Soils – the engine room for our plants

Ruth Chalk
Project Officer Resource Management, Subtropical Dairy

Plants need water, nutrients and sun to grow, and soils are the tank that holds and releases both our water and nutrients. It is therefore vital that we take care and understand our soils and the role that it plays in growing our crops and pastures.

Soils and their performance and function is a complex science. So much of what we do relies on the function and efficiency of our soil to make high quality forage. Comparably, Australia has naturally low soil fertility by world standards. As such it is very important that we manage soil fertility and its health in order to remain productive for the future.

There are many physical, chemical and biological components that need to be assessed when looking at soil health, but as a start, you can look at soil pH, organic matter, cation exchange capacity, and calcium to magnesium ration (Ca:Mg). The most important step to understanding the current status of these four indicators is by getting a soil test.

It is recommended that a soil test is taken by a qualified person and that the lab performing the analysis is both accreditated for NATA (National Association of Testing Authorities) and ASPAC (Australasian Soil and Plant Analysis Council). The comprehensive soil test will range between $140 to $200 per test depending on the advice given and the analysis performed. The cost of performing soil testing across your farm is minimal compared to the $35,000 (QDAS 2018) worth of fertiliser applied each year across the farm.

Some of the soil health indicators are interlinked, so it is advised that you speak to an agronomist before embarking on the application of fertiliser and amendments.

Soil pH

Soil pH, whether it be acidic, neutral or alkaline, is extremely important in relation to nutrient availability for plant growth. Some plants thrive in more alkaline soils (e.g. asparagus, beets, carrots) more than others and conversely some plants are more tolerant to low soil pH (e.g. lupins, sorghum, triticale, oats, kikuyu). The table below shows the effect of soil pH on nutrient availability to the plant. As the soil gets more acidic below 5.5 pH ($CaCl_2$:1:5) the availability of nitrogen, phosphorus, potassium and sulfur declines. As the soil pH increase over 8 ($CaCl_2$:1:5), phosphorus and nitrogen become less available. It is important to know which method is being used to measure the soil pH. The two methods are Calcium Chloride ($CaCl_2$ (1:5)) or water (1:5). As a guide, the soil pH $CaCl_2$ (1:5) result will be about 0.5 to 0.8 of a unit below soil pH water (1:5).

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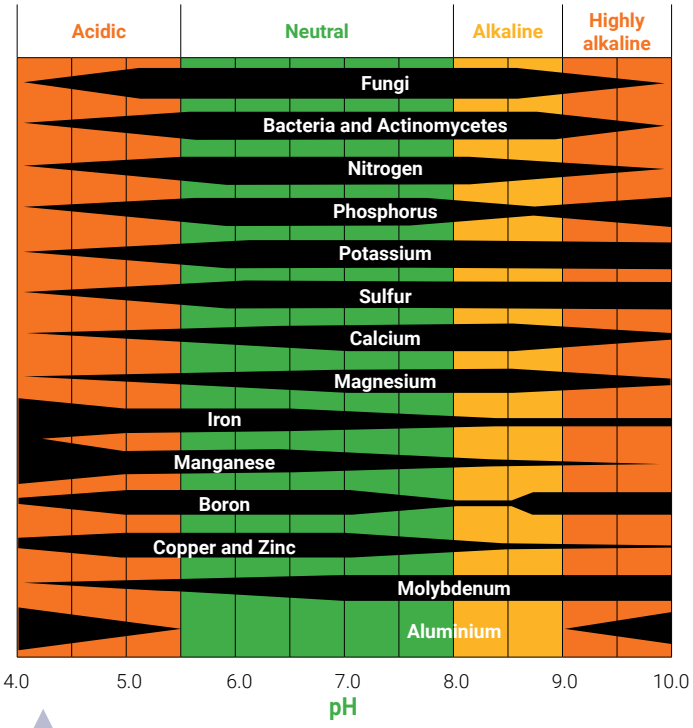

Effect of pH (1:5 water) on nutrient availability. ***Source:*** *Incitec Pivot LTD (2008) Agronomy Advantage Manual*

