Demonstrating Sustainable FARM PRACTICES

Understanding Soil Analysis - Chris Alenson Aug '14

Introduction

Soil analysis is one of the many tools that soil scientists and land mangers use to provide information that may assist them with on-farm management. The analysis deals with the chemistry of the soil and usually provides a recommendation of suggested amendments.

There may be a number of reasons why soils on a property are being sampled and analysed. There may be crop health problems or areas of crops where growth or production appears to be limited. Perhaps there are animal health problems, poor fertility or growth rates are not what is expected. Many farmers also use soil analysis as a monitoring tool to ensure that fertility and plant nutrients are at an appropriate level for the farm's intended use.

Some land owners may wish to sample their soils to check whether chemical residues are still evident in previously managed soils.

It is important to emphasise that in sustainable land management soil analysis is only one of the many tools that are used to provide important information on the quality of the soil on that farm. The range of observations which are regarded as good indicators of soil health and quality include soil analysis, plant and animal health, number of earthworms, soil structure, tissue analysis, the depth and density of root material, weed burdens, water infiltration and many others. . It is only after a range of these observations have been made including the soil analysis that decisions for soil management can be made. On their own a soil analysis may be misleading in indicating problems with plant nutrition. Sufficient plant nutrients may be present in the soil but structural problems, pH or low biological activity may be affecting the mobilisation of these nutrients.

Why do analyses and recommendations from different laboratories vary so much?

There are a number of reasons why analyses vary from different laboratories and perhaps the main one is the different extractant methods that are used by the laboratories. The type of laboratory equipment used to detect the nutrient elements and the method of reporting can also provide variation between laboratories. Phosphorus analysis is an example of the variation that can occur where there is at least seven different extractant methodologies that are considered appropriate for different soil and cropping conditions. Some of these analyses attempt to provide what might be considered available phosphorus while other methodologies provide more of the total phosphorus pool.

Reliability Issues of the Analysis

The major issue involved in the reliability of the analysis is the sampling. The analytical data is only as good as the sample itself and this means a strict protocol in sampling is required to ensure statistically reliable information. Some research indicates that more than 300 samples maybe required to adequately characterise a property. This is of course not practicable, so generally 20 -30 samples would be taken from a 20 hectare area.
Remember that it is quite probable that a teaspoon of soil in the lab will represent about 10,000 tons of soil from a 4 hectare field!

Avoidance of soil contaminants like fertilisers, areas around water troughs or where animals camp may bias results and lead to incorrect recommendations . Different soil profiles should be sampled separately.

Although some extractant methodologies provide consistent results over different seasons it is strongly recommended that sampling is done at a similar seasonal time and sample locations are recorded.

The Soil Analysis

An accredited laboratory should be chosen that provides a wide range of analyses of major, minor and trace elements. Although not regularly analysed this author suggests the analysis for total nitrogen and total phosphorus to give an indication of the total pool of these nutrients and as such may be suggestive of management strategies that assist in mobilising these nutrients. This analysis will not be used to estimate fertiliser recommendations.

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pH
Soil acidity and alkalinity are described by the term pH.
The degree of acidity or alkalinity is expressed on a scale from 0 (mostly acid) -14 (mostly alkaline) 7 being neutral. The scale is logarithmic, that means that each number moving down the pH scale is 10 times more acid than the one before it. A pH of 4 will be 100 time more acid than a pH of 6. Acidity in the soil is signified by the Hydrogen ion (H+). A balanced soil particle (colloid) which is negatively charged attracts plant nutrients such as calcium, magnesium, potassium and other trace elements. When acidity is seen many of the exchange sites on soil colloids (clay &/or humus) are occupied by the hydrogen ion.

The recognised treatment for modifying acid soils is to lime them but soil analysis gives an important guide as to what liming material should be used. The American soil scientists William Albrecht stated that, "Don't lime to fight soil acidity. Use lime to feed the plant". He is referring to the fact we should be emphasising the role of calcium in plant nutrition and not being over concerned about acidity which is still required to etch mineral particles and release nutrient elements.

Most soil analysis provide pH both in water and calcium chloride. The calcium chloride test is more useful for long-term monitoring of pH and is the one most agronomists tend to use for fertiliser and plant recommendations. This measurement is 0.5-0.8 lower than if measured in water.

The pH measured in water has been the test most commonly used in Victoria for over 30 years. It tends to reflect more the current soil conditions than does the calcium chloride method. It is however more subject to seasonal variations and can vary as much as 0.6 unit. It is generally recommended that soil testing is performed at a similar seasonal time to avoid soil variability.

Cation Exchange (CEC)
Cation Exchange is the ability of the soil to absorb certain plant nutrients. It has often been referred to as the pantry in the soil containing the plant foods. The higher the CEC the more nutrients the soil can contain. It is determined by the amount of the soil colloids, clay and humus. A sandy soil will have a much lower CEC than a clay soil and a soil that is also higher in organic matter/humus will also have an increased CEC.

William Albrecht and many soil scientists use the cation balancing in the CEC to bring soils into better balance both physically in terms of its structure and importantly it supply of major soil nutrients. The suggested percentage loading in the CEC is as follows:

	Ideal
Ca	65-70%
Mg	14-16%
K	3-7%
Na	1.7%
H	10-11%

An exchangeable magnesium percentage of more than 20% could induce potassium deficiency. Conversely if exchangeable potassium is greater than 10% magnesium deficiency may occur.

