Tungkillo Landcare Group Lime Trials

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Disclaimer

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Executive Summary

Following concerns about liming products no longer being available, two trials (Cameron's and Bartch's) were established with the Tungkillo Landcare Group to compare liming products. Support for the trials was provided by Natural Resources, SA Murray Darling Basin (SAMDB) through funding from the Australian Government's National Landcare Program (NLP). Cameron's site was established on a cropping paddock and Bartsch's on a long term low input pasture paddock with the sites established in 2014 and monitored through until December 2017. Key measurements included soil pH changes, yield of crops and dry matter from pasture cages on the pasture site.

The Cameron cropping trial has demonstrated crop yield responses to lime applications in two of the four years, when sown to barley (sensitive to lime- up to 25%) after 2 years and wheat (moderately tolerant- up to 50%) after 4 years. No response was observed in year 1 and no yield monitoring was undertaken in year 3 when under lupins.

Yield responses were more significant with the higher quality products and four years after application these better quality lime products were still responding comparatively better although the coarser products were also having an impact. The higher rates of application (6 t/ha) have resulted in greater responses.

The Bartsch pasture site demonstrated pasture growth responses of an inconsistent nature over the four years of the trial. A cumulative response based on all pasture cuts by lime type shows that over the four years increases in dry matter of at least 4-5 t/ha have been achieved over the control plots.

Lime movement over the 4 years at the pasture site where no soil cultivation occurred showed the higher quality products to have moved slightly further down the soil profile with pH change evident at approximately 7-10cms while the coarser products had a greater effect in the top 5 cms of the soil profile and less impact deeper.

The nature of these trials have allowed some comparisons to be made between liming products. In general, the two better quality products seemed to have reacted quicker, moved further into the soil and after 4 years were still in front of the coarser products. These trials showed little impact from calciprill and liquid lime applied at much lower rates although they were not placed in the ideal location.

Further work is still required to examine the full impact over time of different rates and products on subsurface layers.

Introduction

Tungkillo Land Care Group members were keen to look at methods of liming acidic paddocks and their effectiveness. In recent years the loss of "Nutrilime" as a cheap and good quality liming product and the Angaston quarry no longer producing its finer grade agricultural lime has resulted in the two cheapest and higher grade products not being available. Landholders are now considering what the best options are for liming acidic soils. Also, some landholders have issues with grass tetany and are considering whether dolomite offers any advantages in supplying Magnesium to their livestock. Some new products have been proposed as alternatives.

In this assessment subsoil acidity needs consideration as it is becoming more common in this district.

With support provided by Natural Resources, SA Murray Darling Basin (SAMDB) through funding from the Australian Government's National Landcare Program (NLP) two sites were established comparing existing and new liming products. Additional support funding was provided from Grain Research and Development Corporation (GRDC) and Department for Environment and Water (DEW) for components of the project.

Method

Following an initial discussion on site in August 2013 between landholders, the chair and co-ordinator of the Tungkillo Landcare Group, Natural Resources SAMDB staff and PIRSA Rural Solution staff two proposed sites were selected. The aim was to develop one site on a lower intensity grazing property (Bartsch east of Mt Pleasant), common in this area, while the other on a more intensive cropping/ grazing property (Cameron south of Tungkillo).

Actual site development was a lengthy process between Dec 13th 2012 and March 14th 2013. This process was delayed a number of times due to the first site selected at Bartsch being unsuitable from a surface pH viewpoint and then delays in defining subsequent sites due to extreme weather, and bushfire rehabilitation programs.

Trials were established using a range of products including the new pelletised product Calciprill. Trials were replicated, using a Randomised Complete Block Design. Discussions were held with Kym Gladigau (local lime spreader) about product selection. A trial lime spreader obtained from the South Australian Reserch Development Institute (SARDI) was used to spread the products, apart from the Calciprill which was spread by hand on Bartsch's and by the landholder's drill seeder on Cameron's where the product was drilled into the soil. Note drilling was done prior to seeding so application was not in the seeding rows. Surface applications were also undertaken with Calciprill.

Products selected were:

Product	Comments
Calciprill	A new pelletised liming product. Much dearer but has been described as more effective. Can go through the fertiliser box on normal seeding equipment as the pellet is similar to handle to MAP or DAP
Agricola	A high quality lime – dispersive effect in soils. Similar to Cawtes at Murray Bridge but slighter better quality
Angaston	Pure but coarse local product from Angaston quarry
Goolwa Quarries Lime	Lower quality by-product from road lime quarry at Hartley
Southern Lime dolomite	Fine high quality dolomite produced at Sellicks Hill. Milled super-fine for better effectiveness

Further characteristics on lime quality and the products used is shown in Appendix 1.

A liquid lime treatment (fine calcium carbonate in suspension) was added in May 2015 to Cameron's site. The liquid lime product is promoted as highly effective, with recommended application rates of 5-10 L per ha.

Dry matter assessments were undertaken by quadrat sampling from pasture cages in the pasture site. Crop yields were calculated from small plots using the SARDI trial plot harvester. Field soil sampling was undertaken using gauge augers for multi-depth sampling and a press-in 0-10cm soil sample for 0-10cm samples whilst laboratory soil analysis of the samples was undertaken through APAL in Adelaide.

Site Information and Treatments

Bill and Annette Cameron

Location: Top Windrow Paddock

Soil Type: thick bleached sand over brown mottled clay

acid to 100cm, high Phosphorus, very low Potassium, adequate Sulphur

	water	CaCl2	Al mg/kg
soil pH 0-10:	5.1	4.4	5.2
soil pH 10-20:	4.8	4.2	9.2

	Lime	Rate	Application
Treatments:	Control	Control	surface
	Control	Control	furrow
	Calciprill	L	surface
	Calciprill	H	surface
	Calciprill	L	furrow
	Calciprill	H	furrow
	Agricola	L	surface
	G Q Lime	L	surface
	Angaston	L	surface
	S L Dolomite	L	surface
	Agricola	H	surface
	G Q Lime	H	surface
	Angaston	H	surface
	S L Dolomite	H	surface

L- low rate 3 t/ha, H- high rate 6 t/ha

Calciprill L 300 kg/ha, Calciprill H 600 kg/ha- furrow treatments were inserted using seeding drill prior to seeding

Liquid Lime was applied on the surface of selected spare plots at 50 litres/ha on 28/5/15.(3x recommended rate although placed on surface not in the planting row)

Figure 1- Cameron's Trial Layout

	ID	Rep	Plot	Lime	Rate	Application	10	5	10	ID	Rep	Plot	Lime	Rate	Application	Plot width	Cu PW
FENCE	1	A	1	S L Dolomite	H	surface				33	C	1	Agricola	L	surface	4.5	4.5
	2	A	2	Control	Control	furrow				34	C	2	Control	Control	furrow	9	13.5
	3	A	3	Spare	Spare	Spare				35	C	3	Spare	Spare	Spare	4.5	18
	4	A	4	Calciprill	L	surface				36	C	4	S L Dolomite	L	surface	4.5	22.5
	5	A	5	Agricola	L	surface				37	C	5	G Q Lime	H	surface	4.5	27
	6	A	6	Spare	Spare	Spare				38	C	6	Control	Control	surface	4.5	31.5
	7	A	7	Agricola	H	surface				39	C	7	Calciprill	H	surface	4.5	36
	8	A	8	G Q Lime	H	surface				40	C	8	Agricola	H	surface	4.5	40.5
	9	A	9	Control	Control	surface				41	C	9	G Q Lime	L	surface	4.5	45
	10	A	10	Angaston	L	surface				42	C	10	Calciprill	L	surface	4.5	49.5
	11	A	11	Angaston	H	surface				43	C	11	Angaston	H	surface	4.5	54
	12	A	12	S L Dolomite	L	surface				44	C	12	S L Dolomite	H	surface	4.5	58.5
	13	A	13	Calciprill	L	furrow				45	C	13	Calciprill	L	furrow	9	67.5
	14	A	14	G Q Lime	L	surface				46	C	14	Angaston	L	surface	4.5	72
	15	A	15	Calciprill	H	surface				47	C	15	Spare	Spare	Spare	4.5	76.5
	16	A	16	Calciprill	H	furrow				48	C	16	Calciprill	H	furrow	9	85.5
FENCE	17	B	1	G Q Lime	H	surface				49	D	1	Spare	Spare	Spare	4.5	4.5
	18	B	2	Agricola	H	surface				50	D	2	Agricola	L	surface	4.5	9
	19	B	3	S L Dolomite	L	surface				51	D	3	Angaston	H	surface	4.5	13.5
	20	B	4	Calciprill	H	furrow				52	D	4	Calciprill	H	furrow	9	22.5
	21	B	5	Angaston	H	surface				53	D	5	S L Dolomite	H	surface	4.5	27
	22	B	6	Agricola	L	surface				54	D	6	Angaston	L	surface	4.5	31.5
	23	B	7	Control	Control	furrow				55	D	7	Control	Control	furrow	9	40.5
	24	B	8	Calciprill	H	surface				56	D	8	G Q Lime	H	surface	4.5	45
	25	B	9	Calciprill	L	surface				57	D	9	S L Dolomite	L	surface	4.5	49.5
	26	B	10	Spare	Spare	Spare				58	D	10	G Q Lime	L	surface	4.5	54
	27	B	11	Spare	Spare	Spare				59	D	11	Control	Control	surface	4.5	58.5
	28	B	12	Calciprill	L	furrow				60	D	12	Calciprill	L	furrow	9	67.5
	29	B	13	G Q Lime	L	surface				61	D	13	Calciprill	L	surface	4.5	72
	30	B	14	Angaston	L	surface				62	D	14	Agricola	H	surface	4.5	76.5
	31	B	15	S L Dolomite	H	surface				63	D	15	Calciprill	H	surface	4.5	81
FENCE	32	B	16	Control	Control	surface				64	D	16	Spare	Spare	Spare	4.5	85.5
				gate											trial length	171	m