Soil test ECEC (cmol (+) /kg	Lime required (t/ha) to lift the pH of the top 10cm:			
	From 4.0 to 5.2	From 4.3 to 5.2	From 4.7 to 5.2	From 5.2to 5.5
1	1.6	0.8*	0.3*	0.2*
2	2.4	1.2	0.5*	0.4*
3	3.5	1.7	0.7	0.5*
4	3.9	2.1	0.9	0.6
5	4.7	2.5	1.1	0.7
6	5.5	3.0	1.2	0.8
7	6.3	3.3	1.4	1.0
8	7.1	3.8	1.6	1.1
9	7.9	4.2	1.8	1.2
10	8.7	4.6	1.9	1.3
15	12.5	6.7	2.8	1.9

0.5 t/ha
1.0 t/ha
1.5 t/ha
2.0 t/ha
2.5 t/ha
3 to 4 t/ha
Split applications advised**

Limestone required (fine and neutralising value (NV) > 95) to lift pH ($CaCl_2$) of the top 10cm of soil to 5.5. ***Source:*** *AgFacts NSW DPI, Soil Acidity and liming*

**It is recognised that low rates of lime are impractical to apply, but over-liming can cause nutrient imbalances, particularly in these light soils **Do not apply greater than 4 t/ha in a single application , so as to minimise any problems that could arise from over liming.*

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Organic Matter

Soil organic matter is a build-up in the soil of partly decayed plant and animal residues. The major roles of organic matter in the soil are adding nutrients and improving the soil's structure and water holding capacity. Soils with low organic matter have 'poor' structure, hold little water and erode or leach nutrients easily. Whereas, soils with high levels of organic matter have 'good' structure, good water-holding capacity and reduced erosion and leaching. When organic matter is fully broken down, one of the things that is left is humus. Humus has some useful qualities such as its ability to adsorb nutrients and higher quantities of water (than clay). Increasing soil organic matter rapidly can be a very expensive exercise, so it is important to develop a sound economic and agronomic plan to improve its levels. Activities that will help improve soil organic matter include mulching, minimum tillage practices, cover crops, and addition of manures (regularly monitoring of potassium, sulfur, salt and heavy metal levels need to occur with this practice).

Cation exchange capacity (CEC)

Nutrients in the soil that have charges are called ions. Some carry positive charges (cations e.g. Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Potassium (K^{+}) and Sodium (Na^{+}) and some carry negative charge (anions e.g. Nitrate (NO_3^-), Sulfate (SO_4^{2-}). CEC is a measure of the soil's capacity to absorb and hold cations. This measurement provides an indication of the amount of nutrients available in the soil, their ratios, and the soil's ability to hold nutrients. When a soil has a high CEC it can hold more nutrients. In general, higher clay content soils will have a higher CEC level then sandier soils, which will have a lower CEC level. A way to improve your CEC is by increasing your soil organic matter. A good benchmark is for soils to have a CEC of 10 cmol(+)/kg and above.

Calcium to Magnesium Ratio (Ca:Mg)

Calcium and magnesium are essential nutrients that are cations (positively charged ions) which are exchanged from clay particles or negative charges in the soil organic matter. Both nutrients are required by the plant for their nutritional roles, but they also play a very important role in the soil structure. As an approximate guide, soils should have a Ca:Mg ratio of 1.5:1 or more. Soils that do not have enough calcium are more prone to disperse, especially if other cations like sodium are dominant. In the case where the Exchangeable Sodium Percentage (ESP) is 6% or greater, there is a high probability that the soil is sodic and could be dispersive (small clods in paddock) or susceptible to surface crusting. For sodic soils the addition of gypsum and organic matter will improve soil stability and structure. In order to choose the right product to correct this ratio and any associated issues, an evaluation of other cations needs to occur. This is best completed by an agronomist.

The ultimate goal is for our soils to hold nutrients and retain water for the plant to use to grow high quality crops and pastures. Soils with a pH in the optimum range of 5.5 to 8 pH ($CaCl_2$ (1:5)) will allow for the greatest uptake of nutrients by the plant in comparison to acidic and alkaline soils. Soils with an optimum level of organic matter will have good CEC levels and improve water holding capacity, nutrient retention and soil structure. Through increasing your organic matter in sandier soils you can increase its ability to hold those positively charged nutrients as well as retaining more water, thus becoming a more productive soil.

The Fert$mart Dairy Soils and Fertiliser Manual provides for a valuable source of information which can be found at fertsmart.dairyingfortomorrow.com.au.