Soil pH change over time and the outcomes of a farmer led Lime trial, west of Condobolin NSW: a Case study.

Abstract:

In 2014, assessment of a previous soil pH monitoring site, sampled 14 years prior, and a farmer led on-farm lime trial was conducted west of Condobolin NSW. In the on farm lime trial the farmer had independently applied 3 different rates of lime to an area that is subjected to dryland cropping and grazing. The impacts of the varying rates of Lime were assessed via: soil coring, in-crop wheat biomass assessment, tiller counts and volume of grain achieved at physical maturity. Results showed that at the previous soil pH monitoring site, pH levels had decreased and subsurface soil acidification was occurring down to 30cm; and in the on farm lime trial the higher application rate of Lime achieved a higher pH in the top 10cm of the soil profile, prevented soil acidification from reaching lower sections of the soil profile and achieved notably higher plant biomass / number of tillers and volume of grain when compared to no Lime or reduced Lime applications.

Key Points:

1. Visually the impacts of Lime may not be seen, but the benefits of Lime are evident when comparing Limed areas plant biomass and yield with that of un-Limed areas.
2. Application of Lime is shown to halt sub soil acidification which is costly to address and will impact upon future sustainability and productivity of an agricultural enterprise.
3. Appropriate rates of Lime are shown to increases yield.

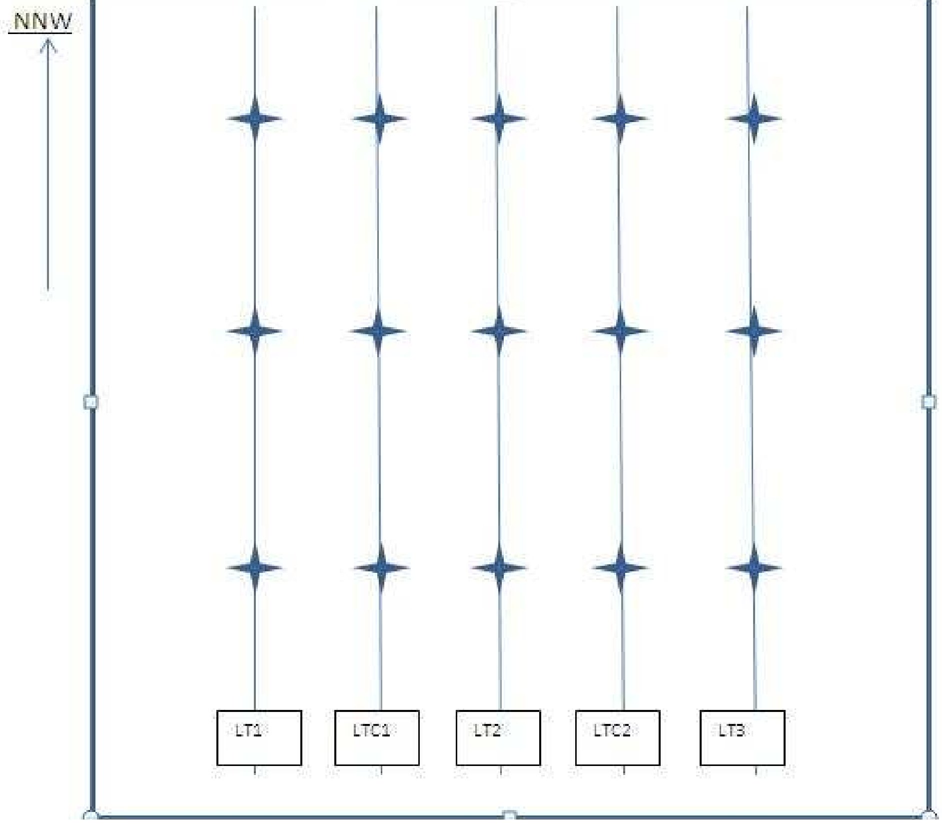
Overview:

On the 28th of April 2014 soil coring was conducted at a property West of Condobolin to identify possible changes in soil pH identified via a previous soil acidity sampling program conducted in the late 90's/early 2000's by Central West Farming Systems (CWFS). Soils of the property are predominantly Red Clay Loam. The operation is a mixed farming enterprise which includes sheep and cropping. Cropping is predominately wheat. The annual average rainfall experienced on the property is 400-425mm. Stubble retention is practiced within the cropping system with stock grazing the stubbles at identified key times.