Note, liquid lime placed in spare 1 treatment, spare 2 became the control normal

Establishing trial at Cameron's

Bill and Paula Bartsch Trial

Location- Low in paddock north of the house

Soil Type: Thick loamy sand with bleached A2 over yellowish brown clay

Acid to 60cms, Phosphorus very low, Potassium and Sulphur adequate

Site initially pHCa 4.3, Al 2.3 ppm

At Bartsch site treatments are:

Lime	Rate
Control	Control
Calciprill	L
Agricola	L
G Q Lime	L
Angaston	L
SL Dolomite	L

All limes applied at approximately 3 t/ha, Calcriprill at 300kg/ha- surface applied

Figure 2- Bartsch trial layout

D (2)	Distance	← 10m →	ID	Rep	Plot	Lime	Rate
3	4		1	A	3	S L Dolomite	L
6	8		2	A	8	Angaston	L
9	12		3	A	9	Control	L (nil)
12	16		4	A	10	G Q Lime	L
15	20		5	A	11	Calciprill	L
18	24		6	A	12	Agricola	L
21	28		7	B	2	G Q Lime	L
24	32		8	B	4	Control	L (nil)
27	36		9	B	5	Agricola	L
30	40		10	B	9	Calciprill	L
33	44		11	B	10	Angaston	L
36	48		12	B	12	S L Dolomite	L
39	52		13	C	4	Angaston	L
42	56		14	C	5	Agricola	L
45	60		15	C	7	S L Dolomite	L
48	64		16	C	8	Calciprill	L
51	68		17	C	9	Control	L (nil)
54	72		18	C	10	G Q Lime	L
57	76		19	D	1	Agricola	L
60	80		20	D	2	Control	L (nil)
63	84		21	D	3	G Q Lime	L
66	88		22	D	7	Angaston	L
69	92		23	D	9	Calciprill	L
72	96		24	D	12	S L Dolomite	L

Rainfall 2014-17

Rainfall data is from the Mt Pleasant weather station, 5 km north of Tungkillo. Table 1 shows monthly rainfall figures and long term means for Mt Pleasant, SA, from the Bureau of Meteorology. It is closest to the Bartsch property, and has over 100 years of rainfall data to calculate long-term averages. Mt Pleasant would have a higher rainfall then the Cameron's property – Bill has indicated his average to be around 475 mm while Mt Pleasant is 671 mm. The Bartsch site is probably slightly less as well, approximately 600mm. However, the trends are still the same.

The 2014 season began with a high rainfall event in February, which occurred before the treatments were in place. Rainfall was close to normal in April and May, and above average in June and July. The remainder of the growing season (Aug / Sept / Oct) had rainfall well below average, and this impacted strongly on crops and pastures, with yields lowered and pastures drying early.

The 2015 season began with above average rainfall in April. May rains were close to the long term average. June was well below average, July and August somewhat below average, and September and October well below average. Total growing season rainfall was well below average and crops and pastures were strongly affected by the dry warm spring. Crop yields were decreased and pastures dried out early.

The 2016 season had a relatively dry April followed by mostly well above average rainfall for the rest of the year. Waterlogging occurred at both sites which restricted growth for a period of time.

The 2017 season was characterized by a very dry June which restricted pastures for a period of time followed by around average conditions for the rest of the year.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2014	10.8	158.4	18.2	50.4	43.4	146.0	138.8	21.4	30.2	8.4	34.0	21.6	681.6
2015	63.8	0.0	5.8	98.0	71.0	24.6	67.0	67.6	27.6	*8.8*	13.8	5.6	*453.6*
2016	18.0	31.0	46.0	16.8	120.0	112.0	153.8	80.8	184.0	83.0	38.8	140.0	1024.2
2017	46.8	36.4	15.6	35.0	40.2	*13.6*	*118.6*	*179.4*	62.2	30.8	*39.4*	*44.2*	*662.2*
Mean	24.8	24.3	26.3	48.2	73.1	*89.5*	*93.9*	*90.1*	76.2	56.4	*35.1*	*31.6*	*671.5*

Table 1- Rainfall at Mt Pleasant

Results- Year 1, 2014

Cameron's Cropping Site, 2014

On Cameron's, monitoring in year 1 included dry matter and grain yield of the barley by treatments, and on one replicate, examination of lime movement into the profile.

Both dry matter and yield results did not show any liming response (See figures 3 and 4). This can be explained by the distance the lime has moved into the soil which is shown in figure 5 where the change in pH only extends to around 50 mm or so with the deeper layers still being quite acidic.

Figure 3- Dry matter cuts by lime treatment – Oct 2014

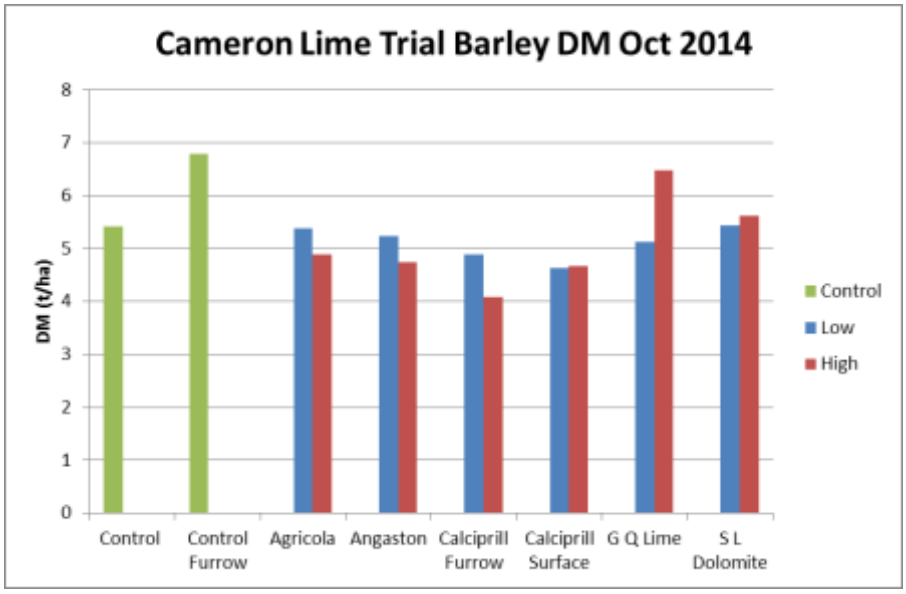
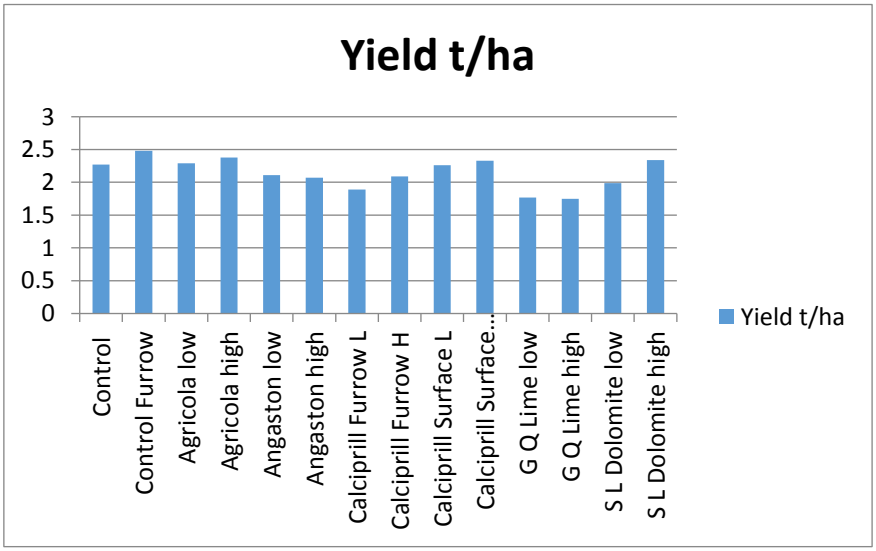
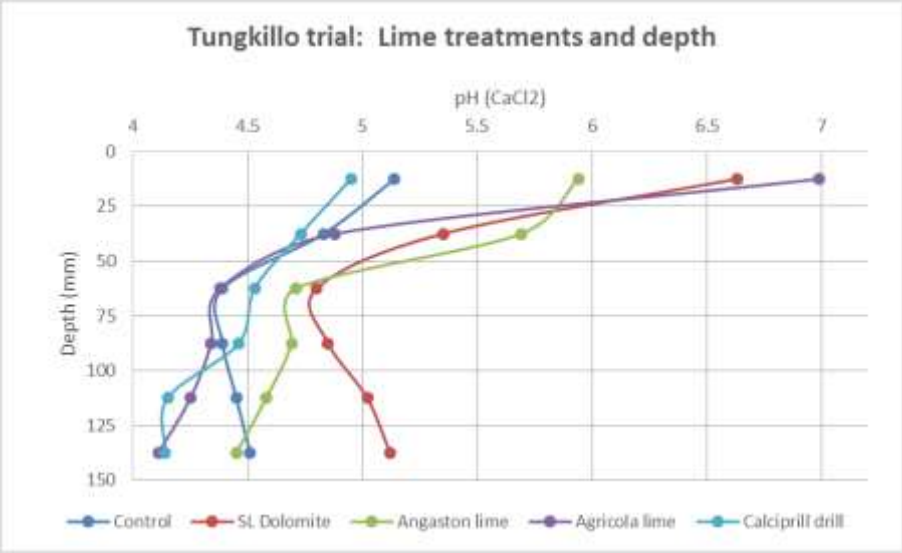


Figure 4- Grain yield results by lime treatment December 2014



An assessment of soil pH change after one year is shown in Figure 5 and indicates a large pH increase in the top 25 mm from the three lime products but little change in the Calciprill treatment.

