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Australian Soil club

Welcome

Welcome to the fourth issue of the Australian Soil Club Newsletter. This issue is the first of two based on the theme of soil testing, a popular topic requested by members. The articles are based on presentations made at the University of WA's "Centre for Land Rehabilitation" (CLR) workshop earlier this year, "Maximising Benefit from your Soil Test." For further information on the CLR, email cladmin@cyllene.uwa.edu.au or visit the website www.clr.uwa.edu.au.

The University of Western Australia

CENTRE FOR LAND REHABILITATION

In this issue:

For further information, contact:

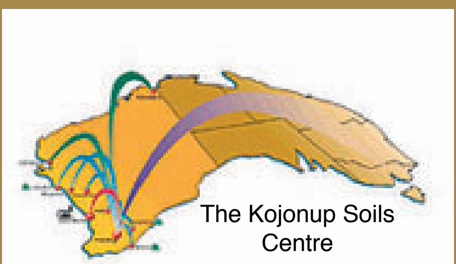
Professor Lyn Abbott

School of Earth and Geographical Sciences (Soil Science)

The University fo Western Australia

Crawley, WA 6009

Email: labbott@cyllene.uwa.edu.au



The Kojonup Soils Centre

Annual membership of the Australian Soil Club is $33 ($40 for overseas subscribers). If you would like to receive further information about the Club, please email Jen Slater: organic@agric.uwa.edu.au

The Soil Fertility Debate:Choosing Between Different Recommendation Systems

by Bill Bowden, Research Officer, WA Department of Agriculture, Northam.

There has been a proliferation of fertiliser recommendation systems being offered to growers in Australia. This has resulted in a heavy demand for "an objective or unbiased view" on the pros and cons of each and even an opinion on which is best. The nature of my training and background experience inevitably affects my outlook and means that I am biased towards the traditional approach. My credentials for this task are that I have had over 35 years of experience in trying to develop fertiliser recommendation systems which are adapted to WA conditions. These systems include soil and tissue testing, calculation from simple budgets to more complex modelling, trial strips and burnt windrow comparisons. At the WA Department of Agriculture, we have a range of fertiliser decision making tools which we hope are used on a "horses for courses" basis.

The purpose of this summary is to address the guidelines for discriminating between the many systems on offer in Australia today; ie some of the rules for addressing the soil fertility debate.

The Debate

The main controversy has arisen from a belief by some growers that their soil fertility has deteriorated markedly as a result of using traditional fertility management practices. While there has been a lot of soil degradation in the past decades, it is simplistic to blame fertiliser management alone. Intensity of cropping, cultivation practices and greater productivity (and profitability) all have a role to play. And, in fact, many of the fertiliser management practices have had demonstrable, positive effects on soil fertility (eg soil P status, soil organic matter levels on light soils).

The debate has been fuelled by the introduction and offering of alternative approaches to soil fertility management. The main question is whether you should fertilise to improve the soil or to maximise cash returns from the crops. You can do both at the same time but there is a time dimension to cash flow which often means that these alternative philosophies come into conflict.

Overriding and confusing the debate is the credibility of different operators and the soil testing and interpretation methods they use.

Features of credible fertiliser recommendation systems:

1. Evidence that a recommendation system has been adapted for local farming conditions. Locally determined critical levels depend not only on how different crops were grown but also on things as mundane as the soil sampling and chemical analysis techniques which were used for those calibrations.

Why is local calibration so necessary and what is it?

The principles of soil fertility and plant nutrition **are** equally applicable anywhere in the world, but in any given environment, agriculture **is** unique and any recommendation system of any value has to pay more than lip service to that uniqueness. The yield responses depend as much on the growing conditions and crop demand as they do on the level of extractable nutrient. In WA, our unique mix of soils, seasons and crops mean that it is quite unlikely that critical levels determined elsewhere in the world might be relevant for us. I can give you examples of how such transference of results from one side of the world to the other have gone horribly wrong - even from one end of our agricultural areas to the other poses major problems for us.

Any one can analyse a soil sample for any element known to mankind. The problem is in making those analyses meaningful in terms of the likely responses of our commercial crops to remedial dressings of fertilisers or ameliorants. To determine whether our crops respond to nutrient inputs, we have to carry out trials with those crops in our environment. For each trial you get a soil test figure and a level of response. A set of data is developed from the results which can be used to determine a critical level in the soil below which you expect significant responses. Unfortunately there are few short cuts for this work.

Going along with this need for soil analyses to be related to local crop response, is a need for the sampling and chemistry to be the same as that used for determining the critical levels. If it is not the same, then the original trial work does not have to be repeated, but adjustments do have to be made by matching the new with the original soil test. We have soils in our soil bank (soils collected from 'calibration' trials and stored in South Perth – since about 1972-3), which can and have been used for this purpose.

In WA we have local soil test calibrations for the major nutrients: phosphorus (P), potassium (K), sulphur (S - CSBP). We have nitrogen (N) recommendation systems based on literally thousands of local trials. There are local calibrations/critical levels for the trace elements copper (Cu) and zinc (Zn). We have local data (soil pH and aluminium (Al) critical levels) for determining whether you need lime or not. And we have some local data on whether our soils with structure problems, are likely to be responsive to gypsum.

