Soil pH Benchmarking 2020-21

Background

Soil pH is known to be quite variable down the soil profile. Many of our soils have clay at depth and low pH can cause aluminium toxicity which literally burns the fine plant roots, this can severely impact on crop and pasture growth as roots are unable to access soil moisture and nutrients.

Ten paired monitoring sites were selected across the Island with consideration of rainfall, soil type and land use (perennial pasture (Kikuyu) and continuous no-till stubble retention cropping) compared to annual pasture (clover and annual grasses). Soil pH was monitored down to 50 cm.

Method

As part of the Soil Carbon Benchmarking project, all soil samples were also measured for soil pH. Sampling methodology was based on the existing SA long-term pH monitoring site protocols. Ten 'paired' paddocks were selected to compare the effect of rainfall, soil type and management practice on pH to 50 cm (Table 1). In some instances, the annual pasture site was on an adjoining neighbour's property.

Table 1. Site list showing soil type, rainfall, farming system comparison and years under management.

Site		Soil type	Rainfall	Site	Lime history
1A	1	Ironstone	6-700mm	Pasture - Kikuyu	2018 2.5t/ha
1B	2			Pasture - Annual	2018 2.5t/ha
2A	3	Sand over clay	<500mm	Pasture – Kikuyu	-
2B	4			Pasture - Annual	-
3A	5	Ironstone	6-700mm	Pasture - Kikuyu	
3B	6			Pasture - Annual	-
4A	7	Sand over clay	<500mm	Pasture - Kikuyu	2005 2.5t/ha
4B	8			Pasture - Annual	2005 2.5t/ha
5A	9	Ironstone	7-800mm	Pasture - Kikuyu	2010 & 2015 2.5t/ha
5B	10			Pasture - Annual	2010 & 2015 2.5t/ha
6A	11	Sandy loam over clay	6-700mm	Pasture - Kikuyu	-
6B	12			Pasture - Annual	-
7A	13	Sandy loam over clay	<500mm	Crop - continuous	2013 2.5t/ha
7B	14			Pasture - Annual	2016 2.5t/ha
8A	15	Sand over clay	5-600mm	Crop - continuous	2000, 2008, 2015 & 2019 2.5t/ha
8B	16			Pasture - Annual	2002, 2008, 2015 & 2019 2.5t/ha
9A	17	Ironstone	<500mm	Crop - continuous	2020 5t/ha
9B	18			Pasture – Annual	-
10A	19	Sand over clay	5-600mm	Pasture - Multi sps	2017 2.5t/ha
10B	20			Pasture - Annual	-

At each site ten soil cores were collected for depths; 0-5, 5-10, 10-30, and 30-50 cm and bulked to have one sample for each depth and the soil was analysed for pH 1:5 $CaCl_2$.

Results

Soil pH readings down to depth are presented in Table 2. pH($CaCl_2$) less than 5 will restrict root growth, thus limiting crop and pasture plants access to water and nutrients.

The results show that where lime has not been applied (especially sites 3B, 6A, 6B and 10B) had the lowest pH readings in both the topsoil and to depth. Site 4A & 4B had been limed but over 15 years ago and the results show that the site has re-acidified. Site 7B was limed 8 years ago and is also showing signs of re-acidifying. This re-enforces the need to re-apply lime.

A number of sites are showing an ‘acid throttle’ (such as sites 1A, 1B, 7A, 10A). An ‘acid throttle’ occurs when there is a layer of soil with a low pH which would be sufficient to restrict root growth, thus limiting the crops access to water and nutrients. This can occur where lime has been broadcast and has increased the surface pH, but at depth the pH is still very acidic. Compare those sites to sites 8A & 8B where lime has been applied four times in the last 20 years. This constant re-application has driven the lime to depth.

Site 9A has had one application of 5t/ha with some incorporation as it’s a cropping site and shows a good pH down to depth, compared to its adjacent site 9B which has had no lime applied and is highly acidic in the top 10 cm.

Interestingly there appears to be a trend of higher pH($CaCl_2$) in kikuyu pasture than annual pasture. This may be due to the roots of the kikuyu absorbing soil nitrates at depth.

Table 2. pH in calcium chloride for each soil depth.