Data obtained from the previous soil acidity sampling program included a GPS reference point and a single value; 4.8 pH (CaCl). Investigation identified that the figure was obtained from the 0-10cm (approx.) section of the soil profile, with samples randomly collected from the paddock surrounding the GPS location, bulked together, thoroughly mixed, and a 350-400grm representative sample removed and sent away for analysis. In 2014, the original historical sample site was revisited and coring to a depth of 120cm was achieved. To assist in identifying the occurrence of sub soil acidity within the soil profile the 120cm core was divided up into the following sections: 0-10cm, 10-30cm, 30-60cm, 60-90cm & 90 to 120cm. This process was repeated at 5 individual sites distributed every 200mtrs along a single transect running NNW with the original sample site identified as Site1.

Previously, farmer led on farm lime trials have occurred on this property in a separate location. As per; Figure 1, the trial design was 3 separate strips approx 20mtrs wide which were treated with varying rates of Lime. The exact lime application rates were not recorded however rates of lime were applied at the following order of magnitude: LT3>LT2>LT1. The limed strips were separated by approx 20mtr wide "control" strips; LTC1 and LTC2.

Figure 1. On farm, Lime trial site plan.



To identify the outcomes of the liming activities; both limed and un-limed "transects", were sampled at 3 locations along each transect. For each transect sampling sites were separated by approx 200mtrs. Samples were sent to CSBP analytical laboratories for analysis. All pH data is as per CaCl analysis. To maintain an overall indication of each transects pH, as per the previous project, an average from all of the sites from within each of the soil core sections was achieved with results provided in: Table1.

To identify the impact of lime treatments upon the growth of the 2014 wheat crop; biomass cuts were taken at physiological maturity, number of tillers counted and sample weight of grain achieved. Results achieved are provided in Graphs 1 & 2.

Results:

Data shows that for the Historic site pH decreased from 4.8 to 4.5 within the 0-10cm section of the soil profile, a change of 0.3 or a 3 fold increase in increase in acidity – which may be considered to be a moderately significant increase in acidification. Assessment of the remaining soil profile sections (Table 1.) demonstrates the following:

a) 10-30cm: pH of 4.5 was observed, indicating the occurrence of sub soil acidification, significant to impact upon crop growth;

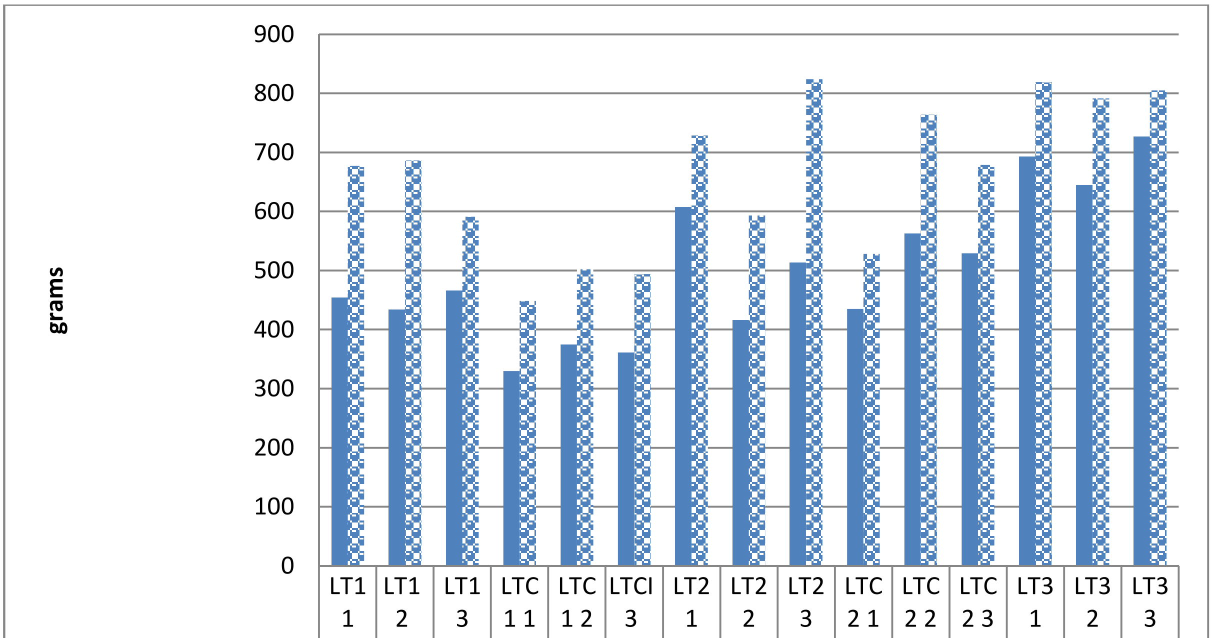
b) 30 – 60, 60 – 90, 90 – 120: as per Table 1, an increase in pH, or an increase in alkalinity, with depth is viewed – as is expected in the Red Clay Loam Soils of this region (Dr N. Fettell, 2014 pers com).