2. A credible recommendation system should be tailored to deliver advice for the highs and lows of crop demand, which vary according to management and season. Higher yielding crops need more nutrients (from either soil or fertiliser) than lower yielding crops. Several studies have shown that yield demand is equal to, if not more important than the soil supply of nutrients in determining the fertiliser requirements of crops.

3. A good recommendation system should provide a sensitivity analysis; ie it should show you the yield, quality and dollar consequences of spending more or less dollars on fertiliser, for different season or management scenarios. We found that this capability was invaluable in helping farmers in times of financial stress such as following several years of drought. What are the dollar consequences of cutting fertiliser rates? What if the coming season is a scorcher? The answers to the dollar questions are VERY individualistic; they vary from farmer to farmer, with stage in life and with short-term cash flow shortages or surpluses. A sensitivity analysis helps address the "how much fertiliser?" questions from an individual's point of view.

4. A credible adviser or advisory system will try to give you not only short-term ("apply this amount of this fertiliser this year") but also the more long-term implications for, and fertility requirements of, your soils. A recommendation delivered as a computer printout may look like it meets your individual needs, but can not replace a good adviser – although dollars may well dictate that you go for the former.

"Feed the crop" versus "Feed the soil" debate.

Many farmers crave for more than simple fertiliser advice. They want more holistic fertility advice. There is a school which plays up some of the soil destructive effects while playing down the positive, productive effects of simple crop orientated fertiliser systems. They say that if you fertilise/ameliorate to bring the soil up to target fertility levels, then crop health and production will take care of itself. Such soil fertility targets, particularly when they have been established elsewhere in the world, should always be questioned for local applicability and economic viability.

Having highly weathered soils of low, natural, nutrient status, means that most of the chemical fertility in WA soils, has been developed using producers' scarce funds. If you are tight for funds then you have to get a dollar return relatively soon after you have invested the dollar in fertility. The most immediate dollar return comes from responses in the current crop and I guess that is why our major research investment has gone into understanding crop rather than soil, requirements. Responding to short-term (immediate crop demand) versus long-term (run down of soil nutrient status) issues is a continuing bone of contention between the competing recommendation systems. Macronutrient cation (potassium (K), calcium (Ca) and magnesium (Mg)) nutrition is a case in point.

For example, back in the '60s, we knew that K deficiency of crops and pastures was going to become more widespread, because K fertility is low on the light soils in WA and we were running down stocks in the products being removed. However, we did not adopt a system to replace the potassium we remove until we knew we were running into danger of having major losses of yield due to K deficiency. You do not put K dollars out onto our K fertile soils just because the crop removes K – it might take 100 years before you get a dollar back for that investment. Now that much of the agricultural areas have run down, we must use K fertilisers. And because our diagnostic systems are not foolproof, we should be considering insurance dressings of K before the critical soil fertility levels are reached. In WA, Ca and Mg nutrition will follow the same history as K. Already we are seeing occasional Ca deficiency in sensitive crops such as canola and if we continue the trend towards using Ca free fertilisers, paying responses will become more frequent.

This short-term thinking obviously goes wrong when early treatment could stop a long term, expensive-to-cure problem from arising. Such is the case with liming to prevent subsoil acidification. Other soil ameliorations sometimes take time to have a paying effect. Overcoming surface sealing, rainfall infiltration and soil structure problems using gypsum may not give a return until a season comes when having an "all week soil" rather than a "Sunday soil" lets you seed a few hundred hectares which otherwise would have been left out of the cropping program.

Calcium/Magnesium ratios

The use of critical soil calcium to magnesium ratios is sometimes used as a determinant of soil health and fertility. Ratios outside certain limits are used to justify the use of large quantities of lime, dolomite and gypsum.

For crop nutrition where you think in terms of 10s or maybe 100s of kg/ha, I reckon you fertilise the crop according to the sufficiency theory (which says use fertiliser when your soil nutrient levels are below some "critical" point). There is no solid local, or, despite decades of research, overseas evidence that the ratios are any better than the sufficiency levels for determining nutrient requirements.

When it comes to ameliorating soils (lime, dolomite and gypsum), you have to use tonnes/ha to have an impact on soil properties (unless you only want to change the nature of small proportions of the soil).

Traditionally we have used pH and aluminium tests as well as crop bioassays, to determine whether we need lime. Ratios do not help us much in this decision although you might change your lime to dolomite if Mg levels are low and the dolomite is sufficiently cost effective.

For changing soil physical properties such as surface sealing and soil structure, we traditionally recommend gypsum if soil clods disperse in rainwater. For soils of low pH (and high buffering?) you could use lime rather than gypsum to provide the calcium to stop this dispersion. I have yet to see the evidence for the value of using lime on soils of pH 7 and above where lime is up to 100 times less soluble than gypsum. There is anecdotal evidence that lime has a longer lasting effect than gypsum under such conditions but I do not know why and would welcome any data and suggestions on how it works.

