Is soil acidity affecting perennial pastures in the NAR?

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Background:

Soil acidity is a major issue confronting Western Australian agriculture. Extensive soil sampling completed by DAFWA and Precision SoilTech throughout the WA wheatbelt over the last 10 years has shown that 70% of wheatbelt top soils have a pH below 5.5 and 50% of wheatbelt sub soils have a pH below 4.8. Crop and pasture production can suffer when grown on soils with these levels of soil acidity. This is primarily because acid sub soils have elevated levels of soluble Aluminium, which is toxic to roots and restricts their growth.

There is a paucity of soil acidity data for the coastal sandplain north of Perth where perennial pastures are increasingly being grown. To remedy that Evergreen Farming obtained funding from NACC and the Federal Government last year to gather some preliminary data on the extent and severity of soil acidity under perennial pastures in the Northern Agricultural Region (NAR).

Method:

Twenty farms belonging to Evergreen Farming members, spread from Gingin to Geraldton, were chosen to take part in the project. On each farm two paddocks of perennial pastures were monitored, and within each paddock, 5 separate sites were sampled to account for any soil type and spatial variability. At each site, soil was sampled at 5 different depths: 0-10cm, 10-20cm, 20-30cm, 30-40cm and 40-50cm. The sites were all sampled in April 2016 by Precision SoilTech, a specialist soil sampling company based in Perth. They then analysed each sample for soil pH in May 2016.

Each participating farmer received a personalised report from Precision SoilTech with the soil pH at each sample site and depth colour coded (red = highly acidic, orange = acidic, yellow = slightly acidic, green = ideal, blue = neutral / alkaline) and overlaid on to an aerial photo. This makes interpretation of the information incredibly easy.

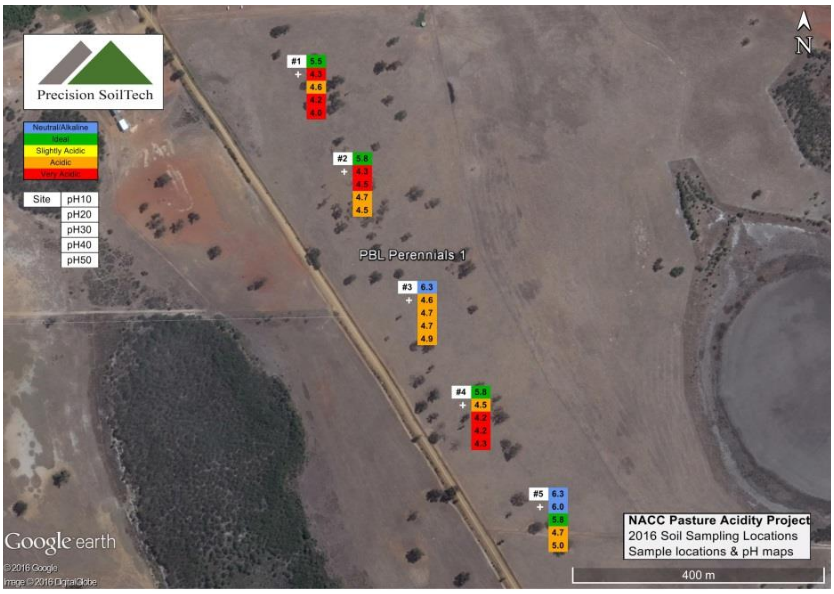

Figure 1: An example paddock report showing the exact location of each sampling site and soil pH has been colour coded for easy interpretation.

Results:

The results from the 200 sample sites in this project showed remarkable similarities with the previous Wheatbelt study mentioned at the start of this article. In this project, 75% of top soil (0-10cm) samples had a pH less than or equal to 5.5 (Figure 2), 45% of sub soil (20-30cm) samples had a pH less than or equal to 4.8 (Figure 3), and 45% of super sub soil (40-50cm) samples had a pH less than or equal to 4.8 (Figure 4).