Organic matter
Organic matter's role in maintaining soil structure, nutrient supply, food for soil biology and water storage cannot be overestimated.
It is understood that More than 75 percent of Australian farming soils have organic carbon contents less than 1.75 percent. Organic matter decomposing to humus is a significant storehouse of essential nutrients such as 95% Nitrogen, 60% Phosphorus 70%, Sulphur and trace elements. It is therefore critical that it is managed with the degree of importance that is required. Organic carbon is analysed and the amount of organic matter is determined by multiplying the OC by a factor of 1.6 to 1.74

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Available Nitrogen and total Nitrogen

Nitrate nitrogen

Interpretations of soil tests for nitrate nitrogen are highly controversial as levels fluctuate widely depending on the season (temperature) or soil moisture levels. Some laboratories therefore resist analysing this nutrient. Levels between 10-20ppm for nitrate are generally suggested as good levels but great care should be exercised in acting on recommendations for nitrogen additions as seasonality, soil moisture and biological activity all play a role in mobilising nitrate nitrogen. It is estimated in a biologically active pasture that about 30 pounds (33.6kg) N per ha will be released (mineralized to nitrate) during the cropping season from each 1 percent of organic matter present.

It is important when examining the nitrate levels to also look at the organic matter levels. Given that close to 95% of soil nitrogen is contained in the organic matter a high level on the analysis and a low level of nitrate nitrogen suggests that the organic matter is not cycling (decomposing) adequately. Questions are then directed as to why the soil biology is not breaking down this material.

Total Nitrogen

Total nitrogen is an indication of what reserves may be held in the soil and with good management some of this might be available for our crops. It should not be used as a guide for fertiliser additions. Given that most Australian soils have levels less than 2% a higher level may indicate a good build-up of soil nitrogen which with sound management can be mobilised rather than relying on nitrogen input additions.

Phosphorus

Most Australian soils have less than .02% (200ppm) of phosphorus and as such a great majority of Australian soils have required additional phosphorus to be productive.

The difficulty in analysing for soluble phosphorus lies in the fact that its composition is so variable. It exists in several chemical forms in the soil including both inorganic complexes (with calcium, iron and aluminium) and organic forms. Factors that affect phosphorus availability include soil pH, soil compaction, soil aeration, soil moisture, soil temperature, soil texture and organic matter. A lack of adequate soil O_2 caused by compaction can reduce P uptake by as much as 50%.

“In perennial pastures, organic matter tends to accrue and net mineralisation of P from the microbial biomass and organic residue pools may be a significant source of P”. Pevrill, 1999

To add to the confusion of understanding phosphorus in our soils there are a number of phosphorus tests available that various laboratories utilize. For example, Colwell, Bray and Morgan are some methodologies that are used, but field calibration of these tests in Victorian conditions is rare. Some tests are attempting to determine various available pools of phosphorus while other methodologies are trying to extract more of the total phosphorus that might be less available.

A project that looked at phosphorus on dairy farms established that for a vigorous pasture on a well-stocked farm an Olsen P of between 18 to 22 mg/kg was required. Increased pasture production can be seen from raising the Olsen P to this level.

Levels of Olsen P and levels of plant-available phosphorus (Department of Primary Industries, Victoria, Australia)

Olsen P (mg/kg)	Availability
Below 12	Low
12 to 17	Marginal
18 to 22	Adequate
Above 22	High

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Total Phosphorus

As most Australian soils have less than .02% (200ppm) of phosphorus a soil analysis for total phosphorus may be suggestive of past fertiliser practices that have built the total phosphorus pool. While not being utilised for fertiliser recommendations it can be useful in determining management practices which might access some of this fixed phosphorus.

Potassium

Potassium in the soil is found in the soil solution, fixed on soil colloids and soil mineral particles such as feldspars and in the lattice of clay minerals. Soil testing laboratories in Australia measure plant available potassium which is the potassium in solution and the more exchangeable potassium held on soil colloids.

A more vigorous extractant, such as the Colwell extractant (sodium bicarbonate), or Skene extractant (hydrochloric acid) removes soluble, exchangeable and some fixed potassium. These values are usually reported in milligrams per kilogram of soil (mg/kg).

The appropriate level of available potassium for good pasture growth depends very much on the soil type. Clay soils have a higher nutrient holding capacity and need higher levels of available K than do sandy soils where potassium might easily be leached from the profile.

Sulphur

Similar to nitrogen humus is an essential supplier of sulphur providing up to 70% of this essential element. Sulphur like phosphorus is stored on the positively charged surfaces of iron and aluminium oxides and can only be taken up by plant roots in an ionic form. Sulphate (SO_4) is an anion.

The methodology for extracting sulphur (KCl) takes into account some of the sulphur that will become available from the breakdown of organic matter which in dairy pastures is often present as thick root mats and therefore has a potential to supply sulphur via organic matter decomposition.

Trace Elements

Soil testing interpretation is difficult as critical concentrations vary between soil types and plants, and extraction procedures for elements can vary between laboratories. Generally levels are given as guidelines rather than levels that indicate a response from a designated addition. Observations by the land manager are critical in terms of monitoring pasture productivity, animal production and health as indicators of trace element deficiencies.

Plant tissue testing is the preferred method for diagnosing trace element toxicities, deficiencies, and imbalances for plants.

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