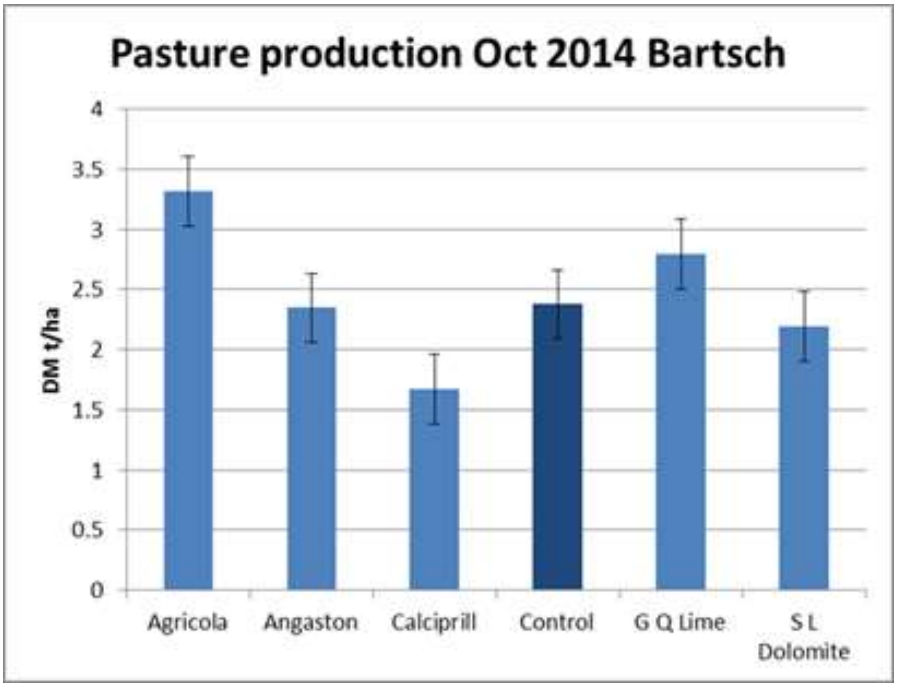
Figure 5- Change in pH by some lime treatments- note from one rep only, early 2015



Bartsch's Pasture Site, 2014

On the Bartsch site monitoring was being undertaken by the establishment of pasture cages and cuts. Cuts were made in October 2014 with the results shown below in Figure 6. These results are from the means of three reps and possibly show some response. Pasture cuts were not undertaken after this due to the poor Spring.

Figure 6- pasture production from cuts by treatments



Results- Year 2, 2015

Cameron's Cropping Site, 2015

The trial site sown to barley was affected by disease and dry conditions. A clear effect of location was seen across the site, with high yields at the ends of the trial and low yields in the centre. This was in part due to soil being sandier, less fertile and more prone to disease in the middle of the plots. A plot of controls across the site was used to calculate the effect of location on the grain yield and to transform the data. Transformed data was then analysed and large outliers removed. This showed considerable variation in the data in this year due to the disease effects and dry season as displayed in figure 7..

Figure 7- Cameron's Variable Control

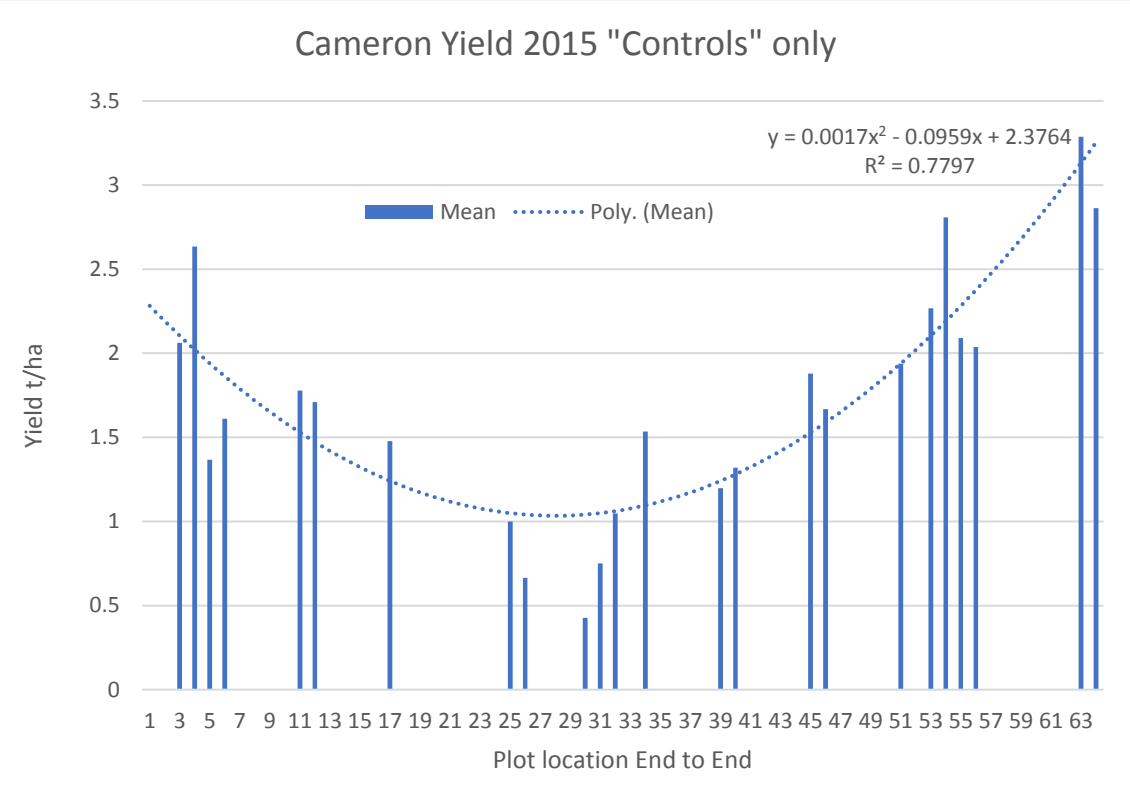
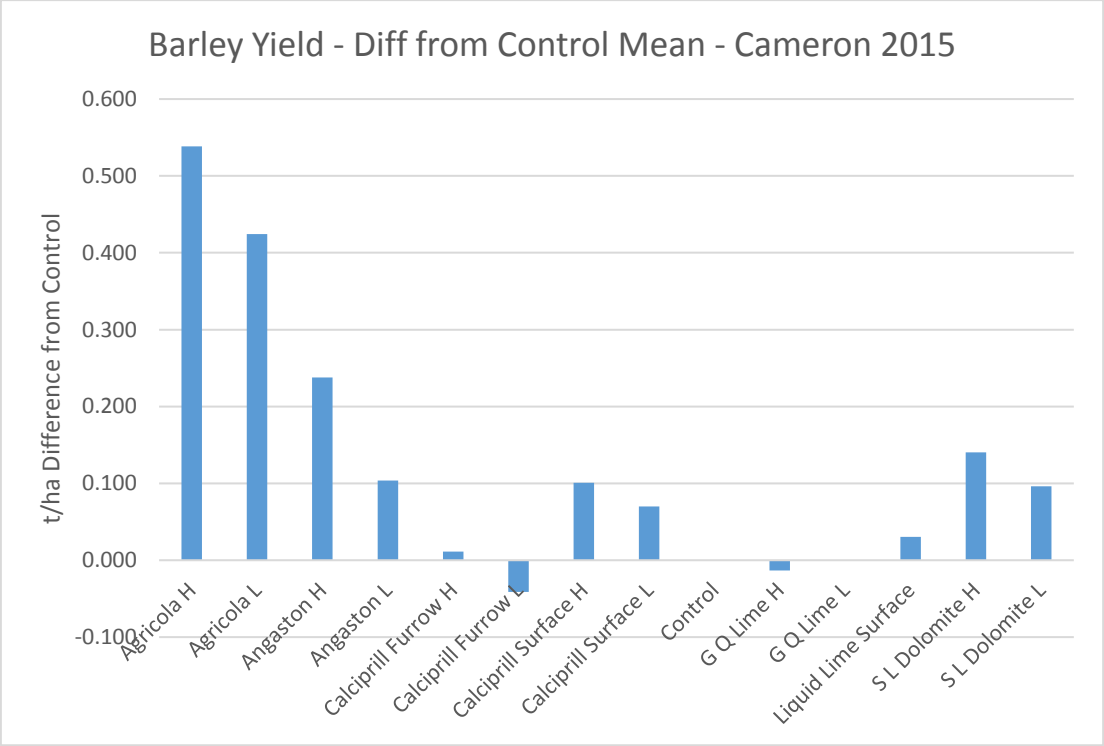


Figure 8 – Cameron's Yield difference from Control by treatment



The results showed a significant effect of treatment (P= 0.034) on yield. Minimum non-zero LSD was 0.2 t/ha. (see Figure 8)

This indicated that the Agricola lime has an effect (both high and low rates, with the higher rate having an increased yield effect). The Angaston High rate of lime has a smaller effect. All other treatments are not significantly different to the control in this year although the means of the Goolwa and Southern Lime products are above the controls. Given the constraints of the season, pH may not have been the strongest limiting factor at the site.