Table.1. Condobolin West property averaged pH readings (CaCl).

Condo West pH (CaCl2) - On farm lime trial - Lime strips .		
Site id	Depth	pH (CaCl)
LT1	0 to 10	5.5
LT2	0 to 10	4.6
LT3	0 to 10	6.0
LT1	10 to 30	5.3
LT2	10 to 30	5.1
LT3	10 to 30	6.5
LT1	30 to 60	6.2
LT2	30 to 60	5.8
LT3	30 to 60	7.6
LT1	60 to 90	7.3
LT2	60 to 90	7.6
LT3	60 to 90	8.0
LT1	90 to 120	8.1
LT2	90 to 120	7.5
LT3	90 to 120	8.3

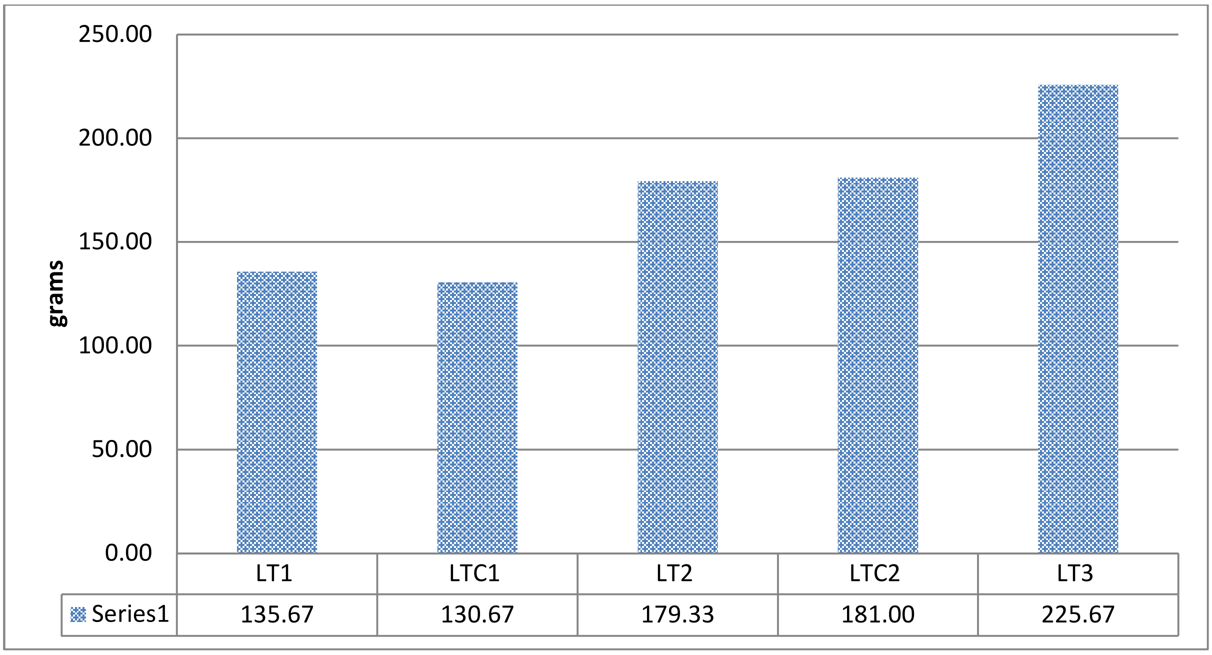
Condo West pH (CaCl2) – On farm lime trial – Control strips (no lime).		
Site id	Depth	pH (CaCl)
LTC1	0 to 10	4.5
LTC2	0 to 10	5.0
LTC1	10 to 30	4.6
LTC2	10 to 30	5.6
LTC1	30 to 60	5.4
LTC2	30 to 60	7.0
LTC1	60 to 90	6.7
LTC2	60 to 90	7.8
LTC1	90 to 120	7.2
LTC2	90 to 120	8.2