When the distribution of soil pH in the top soil (0-10cm) is compared to the sub soil (20-30cm), it is easy to see that the sub soil pH is on average more acidic (Figures 2 and 3). The average pH of the 200 top soil (0-10cm) samples was 5.2, compared to 4.9 for the sub soil (20-30cm) and 5.0 for super sub soil (40-50cm).

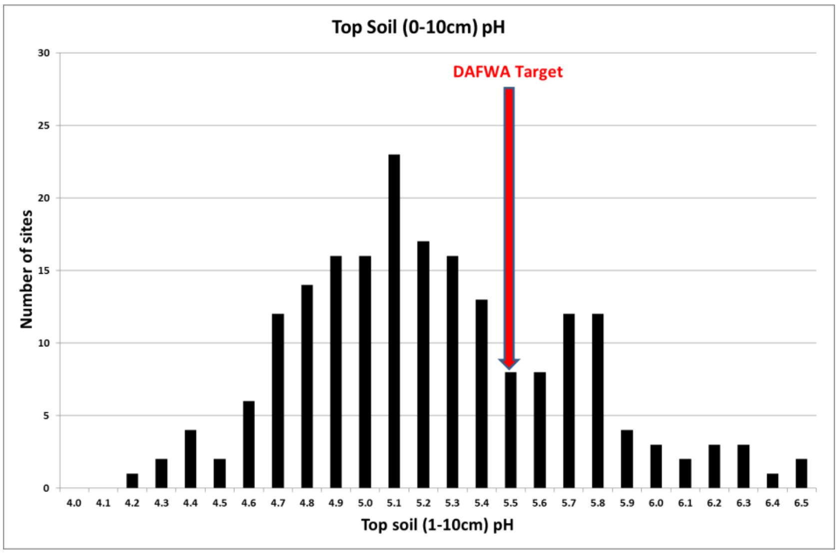

Figure 2: The frequency distribution of top soil (1-10cm) pH from the 200 sample sites involved in this project. The red arrow indicates the DAFWA top soil pH target of 5.5.

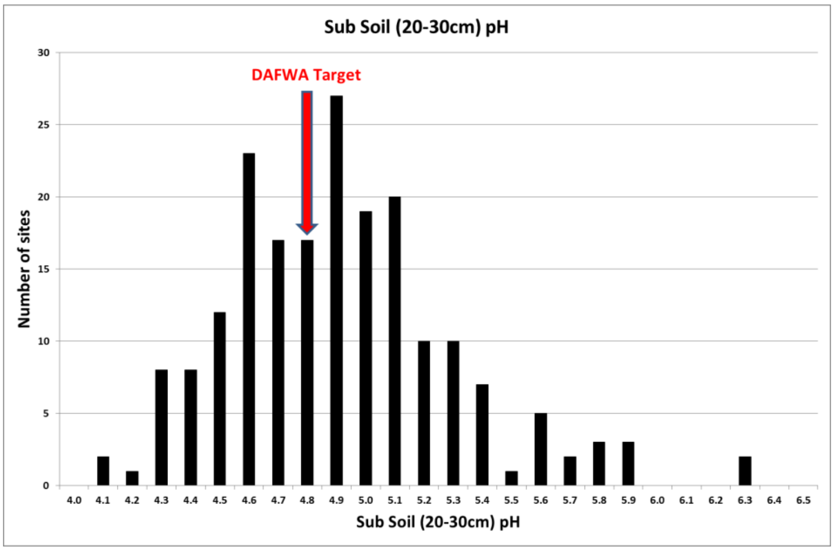

Figure 3: The frequency distribution of sub soil (20-30cm) pH from the 200 sample sites involved in this project. The red arrow indicates the DAFWA sub soil pH target of 4.8.