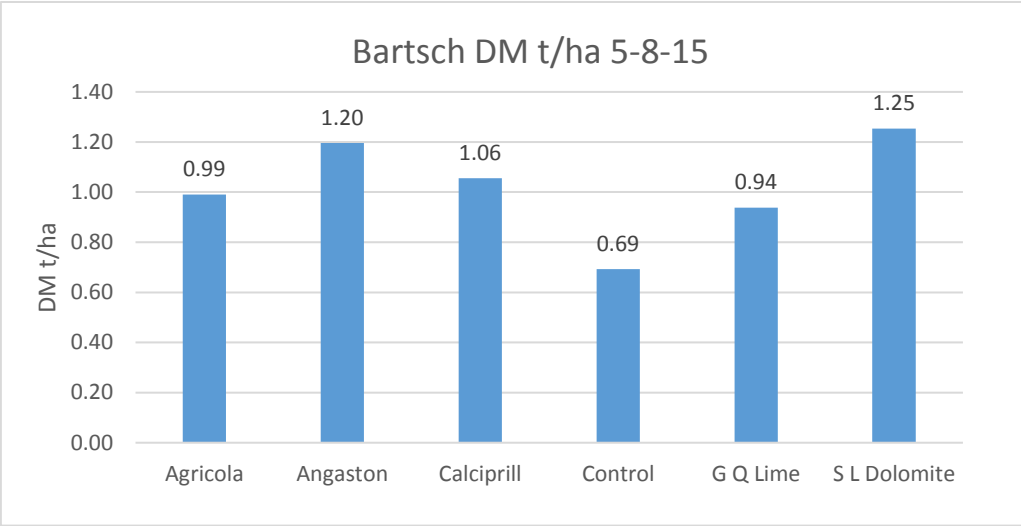
The results also show a trend of higher yields from high lime rates when the same lime sources are compared.

Bartsch's Pasture Site, 2015

The Pasture trial was measured for dry matter on the 5th Aug 2015 and again on the 24th Sept 2015. After this date the pasture died due to lack of rain. (see Figure 9 and 10)

Highest biomass was measured in August. September was a dry month and the pasture was already decreasing in growth rate at this stage in the year.

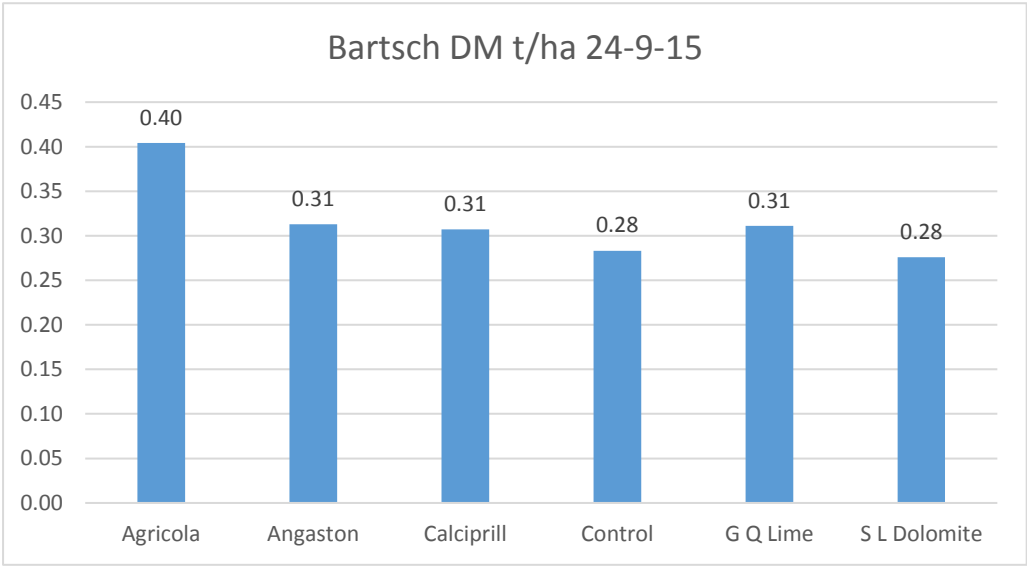
Figure 9 Bartsch Pasture trial dry matter 5/8/15



P = <0.001 *LSD 0.22 t/ha*

In August, all limes showed improvements over the control.

Figure 10 Bartsch pasture trial dry matter 24/9/15



P = 0.226 *LSD = 0.11t/ha*

In September, only Agricola lime showed improvement over the control.

The changes in pasture dry matter production through the season show that the effects of lime vary with seasonal conditions. Only limited monitoring of the pasture production was undertaken.

Results- Year 3, 2016

Cameron's Cropping Site, 2016

A soil pH by depth assessment was undertaken to examine lime movement down the profile.

Soil tests were taken from selected treatments in 2 replicates of the Cameron Trial on 3/3/2016. This is 2 years after the application of lime to the trial site.

Treatments selected were those with high rates of lime, the controls and the Calciprill and Liquid Lime plots.

The samples were taken by hand using a gouge auger, and separated into 2.5 cm depth increments down to 15 cm. These samples were bulked by depth within each plot and sent to APAL for pH analysis.

Depth (cm)	Agricola	Angaston	Calciprill	Calciprill (Furrow)	Control	Control F	G Q Lime	Liquid Lime	S L Dolomite
0 - 2.5	7.0	5.9	5.1	4.7	5.0	4.9	6.7	4.8	6.1
2.5 - 5	5.4	4.8	4.4	4.4	4.5	4.5	4.9	4.5	4.6
5 - 7.5	4.3	4.3	4.3	4.3	4.3	4.6	4.3	4.4	4.5
7.5 - 10	4.1	4.2	4.2	4.5	4.4	4.4	4.1	4.3	4.6
10 - 12.5	4.1	4.2	4.2	4.2	4.4	4.4	4.1	4.3	4.7
12.5 - 15	4.2	4.2	4.2	4.1	4.4	4.3	4.1	4.4	4.8

Table 2- pH by Depth and Treatment

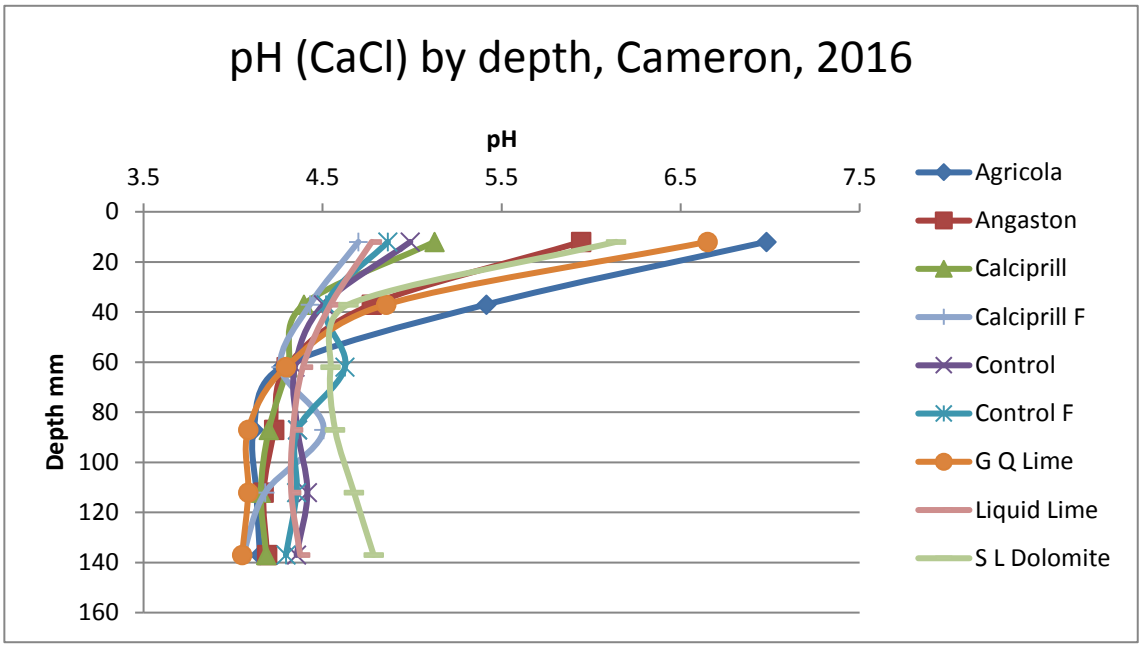
The soil test results show that Agricola, Angaston, Goolwa Quarry Lime (GQ) and Southern Lime (SL) Dolomite have all increased pH in the 0-2.5 cm of the soil. Calciprill (surface), Calciprill (furrow) and Liquid Lime (surface) have not affected the surface pH. (see table 2 and figure 11)

Agricola lime has increased pH in the 2.5 to 5.0 cm of the soil. The other lime products have not significantly affected the 2.5 to 5 cm layer, although Angaston and GQ lime may be moving in that direction.

No lime treatment has altered the pH below 5 cm depth as yet. Southern Lime Dolomite has a higher subsoil pH in the 7.5-15cm zone but expect this is related to the position of the plots for this treatment which are on the very western and eastern end of rep 1 and 2 where the yields and soils have improved somewhat.

No dry matter or yield was measured in 2016 on the Cameron cropping site as the site was established to lupins which are considered very tolerant of acid soils.

Figure 11 pH by depth by treatment, Cameron March 2016



Bartsch's Pasture Site, 2016

A soil pH change by depth assessment was also undertaken for the Bartsch site two years after lime application. Soil samples were collected in April 2016 and tested for pH in 2.5 cm increments down to 10 cm.