Condo West pH (CaCl2) – Historic site. <u>Previous pH: 4.8 (CaCl) @ 0-10 cm</u>	
Depth	pH (CaCl)
0 to 10	4.5
10 to 30	4.5
30 to 60	5.3
60 to 90	7.0
90 to 120	7.9



	LT1 1	LT1 2	LT1 3	LTC 1 1	LTC 1 2	LTCI 3	LT2 1	LT2 2	LT2 3	LTC 2 1	LTC 2 2	LTC 2 3	LT3 1	LT3 2	LT3 3
Dry Weight	454	434	466	330	375	361	607	416	513	435	563	529	693	644	727
Tillers per square mtr	678	687	592	449	503	494	729	593	824	529	764	679	820	792	806

Graph 1. Comparison of dry biomass and number of tillers per mtr square.



Graph 2. Average grain weight by treatment.

Assessment of on farm lime trial results indicate the following (Table 1., Graph 1. & Graph 2.):

a) A relatively consistent order of magnitude within the profiles of the individual limed transects is shown. LT3 has higher pH within the sections of the soil profile than LT1 which has a higher pH within the sections of the soil profile than LT2.

b) As per the historic data set, the profiles generally demonstrate an overall increase in soil pH with depth.

c) Comparison of values achieved for the "Control" strips: LTC1 & LTC2; identify that LTC2 consistently had a higher pH within each of the sections of the soil profile.

d) For LTC1, acidification is evident within both the 0-10 & 10-30cm sections of the soil profile, with pH being significant enough to impact upon plant growth.

e) Biomass dry weight compared with no of tillers per square meter (Graph 1.) shows a relative consistency for transects LT1, LT3 & LTC1. Greatest variation for transects is observed within LT2 and LTC2.

f) A consistent order of magnitude for biomass and no of tillers can be seen within transects: LT3, having more biomass and tillers than LT1, which had more biomass and tillers than LTC1.

g) Data indicates that possible contamination of the transects LT2 and LTC2 occurred at the time of Lime application; ie, lime was applied across both transects in varying rates, as greater variation than expected is seen in the results for each transect when compared with LT1, LTC1 and LT3 which show a consistent trend; ie,

- LTC1= no lime and recorded the lowest pH, volume of grain, biomass and number of tillers per square mtr.
- LT1= least volume of lime but shows an increase in soil pH, volume of grain, plant biomass and tillers per square mtr.
- LT3= maximum volume of lime, shows highest levels of soil pH, volume of grain, plant biomass and tillers per square mtr.

h) Assessment of average grain numbers per transect shows that the highest volume of grain was achieved in LT3 and least within LTC1 – volume of grain correlates with amounts of Lime applied as per the above point (g).

Discussion

Due to the consideration that LT2 and LTC2 may have suffered contamination at the time of application of lime, subsequent discussion will focus upon the remaining transects and the historical site.

The "original" pH of the red clay loam soils of the Western region of NSW is accepted to be non-acidic and have an average pH of 6 (Soilpack, NSW DPI). However variation in pH is known to occur due to topography and vegetation community, with anecdotal evidence for this region identifying that:

a) "Pine & Box country is acidic and the Malle country alkaline"; and,
b) "quartz gravel ridges with Iron Bark growth is acidic country".

