The 2016 pH measurements provide clear evidence inadequate lime is being applied to counter inherent and ongoing soil acidification. From a starting surface pH of 4.8 over a subsurface of 4.6 (in 1996), the highest rate of lime applied has been 2t (1996) and a further 1.5t (2006) is simply insufficient to lift soil pH above the DAFWA stated targets (5.5 over 4.8).

Despite current soil pH being below DAFWA targets, off great interest is the clear differentiation across the site- the more lime applied, the better the soil pH profile. Without any lime application, the profile has acidified at each layer sampled.

We plan to re sample the site again next summer, to determine the impact of the 2t/ha of lime applied by the cooperating farmer in February 2016

Paper reviewed by:

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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.