Site ID	Soil	System		Sample Depth	pH CaCl2
1A	Ironstone	Pasture	Kikuyu	0-5	5.5
1A	Ironstone	Pasture	Kikuyu	5-10	4.7
1A	Ironstone	Pasture	Kikuyu	10-30	5.4
1A	Ironstone	Pasture	Kikuyu	30-50	4.3
1B	Ironstone	Pasture	Annual	0-5	5.3
1B	Ironstone	Pasture	Annual	5-10	4.6
1B	Ironstone	Pasture	Annual	10-30	4.6
1B	Ironstone	Pasture	Annual	30-50	4.5
2A	Sand over clay	Pasture	Kikuyu	0-5	6.1
2A	Sand over clay	Pasture	Kikuyu	5-10	5.5
2A	Sand over clay	Pasture	Kikuyu	10-30	5.6
2A	Sand over clay	Pasture	Kikuyu	30-50	7.3
2B	Sand over clay	Pasture	Annual	0-5	5.8
2B	Sand over clay	Pasture	Annual	5-10	4.7
2B	Sand over clay	Pasture	Annual	10-30	4.8
2B	Sand over clay	Pasture	Annual	30-50	7.4
3A	Sand over clay	Pasture	Kikuyu	0-5	5.3
3A	Sand over clay	Pasture	Kikuyu	5-10	5.0
3A	Sand over clay	Pasture	Kikuyu	10-40	5.2
3A	Sand over clay	Pasture	Kikuyu	40-50	5.4
3B	Sand over clay	Pasture	Annual	0-5	4.6
3B	Sand over clay	Pasture	Annual	5-10	4.7
3B	Sand over clay	Pasture	Annual	10-40	5.0
3B	Sand over clay	Pasture	Annual	40-50	4.5
4A	Ironstone	Pasture	Kikuyu	0-5	4.7
4A	Ironstone	Pasture	Kikuyu	5-10	4.4
4A	Ironstone	Pasture	Kikuyu	10-40	4.6
4A	Ironstone	Pasture	Kikuyu	40-50	5.2

Table 2. cont

4B	Ironstone	Pasture	Annual	0-5	4.4
4B	Ironstone	Pasture	Annual	5-10	4.4
4B	Ironstone	Pasture	Annual	10-40	4.7
4B	Ironstone	Pasture	Annual	40-50	5.2
5A	Ironstone	Pasture	Kikuyu	0-5	5.1
5A	Ironstone	Pasture	Kikuyu	5-10	5.1
5A	Ironstone	Pasture	Kikuyu	10-20	5.0
5A	Ironstone	Pasture	Kikuyu	20-50	4.9
5B	Ironstone	Pasture	Annual	0-5	5.3
5B	Ironstone	Pasture	Annual	5-10	5.1
5B	Ironstone	Pasture	Annual	10-30	4.9
5B	Ironstone	Pasture	Annual	30-50	4.7
6A	Loam over clay	Pasture	Kikuyu	0-5	4.7
6A	Loam over clay	Pasture	Kikuyu	5-10	4.5
6A	Loam over clay	Pasture	Kikuyu	10-20	4.6
6A	Loam over clay	Pasture	Kikuyu	30-50	5.3
6B	Loam over clay	Pasture	Annual	0-5	4.2
6B	Loam over clay	Pasture	Annual	5-10	4.3
6B	Loam over clay	Pasture	Annual	10-20	4.4
6B	Loam over clay	Pasture	Annual	20-40	4.8
7A	Sandy loam over clay	Crop	Continuous	0-5	5.2
7A	Sandy loam over clay	Crop	Continuous	5-10	4.6
7A	Sandy loam over clay	Crop	Continuous	10-30	4.8
7A	Sandy loam over clay	Crop	Continuous	30-50	6.0
7B	Sandy loam over clay	Pasture	Pasture	0-5	4.8
7B	Sandy loam over clay	Pasture	Pasture	5-10	4.4
7B	Sandy loam over clay	Pasture	Pasture	10-20	4.6
7B	Sandy loam over clay	Pasture	Pasture	20-50	5.7
8A	Sand over clay	Crop	Continuous	0-5	5.3
8A	Sand over clay	Crop	Continuous	5-10	5.2
8A	Sand over clay	Crop	Continuous	10-30	5.6
8A	Sand over clay	Crop	Continuous	30-50	5.8

Table 2. cont

8B	Sand over clay	Pasture	Pasture	0-5	5.5
8B	Sand over clay	Pasture	Pasture	5-10	5.3
8B	Sand over clay	Pasture	Pasture	10-30	5.6
8B	Sand over clay	Pasture	Pasture	30-50	5.9
9A	Ironstone	Crop	Continuous	0-5	6.2
9A	Ironstone	Crop	Continuous	5-10	5.4
9A	Ironstone	Crop	Continuous	10-40	5.3
9A	Ironstone	Crop	Continuous	40-50	5.7
9B	Ironstone	Pasture	Pasture	0-5	4.9
9B	Ironstone	Pasture	Pasture	5-10	4.9
9B	Ironstone	Pasture	Pasture	10-35	5.2
9B	Ironstone	Pasture	Pasture	35-50	5.5
10A	Sand over clay	Pasture	Multi sp	0-5	5.1
10A	Sand over clay	Pasture	Multi sp	5-10	4.5
10A	Sand over clay	Pasture	Multi sp	10-30	4.7
10A	Sand over clay	Pasture	Multi sp	30-50	5.4
10B	Sand over clay	Pasture	Annual	0-5	4.8
10B	Sand over clay	Pasture	Annual	5-10	4.4
10B	Sand over clay	Pasture	Annual	10-30	4.4