Pre farming soil pH data is not available for this location. However, the demonstrated increase in acidity of 0.3 for the 0-10cm section of the profile within the region of the Historical site demonstrates the impacts of farming practices overtime i.e.; application of Nitrogen fertilisers and product removal (Table.1). The impact of not addressing soil acidity within the surface layer of the soil profile acidity is shown via the homogenisation of the soil pH between the 0-10 & 10-30 sections of the Historic site soil profile and LTC1 (no lime) within the trial site. It can be assumed that acidity is moving down through the soil profile causing subsurface soil acidification within the 10-30cm section – significant enough to impact upon plant growth. As the pH of a soil decreases, or becomes more acidic, nutrients such as Nitrogen & Phosphorous become less available to a plant (ARIS, 2008) which is clearly demonstrated in the on farm lime trial via the increase in plant biomass/no of tillers per mtr squared an volume of grain achieved when compared to rates of lime(Graph 1.); eg, LT3: maximum rate of lime +maximum biomass/no of tillers and volume of grain; LT1: minimum rate of Lime + lower biomass / no of tillers and volume of grain; and, LTC1: no lime + least biomass /no of tillers and volume of grain.

Comparison of the pH levels between the Historic site and LTC1 within the Lime trial site identifies the impact of not applying Lime within a cropping operation. Both LTC1 and the Historic site (Table 1.) demonstrate a similar homogenisation of soil pH down to 30cm which is acidic enough to impact upon plant nutrient availability and subsequent growth. The pH of 5.3-5.4 within identified within the30-60cm section of the profile at these locations (Table 1.), indicate the possible start of subsurface acidification occurring at a greater depth.

The comparison of pH levels between the individual profiles of LT1 and LT3 shows that LT3 had the most amount of Lime applied, but pH ranges for both sites are within the acceptable levels for crop growth (Arriss, 2008), however the extra application of Lime at LT3 can be seen to have provided a greater biomass / numbers of tillers and volume of grain (Graph 1.).

Conclusion

Results from this on-farm investigation demonstrate that where cropping activities occur within the Red Clay Loam soils of the Central West of NSW, soil acidification can increase in magnitude over time and that lime is required to ameliorate the effects of agricultural activities; i.e., product removal and nitrogenous fertilisers, which are known to cause soil acidification (Gazey & Davies, 2009). Results also demonstrate that without the application of Lime to a cropping environment, over time, acidification will move down through the soil profile causing sub soil acidification. Subsoil acidification further impacts upon plant growth (Jenson 2010) and associated yield as well as increasing the cost of acid soil rehabilitation (Gazey & Davies, 2009). The long term benefits of applying Lime within the Red Clay Loam soils of the Central West of NSW are clearly demonstrated via the on farm trial; ie,

a) Where the maximum amount of Lime was applied (LT3); a "normal" increase in pH is viewed descending through the profile, the soil pH levels are such that plants can effectively access nutrients within the soil profile, which is reflected in the greater biomass /number of tillers and volume of grain.
b) Where less Lime was applied (LT1) pH levels are still appropriate for plant nutrient uptake however a reduced plant biomass /number of tillers and volume of grain was achieved when compared to LT3.
c) Where no Lime was applied (LTC1), Sub surface acidification is occurring, and the lowest biomass /no of tillers and grain volume was observed.

This on farm Lime trial clearly shows that in a cropping environment, appropriate amounts of Lime are required to maintain soil pH. If Lime is not applied to address factors such as Nitrogenous fertiliser applications and product removal, acidification of the top section of the soil profile will occur. If Lime is not applied at this stage acidification will move down through the soil profile causing subsurface acidification. As soils become more acidic nutrients required for plant growth become less available.

Appropriate rates of Lime applied to a cropping environment mean that the pH of the soil will allow plants to effectively access available nutrients which translate into plant growth, grain yield and maximising the value of fertiliser inputs.

Lime it or Lose it!

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