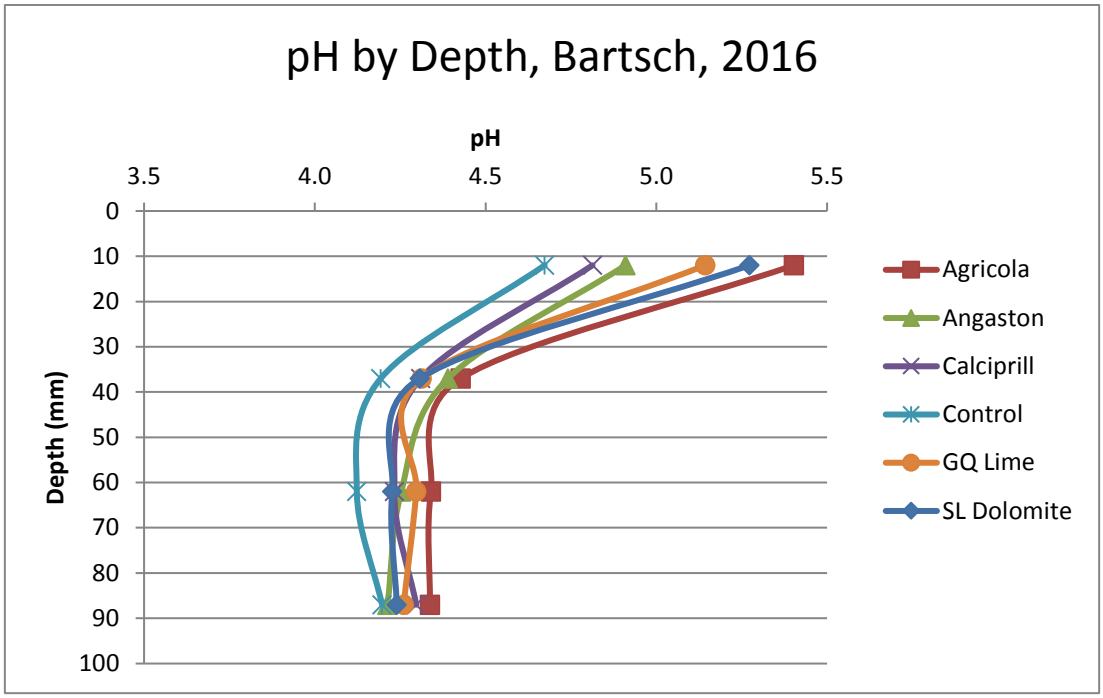
Results showed that the top 2.5 cm had changed pH the most, and that Agricola lime was the most effective, followed by Southern Lime Dolomite and Goolwa Quarries Lime. (see table 3 and Figure 12)

Depth (cm)	Agricola	Angaston	Calciprill	Control	GQ Lime	SL Dolomite
0 - 2.5	5.4	4.9	4.8	4.7	5.1	5.3
2.5 - 5	4.4	4.4	4.3	4.2	4.3	4.3
5 - 7.5	4.3	4.3	4.2	4.1	4.3	4.2
7.5 - 10	4.3	4.2	4.3	4.2	4.3	4.2

Table 3 – pH by Depth and Treatment, Bartsch pasture trial April 2016.

There was very little change below 2.5 cm. This may be because there has been no disturbance of the soil to enable the lime to move faster into the profile. It can be observed from the pasture growth measurements that the lime applied has improved pasture growth even though the depth of the pH change is confined to very shallow parts of the soil profile.

Figure 12- soil pH by depth and treatment, Bartsch site 2016



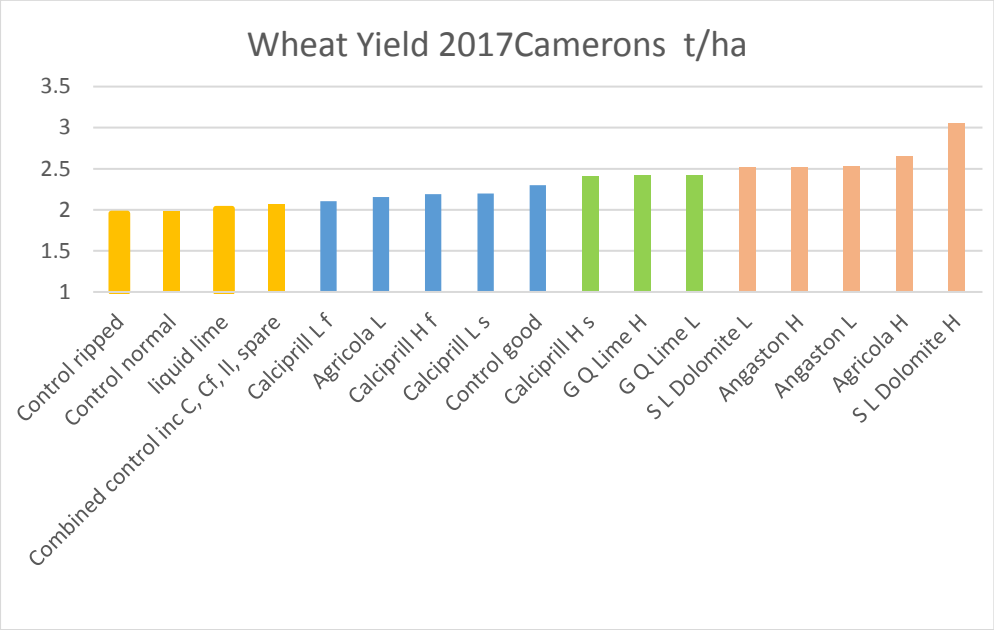
Results- Year 4, 2017-18

Cameron's Cropping Site, 2017-18

In 2017 the site was established to an early- mid season maturing wheat variety. (var. Corack)

The yield of wheat harvested on the site in 2017 is shown below in figure 13.

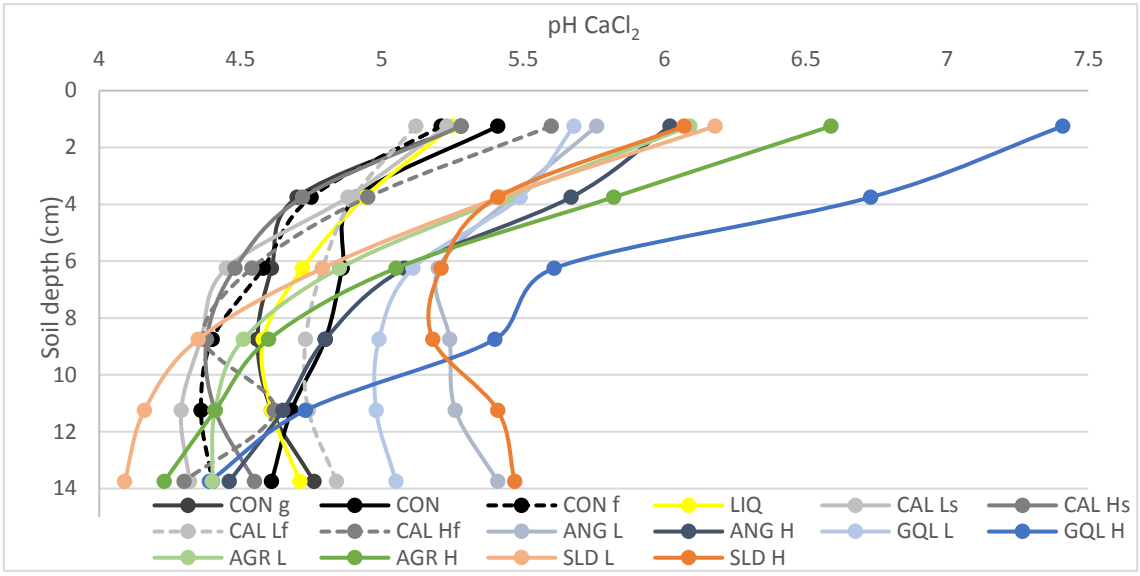
Figure 13 – Wheat yield by lime treatment 2017



Responses were statistically significant with all the high and most of the low lime treatments from the control ripped, control normal and liquid lime. (see Appendix 3) The high rates of the better quality products (SL Dolomite and Agricola) are still provided the best yield response, even after 4 years.