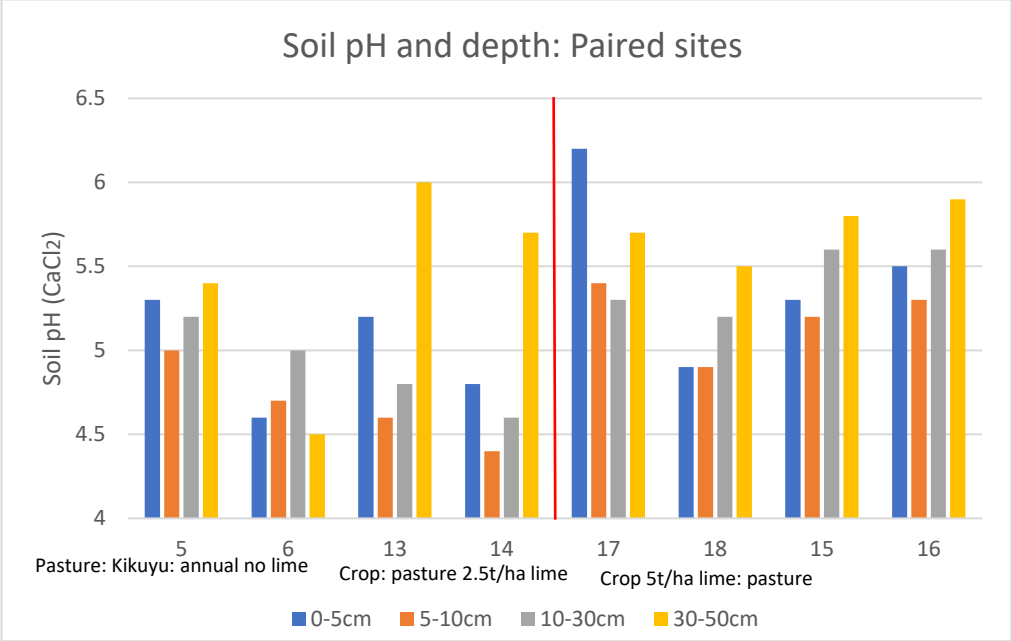

Figure 1. soil pH changes to depth under different management systems

Figure 1. illustrates the impact that the management system and lime application can have on soil pH. Site 5 was a kikuyu site and although had not been limed showed a higher pH down the profile compared to the adjacent annual pasture. Sites 13 and 14 had both been limed but show indications of an acid throttle at 5-10 and 10-30 cm. Note: an acid throttle is a layer of soil with a low soil pH that is sufficient to restrict root growth.
Site 17 has had one application of 5 t/ha with some incorporation and shows a good soil pH to depth
Site 15 and 16, had been limed four times in the last 20 years (2.5 t/ha per year). The constant re-application has driven the lime to depth.

Fifteen of the twenty sites (75%) had pH ($CaCl_2$) values below 5.0 within the 0-30 cm depth and six of those fifteen sites had pH ($CaCl_2$) values below 4.5 within the 0-30 cm depth.

Liming has increased soil pH, but soils will re-acidify over time. Repeated lime applications can help drive the pH change down the profile. A single once off heavy application (with incorporation) can have the same impact – but care must be taken to ensure the soil is not over limed as this can induce trace element deficiencies such as Manganese and Zinc.

There was a trend of higher pH ($CaCl_2$) in kikuyu pasture than annual pasture.

Take home message

- The majority of sites had a soil pH less than pH 5.0 ($CaCl_2$) which will reduce crop and pasture productivity and reduce profitability.
- Soils should be sampled at 0-5 and 5-10 cm rather than 0-10 cm. There is often an 'acid throttle' that is missed if sampling at 0-10 cm.
- Soils that have been limed will acidify over time. An application of lime every 5-6 years may be necessary to keep the soil pH above pH 5.0 ($CaCl_2$).
- Deep rooted perennial grass dominant pastures can be less acidifying than annual pastures.

Funding/Sponsors

Department of Environment and Water

Kangaroo Island farmers who provided sites for monitoring

For further information contact

Lyn Dohle, PIRSA Kingscote:
M 0419 846 204
E lyn.dohle@sa.gov.au

Or contact the PIRSA Office Kingscote for a full copy of the report