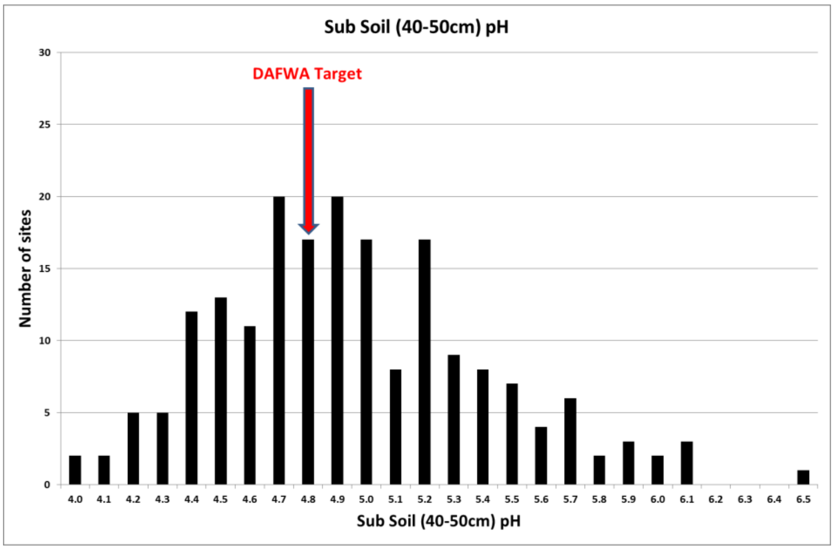

Figure 4: The frequency distribution of super sub soil (40-50cm) pH from the 200 sample sites involved in this project. The red arrow indicates the DAFWA super sub soil pH target of 4.8.

A small number of the project participants had applied lime to their perennial pasture paddocks, while the majority hadn't. Table 1 shows data from a paddock at Walkaway that hasn't received any lime, with the top and subsoil either acidic or highly acidic. In contrast, Table 2 shows data from a paddock at Gingin that has received 4 ton/ha of lime over the last 5 years. The top soil is now in the ideal to neutral range, while the subsoil is still acidic to very acidic.

Table 1: The soil pH at each depth from 5 sites within a Walkaway paddock that hasn't received lime. Note the similarity of topsoil and subsoil pH.

	0-10cm	10-20cm	20-30cm	30-40cm	40-50cm
Walkaway 1	4.6	4.2	4.5	4.3	4.4
Walkaway 2	4.7	4.5	4.6	4.6	4.3
Walkaway 3	4.3	4.9	4.9	4.7	4.6
Walkaway 4	5.3	4.9	4.9	4.9	4.8
Walkaway 5	4.8	4.6	4.6	5.0	4.6

Table 2: The soil pH at each depth from 5 sites within a Gingin paddock that has received 4 ton/ha of lime over the last 5 years. Note the significant increase in topsoil pH compared to subsoil pH.

	0-10cm	10-20cm	20-30cm	30-40cm	40-50cm
Gingin 1	5.5	4.3	4.6	4.2	4.0
Gingin 2	5.8	4.3	4.5	4.7	4.5
Gingin 3	6.3	4.6	4.7	4.7	4.9
Gingin 4	5.8	4.5	4.2	4.2	4.3
Gingin 5	6.3	6.0	5.8	4.7	5.0

Discussion:

The data from this project shows that topsoil and subsoil acidity is just as prevalent under perennial pastures in the Northern Agricultural Region as it is on cropping land in the Wheatbelt. The advice given to wheatbelt farmers for many years has been its “time to lime”. Does the same advice apply to NAR farmers with perennial pastures?

Liming:

DAFWA conducted 69 long term lime trials across the wheatbelt between 1991 and 2012. The average response was a 12% increase in crop yield, two or more years after liming. This is a great data set but unfortunately all 69 trials looked at crop yield responses to liming. None of them looked at pasture production.

Western Dairy has conducted one lime response trial in heavily fertilised annual ryegrass pastures at the Vasse Research Station near Busselton over the last 5 years. Responses to lime have been minimal until this year (2016), when a 10% improvement in pasture production occurred where lime was incorporated 5 years ago. Western Dairy would like to conduct more lime trials over a wider range of soil types to better understand responses to lime in South West dairy pastures.