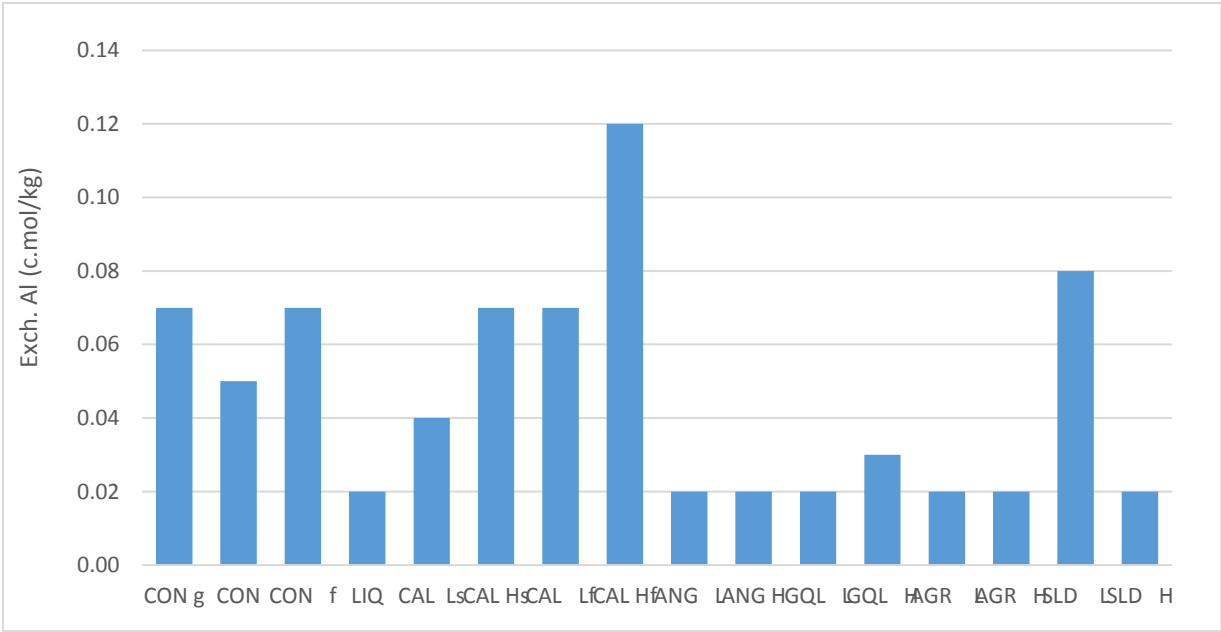
A soil pH by depth assessment was undertaken in March 2018 for single rep only (Rep B- see Figure 14). The site was worked when biochar was incorporated after the depth sampling in 2016. Therefore, some physical movement of lime has taken place through the soil profile to enable most products to get close to 10cms in depth. Three products have a better pH in the 10-15cm layer which are SL Dolomite H, Goolwa Q L and Angaston L- all these are located on the western edge with better growth area of the trial and the increases in pH are more likely to be due to soil variation. Goolwa Q high and Agricola H seem to have had the greatest pH change in this rep.

Figure 14- Soil pH by depth for all treatments in rep B.



The impact of lime treatments on soil Aluminium using the Exchangeable Aluminium test results for 0-10cm samples is shown in figure 15. This highlights much higher Aluminium levels where no lime or Calciprill has been applied in comparison with bulk lime products.

Figure15- Impact of treatments on Exchangeable Aluminium

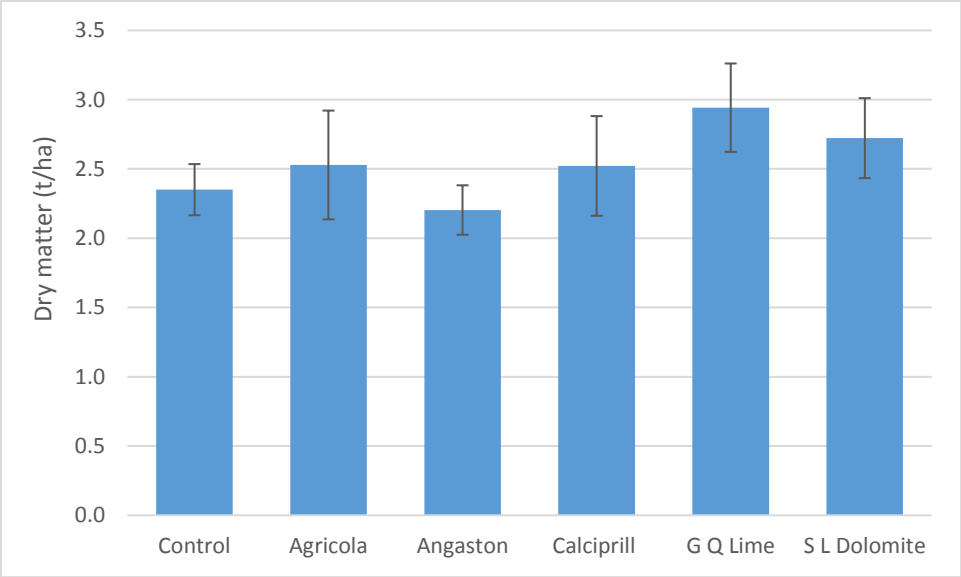


CON g – control good, CON- control normal, CON f- control ripped, LIQ- liquid lime, CAL Ls- calciprill low surface, CAL Hs- calciprill high surface, CAL Lf- Calciprill low ripped, CAL Hf- calciprill high ripped, ANG L- Angaston low, GQL- Goolwa Quarry low, GQL H- Goolwa Quarry high, AGR L- Agricola low, AGR H- Agricola high, SLD L- Southern Lime low, SLD H- Southern Lime high

Bartsch's Pasture Site, 2017-18

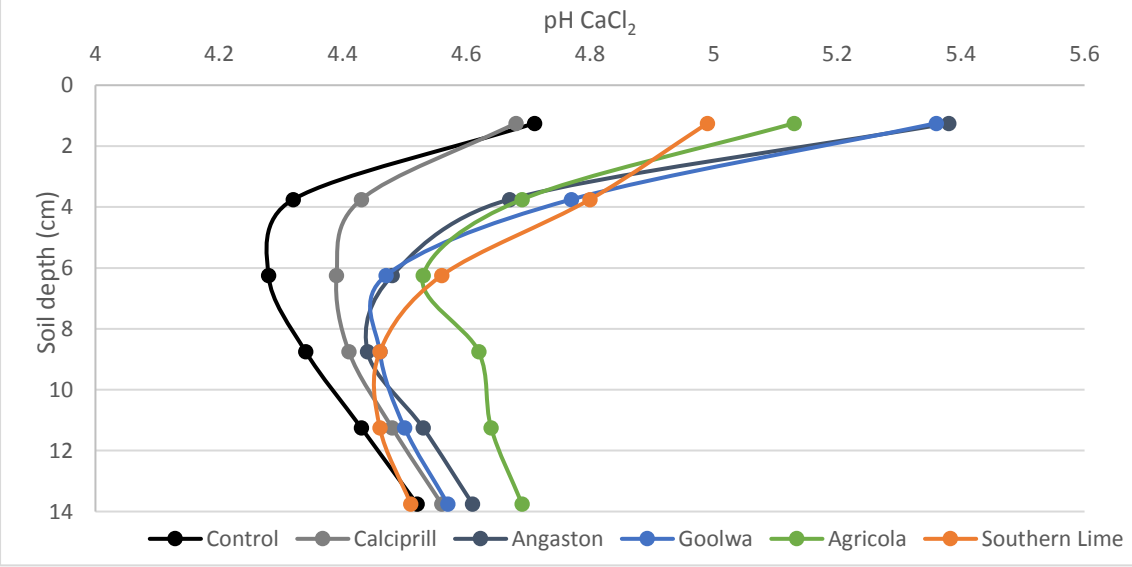
The Bartsch pasture site was cut for dry matter assessment in September 2017 and the dry matter responses are shown in figure 16. Although the graph of the liming treatment means appears to show a response it was not significant in 2017 at the 0.05 confidence level.

Figure 16 – Dry Matter responses by lime treatment, 2017



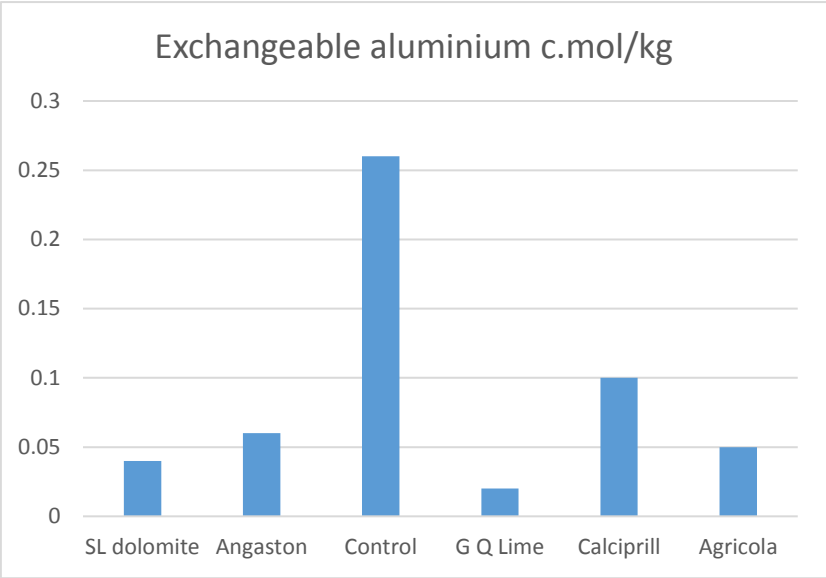
A soil pH by depth assessment was undertaken for rep A in March 2018. No soil disturbance has occurred at this site since the lime were surface applied in 2014. Results in Figure 17 indicate the two coarser products have had the greatest effect down to 2.5 cm while the better quality products have had slighter more impact below 5 cm with only Agricola having an impact below 7.5 cm possibly down to 15cm.

Figure 17– pH by depth and treatment, March 2018



The impact of lime treatments on Aluminium using the Exchangeable Aluminium test as an indicator are shown in Figure 18 with the control and to a lesser extent the Calciprill having higher levels in comparison with the limed plots.

Figure 18- Exchangeable Aluminium by lime treatment, 0-10cm March 2018



Summary and Discussion

Impact on crops

The Cameron cropping trial has demonstrated crop yield responses to lime applications in two of the four years, when sown to barley (sensitive to lime- upto 25%) after 2 years and wheat (moderately tolerant- upto 50%) after 4 years. No response was observed in year 1 and no yield monitoring was undertaken in year 3 when under lupins. Yield responses were more significant with the high quality lime products and at 4 years these better quality lime products were still showing an improved response although coarser products were also having an impact. The higher rate of application (6 t/ha) has resulted in greater responses.

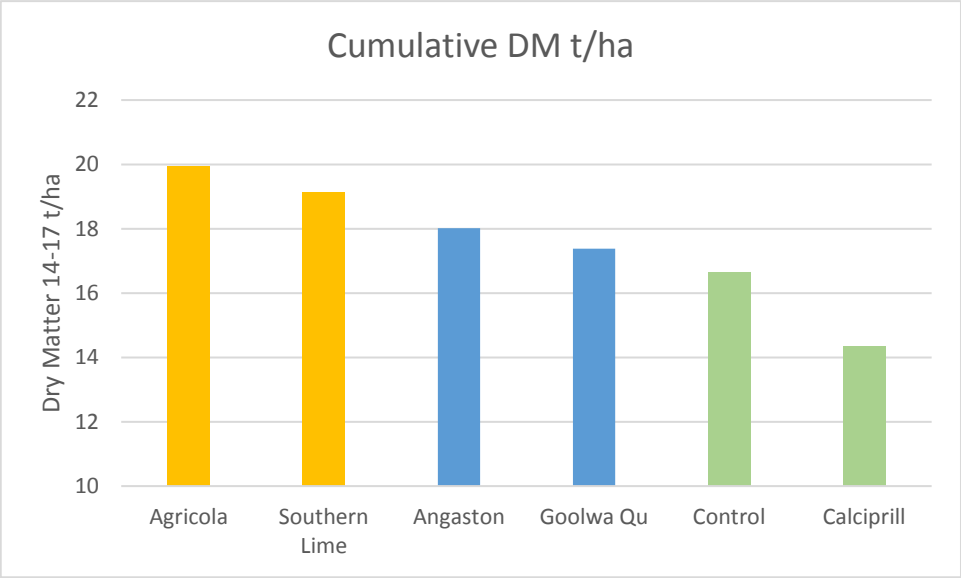
No detection of induced trace element deficiencies were observed due to the application of lime.

The movement of lime reached 5 cm after two years with the paddock worked up in year 3. The better quality limes demonstrated slightly quicker movement through the soil profile.

Impact on pastures

The Bartsch pasture site demonstrated pasture growth responses of an inconsistent nature over the four years of the trial. A cumulative response based on all pasture cuts by lime type is shown in figure 19. Note, these were from selected cuts (1-2 per year) and did not represent all growth. This figure highlights that over the four years increases in dry matter of at least 4-5 t/ha have been achieved over the control plots.

Figure 19 Cumulative Dry Matter Responses from Bartsch Pasture site 2014-17



Calciprill at the recommended rate and applied to the surface did not respond.

Lime movement over the 4 years in this site where no soil cultivation occurred demonstrated that the higher quality products to have moved slightly more down the soil profile with pH change evident at approximately 7-10cms while the coarser products had a greater effect in the top 5 cms and less impact deeper in the soil profile.

Grass tetany effects

One of the initial aims of the project was to look at grass tetany issues. However both sites are considered to be at a low risk of grass tetany due to their ratio of Potassium to Calcium and Magnesium. Plant analysis in November 2016 from the Bartsch pasture site did not find a significant relationship between liming product and plant ratios indicating grass tetany (see Appendix 6). Soil cations from Camerons 0-10cm in 2018 samples showed a similar lack of response. (see Appendix 6)

Comparison of liming products

Due to the design of these trials some comparisons can be made between liming products. In general, the two better quality products seemed to have reacted quicker, moved further into the soil and after 4 years were still outperforming the coarser products. The coarser products were working slowly and moving more slowly throught he soil profile. Angaston quarries have now released a finer grade product which is comparable to Southern Lime dolomite. Even so, the cost needs to be built into this comparison as Goolwa quarry's on farm cost may be considerably less, and Agricola, due to its location, considerable more. This trial also showed little impact from calciprill and liquid lime indicating that the advantage of these products seems to be confined to when their placement into subsoil or planting row offers an immediate and significant advantage. The low rates used and recommendations for these products reflects their relatively high price, and for them to become credible options the price differential needs to drop allowing higher rates to be used.

Lime movement and rates

Lime movement through the soil profile was examined at both sites which highlighted that the old SA standard lime rule of around 2.5cm / year is reasonably close. Also, to achieve impacts below 10cm in depth, lime application rates need to be reasonably high, possibly greater than 2-3 t/ha. The higher rates at Cameron's provided much better yield responses. Further work is still required to examine this impact on subsurface layers.

Future Opportunities

The monitoring of these trial sites could be continued on a casual basis over the next few years.

Cameron's site is partially compromised as the rest of the paddock has had lime applied which means the control areas will have been subjected to alkalinity application via animal movement and excretions. This paddock is likely to now go into pasture for a few years. Of interest would be to observe how deep the higher rates of lime can effect and improve soil pH.

The Bartsch site could have some continued pasture response monitoring and again of interest would be to observe how far the lower rates of lime move into an undisturbed soil.

Appendices

Appendix 1- Lime Quality Assessments of products near MLR- with green background products used in the trials

Source	Neutralising Value %	Effective Neutralising Value %	Calcium %	Magnesium %	Comment
AB Angaston Lime coarse	92	39	36	0.5	Coarse product
AB SL Dolomite	88-95	79-94	24-32	4-7	Fine to handle
Goolwa Quarries lime	81	35	22	6	Coarser to handle
Agricola Robe	85	41 dry, 82 wet	26	5	Dispersive lime not suited to ENV, high surface area
Calciprill	93	9	36	0.7	Granular form not suited to ENV
Other products MLR					
AB Angaston Penlime	97	90	38	0.5	New finer product
Cawtes	87	69	31	2	High surface area

Appendix 2- Managing Soil Acidity Workshop and Field walk Participant Feedback Form Response Summary

1. **How <u>relevant</u> was the workshop to your farm / work area? (please circle)**

   None Little Some Very **13**

2. **How <u>interesting</u> was the information presented today? (please circle)**

   Not at all Of little interest Of some interest Very interesting **13**

3. **How <u>useful</u> was the information presented today to your farm / work ? (please circle)**

   None Little Some **2** Very **11**

4. **What are the three main things that you have learnt from today's workshop?**

determining quality of types of lime x8, different sources of lime X9, affect on 10-20cm layer x2, importance of lime, severity of acidityx3, pH mapping technologies x6, historical works, effectiveness of different products, significance of Al toxicity x3, importance soil testing, economics – need more, acidification rates, accuracy of inoculo kits

5. **Please rank the following sessions? (1 to 5 with and 1 being poor and 5 excellent)**

Session	**Ranking: 3**	**4**	**5**
Introduction to acidity and current lime sources in the North Eastern Hills (Brian Hughes)	1	4	7
Historical Liming Trials and messages (Rebecca Tonkin)	1	3	8
Liming and acidity Monitoring in the Upper River Torrens (Tim Herrmann)	2	4	6
Precision paddock pH testing in grazing and cropping situations (A Harding)	2	4	6
Field visit to trial and pH demo	1	3	8

6. **What is the main soils / land management issue that you would like to address on your property (or as an adviser, in your area)?**

   acidification/ pH x2**, weeds x2, improving perennial composition of pastures, soil testing and determining type and quantity of lime, increasing awareness of acidity- increasing lime and productivityx3, salt, mapping pH and Phosphorus**

7. **What aspect of soil acidity and management would you like more information on?**

   mapping applications, precision applications, lime availability and testing for pH, lime comparisons- economics of each available product

Appendix 3- Statistics from 2017 trials

Cameron's cropping yield 2017

LSD All-Pairwise Comparisons Test of YIELD for TREATMENT

TREATMENT	Mean	Homogeneous Groups
SL Dol H	4123.0	A
Agricola H	3709.5	AB
Angaston L	3539.0	ABC
Angaston H	3516.2	ABC
SL Dol L	3514.7	ABCD
G Q Lime L	3388.5	BCDE
G Q Lime H	3384.7	BCDE
Calprill H	3214.9	BCDEF
Control gd	3135.3	BCDEF
Agricola L	3016.7	CDEF
Calprill L	3012.0	DEF
liquid lim	2821.2	EF
Control n	2779.0	F
Control f	2739.7	F

Alpha 0.05
Critical T Value 2.014
Error term used: Error, 45 DF
There are 6 groups (A, B, etc.) in which the means
are not significantly different from one another.

Appendix 4- Extension Related Activities

A soil acidity workshop was held in October 2014 with various speakers at Mt Pleasant followed by a tour of the Cameron site. Reports have been prepared for Tungkillo Landcare group members, and as article for the AMLRNRMB newsletter. A summary of the participant's response forms is presented in Appendix 2. (attended by 20)

A soil acidity workshop was held at Mt Pleasant NR Centre in May 2015 where this trial was discussed (24 attendees) and a visit of the sustainable agriculture section of PIRSA and some DEWNR staff was made to the site in October 2015.

The trial results were reported in NRMB newsletters in April 2015.

In 2017 results were presented at a Barossa Improved Grazing Group field day at Keyneton (45 participants) and then presented at a follow up meeting in February 2018 (50 participants).

Trial results from Tungkillo have also been used at presentations made at the soil acidity technical workshops in 2015 and 2016 (100 participants), 2017 GRDC update (200 participants), Angaston Ag Bureau 2017 (15 participants), Milang Ag Bureau 2018 (18 participants) and the Pinnaroo Farmers (10 participants).

Lisa Miller from Southern Farming Systems has also requested the results for south west Victoria.

Complimentary Projects

As part of a Landcare Innovations project funded through the Agricultural Bureaus of SA a demonstration site has been developed examining precision pH variation across a paddock on Cameron's. This highlighted that some pH variation occurs across paddocks in the region.

Follow up work through another project has demonstrated the Veris pH mapper more widely in the area.