The lack of long term lime trial data for pastures not only in the NAR but across the state makes it hard to accurately describe what effect liming would have on perennial pastures in NAR. More research is needed.

Having said that, understanding the impact that liming has had on wheatbelt soils is instructive. Figure 5 shows how the soil pH has changed throughout the profile over 20 years following different rates of surface applied lime in 1991 at Kellerberrin. The control treatment, without any lime, has very acidic top and sub soil well below the DAFWA targets. In comparison, the 5 ton/ha of lime treatment has significantly higher top and sub soil pH, which meet or exceed the DAFWA targets. Additionally, aluminium levels throughout the soil profile have declined to below the target level of 2ppm where 5 ton/ha of limes was applied.

It is important to note that surface applied lime will only move down the profile and improve sub soil pH when the top soil has a pH greater than 5.8. If the top soil is very acidic (e.g. 4.5), it might take 2 to 4 ton/ha (or more) of lime to get the top soil pH to 5.8. Then and only then will further applications of lime start working on improving the pH of the sub soil. So, there are two critical elements in dealing with sub soil acidity. Firstly, applying enough lime so that it can move down the profile after having dealt with top soil acidity. And secondly, being patient as the process of lime moving down the profile can take many years to occur. To speed up this process, a number of wheatbelt farmers are using deep ripping (+/- inclusion plates), spading and ploughing, but this is obviously not something that can be done after a perennial pasture has been planted! However, one of the participating farmers in this project applied lime and spaded one of his paddocks 18 months prior to sowing perennial pastures to reduce non-wetting and improve sub soil acidity.

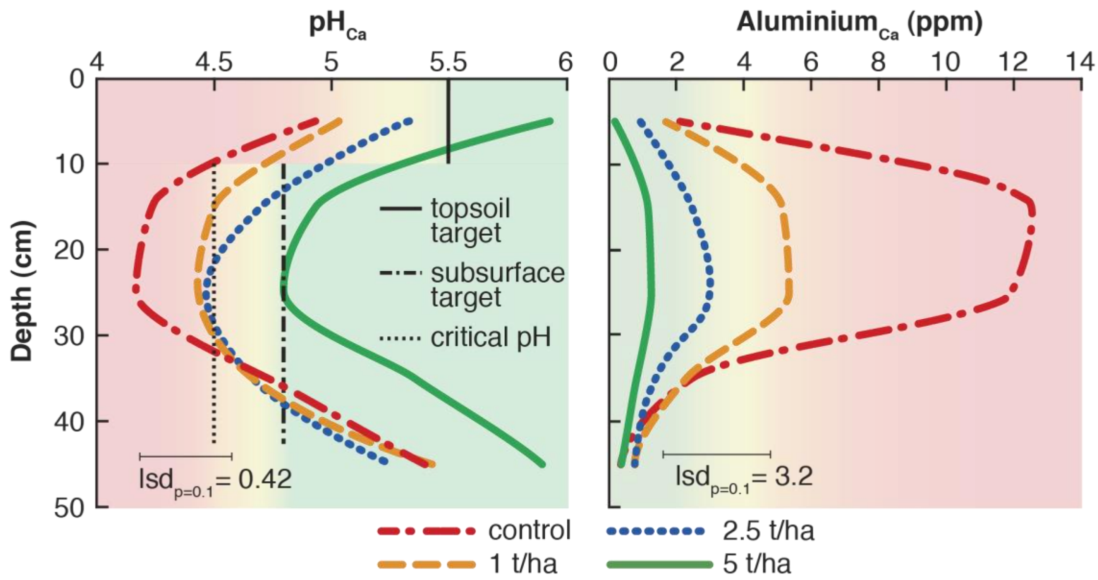

Figure 5: Changes in soil pH and aluminium at different depths after 0, 1, 2.5 and 5 ton/ha of lime in 1991 at Kellerberrin. A further 1 ton/ha of lime was applied across the site in 2000. Source: DAFWA

Acid Tolerance:

Each and every crop and pasture species has a different level of tolerance to soil acidity (Figure 6). Some plants, such as chickpeas, faba beans and medic are very intolerant to soil acidity and won't grow unless soil pH is greater than 5.5 or 6.0. While others such as couch, kikuyu, lupins and cereal rye can grow in very acidic soils down to a pH of 4.0, although they will be more productive at higher pH levels. A number of very important crop species including wheat, barley, canola and oats are somewhere in the middle in terms of acid tolerance.

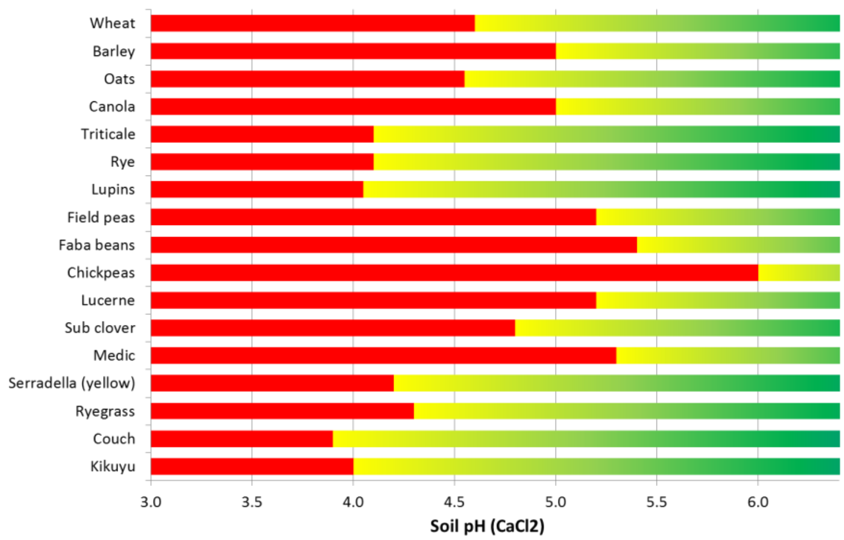

Figure 6: The optimum soil pH range for a number of commonly grown crops and pastures. Red = pH too low, toxicities or deficiencies occur. Yellow = pH in critical range, plants not attaining maximum productivity. Green = pH in optimum range for productivity. Source: Wheatbelt NRM (adapted from DAFWA Farmnote 47/2002)

Growing acid tolerant plants is one way of coping with soil acidity, but only to a point. Due to product removal and leaching, soils become more and more acidic each year. By not applying lime and only relying on acid tolerant plants, soil pH will continue to fall. Eventually the acid tolerant plants will start to suffer and productivity will be lost. The end result will be a farm with lower productivity and a much bigger lime bill to overcome the top and sub soil acidity.

Further research:

This study has raised a number of knowledge gaps that require further research. They include:

1. What is the impact of soil acidity on pasture production in the NAR? How does this vary between different pastures species? And what are the economics of liming?
2. What is the pH of the soil profile below 50cm, given perennial pasture roots can be up to 3.5 metres deep? And does acid soil at depth influence water and nutrient uptake?
3. High soil aluminium levels impair root growth in acid soils. But what are the aluminium levels in our coastal NAR sands?
4. What is the acidification rate of soils growing perennial pastures? Do the deep roots of perennials (potentially recycling leached nitrogen) and low product removal (in the form of livestock) mean acidification rates are lower than for annual crops and pastures? Will this reduce the maintenance amount of lime required in the future once the initial acidity is dealt with?

Summary

This project has shown that top and sub soil acidity is commonplace in NAR perennial pasture paddocks. But what precisely this is doing to perennial (and annual) pasture production and persistence is not entirely known, and needs to be the topic of further research.

This project was delivered by Evergreen Farming. It was supported by NACC through funding from the Australian Government's National Landcare Programme.