Examining soil pH at field day

Appendix 5- soil descriptions

Soil Description Sheet

Site:	Cameron Acidity trial	Owner	Bill Cameron
Date:	1/11/2016	Map	54
Location:	Bill Cameron's paddock, off Black Heath Rd, Tungkillo	Easting	see trial map
Project:	Acidity and Lime trial	Northing	
Land Form:	gently rolling hill slope	Photo:	various
Dom spp:	cropping: barley/lupins (lupins 2016)		

Layer	Horizon	Depth (cm) Top	Depth (cm) Bot	Bd	Texture	Fragment Abd	Fragment Size	Munsell	Colour Dom	Colour Mot 1 a	Colour Mot 1 s	Colour Mot 1 c	Colour Mot 2 a	Colour Mot 2 s	Colour Mot 2 c	Structure Grade	Structure Size	Structure Type	Structure 2nd g	Structure 2nd s	Structure 2nd t	Pans t	Pans c	Pans s	Segregations Abd %	Segregations Nature	Segregations Form	Segregations Size	Segregations 2nd a	Segregations 2nd n	Segregations 2nd f	Segregations 2nd s	Carbonate Rctn	Carbonate Class	pH	Moist	Roots Abd	Roots (cm)	Comments
1	A1	0	20	c	LoS	0			Br							V						0			1	Qz, F	F	3					0		5.19	Moist	3		
2	A2e	20	60	s	S	0			Y-Br							sg						0			0								0		5.17	Moist	2		
3	B21	60	80	g	LtC	0			O-Br			Y			R	m	3	sb				0			0								0		5.03	w	1		
4	B22	80	100		LtC	0			O-Br			Y			R	m	3	sb				0			0								0		4.69	w	1		

Dispersion	weak slaking in clay
Repellence	no

Comments

Area has been limed around the trial site and on treatments - only the control plots are unlimed. Biosolids on entire site in 2016.

Most likely Classification: Bleached-Sodic or Bleached Mottled, Eutrophic, Brown Chromosol; thick, non-gravelly, sandy / clayey, deep(?)

Soil Description Sheet

Site:	Bartsch Acidity trial	Owner	Bill Bartsch
Date:	9/11/2016	Map	54
Location:	Bill Bartsch's paddock, Horwood Rd, Tungkillo	Easting	see trial map
Project:	Acidity and Lime trial	Northing	
Land Form:	gently rolling hill slope	Photo:	various
Dom spp:	pasture: barley grass, rye-grass, wild oats, phalaris, naturalised clover & medic spp, storksbill		

Layer	Horizon	Depth (cm) Top	Depth (cm) Bot	Bd	Texture	Fragment Abd	Fragment Size	Munsell	Colour Dom	Colour Mot 1 a	Colour Mot 1 s	Colour Mot 1 c	Colour Mot 2 a	Colour Mot 2 s	Colour Mot 2 c	Structure Grade	Structure Size	Structure Type	Structure 2nd g	Structure 2nd s	Structure 2nd t	Pans t	Pans c	Pans s	Segregations Abd %	Segregations Nature	Segregations Form	Segregations Size	Segregations 2nd a	Segregations 2nd n	Segregations 2nd f	Segregations 2nd s	Carbonate Rctn	Carbonate Class	pH	Moist	Roots Abd	Roots (cm)	Comments
1	A1	0	20		LoS	0			Dk Br							V						0			1	Qz, F	F	3					0		4.36	Moist	3		
2	A2e	20	60	c	S	0			Br							sg						0			0								0		4.72	Moist	2		
3	B21	60	80	a	LtC	0			O			Y			R	m	3	sb				0			0								0		5.54	w	1		
4	B22	80	100	g	LtC	0			O			Y			R	m	3	sb				0			0								0		6.31	w	0		

Dispersion	weak slaking in clay
Repellence	no

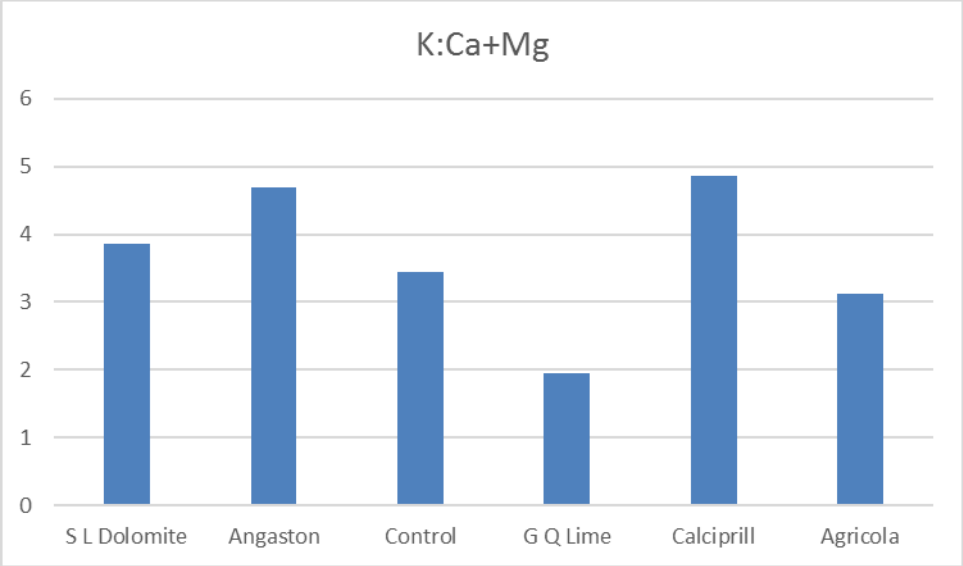
Comments

Most likely Classification: Bleached-Mottled/Bleached-Sodic, Eutrophic, Brown Chromosol; thick, non-gravelly, sandy/clayey, deep (?)

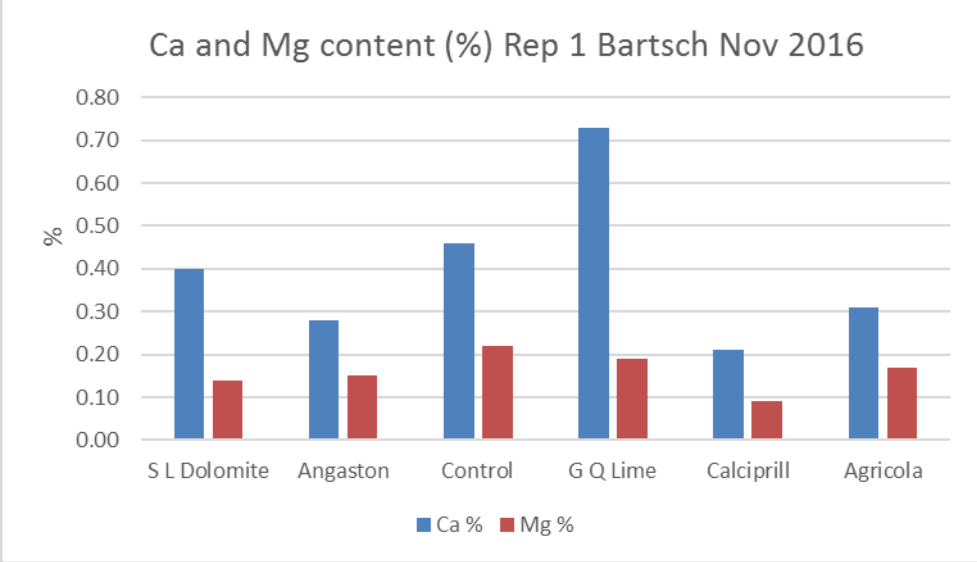
Appendix 6 - Monitoring of Grass Tetany indicators

Plant Analysis Nov 2016 Pasture site

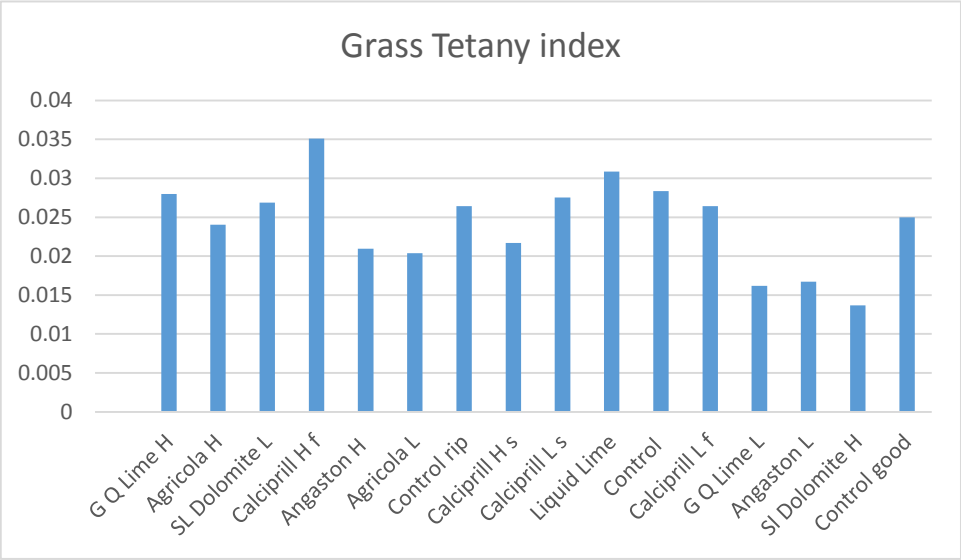
Grass tetany ratio



Ca and Mg content of plants



Soil Indicators of grass tetany Cameron's 2018



If greater than .07-.08 soils are considered at risk of grass tetany.