Farmers who I respect have told me that they believe the Ca/Mg ratio story because in their experience "it works" and it explains things like "sticky when wet and sets like a brick when dry" and that their "best and most productive soils have the right ratios". I admit to having a problem with anecdotal evidence and testimonials. The observations are usually correct, but often the comparisons are invalid because of the confounding of several variables (eg "best and most productive soils" have a lot of good properties, other than the right ratios, going for them). As a result, the interpretations can be quite misleading.

Again, nothing beats having some local data which justifies the claims. In WA, I know of only two efforts to test the ratio claims in a relatively valid way. One was at Kojonup where recommendations based on the 2 main methods were tested. The ratio method costing approximately $700/ha over several years, gave the same or less returns than the local recommendation costing about $60/ha. The other was at the WANTFA site at Meckering where the Ca/Mg ratio was changed down to less than 1 with 17 tonnes/ha of Epsom salts (magnesium sulphate) and up to 16 with 14t/ha of gypsum (calcium sulphate). Once the excess salt was washed out of the soil, there was very little difference in the performance of barley or wheat across the ratios. There is a trial testing the use of lime on poorly structured clays near Gnowangerup and it is yet to show any effects in either the soil chemistry or crop performance – still, early days!

Credible fertiliser recommendation systems use locally calibrated diagnostic methods, adjust fertiliser rates for different yield potentials and allow you the grower to see the yield, quality and dollar consequences of your fertilising decisions. Whether you invest your dollars in short or long-term fertility is a personal decision which can be made with the help of good advice from credible nutritional consultants. Ask your adviser on what he bases his recommendations and worry if they do not have a large component of local calibration/validation behind them. Testimonials are rarely credible authority for recommendation systems.

Contact details:

Dr J.W. Bowden, Centre for Cropping Systems, WA Department of Agriculture, Northam, WA 6401

(08)96902149,
bbowden@agric.wa.gov.au

Glossary

WANTFA: W.A. No Till Farmers Assocation

Lime is calcium carbonate and neutralises acid conditions.

Dolomite is a calcium/magnesium carbonate and does the same as lime but provides both calcium and magnesium to the soil as it neutralises acidity.

Gypsum is hydrated calcium sulphate and is used to ameliorate certain structural problems in some soils. It is also a very cheap source of calcium and sulphur for crop nutrition where required.

Epsom salts is magnesium sulphate. It is far more expensive than gypsum to use agriculturally, but is a source of magnesium and sulphur. It is less likely to be used as an ameliorant of soil structural problems because magnesium has a more dispersive effect than calcium.

Mapping biological soil nitrogen supply using mid infrared technology

by Dr Daniel Murphy and Dr Nui Milton, School of Earth and Geographical Sciences,

The University of Western Australia.

Nitrogen (N) is the primary nutrient limiting crop production in farming systems throughout the world. In our agricultural soils 40-80% of the crop N requirements are met through microorganisms. They breakdown residues and organic matter to release plant available N (*i.e.* biological soil N supply). The remaining N requirement is met through fertiliser applications. To improve N fertiliser management it is important to know the timing and location of biological soil N supply, so that fertiliser N is only applied when and where it is necessary.

Splitting applications of fertiliser N at strategic plant growth stages is becoming common. This maximises the opportunity for crop uptake at the right time and minimises the risk of nutrient leaching. Growers can also spatially adjust fertiliser rates in the field using information gained from yield mapping, through knowledge of best/worst performing areas of a paddock, and by soil type. The next extension of this approach is to utilise spatial soil maps that tell us about the soils capacity for biological N supply together with information on the chemical and physical fertility of the soil. This allows soil constraints limiting crop production to be identified. For example where biological soil N supply is high, less fertiliser N may be needed to achieve optimal yields. Alternatively where biological soil N supply is low greater reliance on fertiliser N is required for adequate crop growth. Variable rate applications of fertiliser N across a field could thus be achieved based on knowledge of biological soil N supply. This would have an economic and environmental (minimising leaching) benefit to growers.

How do we know what the capacity of the soil is for biological supply of N?

In the laboratory we incubated soil and measured available N as an index of biological soil N supply. This method takes one week to complete and is thus both too costly and slow for use as a decision support tool for fertiliser application rates. However, this may all change in the future. Our current work is exploring the possibility of using mid infrared technology to develop calibration curves for a range of soil biological, chemical and physical soil properties (e.g. biological soil N supply, organic matter, pH, electrical conductivity, cation exchange capacity, clay content). The advantage of the mid infrared technology, is that once calibrated soil samples can be collected from the field and scanned rapidly (2 minutes per sample) to provide predictions for a number of soil properties. This process considerably reduces analytical costs meaning that growers could afford to have more soil samples analysed enabling spatial maps to be generated or deeper soil layers to be assessed.

Mid infrared is not as accurate as measuring each soil property by standard analytical techniques but does have a place in the development of soil spatial maps for the purpose of zoning fields to allow for variable management strategies and to identify soil constraints currently restricting crop production. The application of this technology is demonstrated in this article where soil was collected under an oat crop at Dangin in 2003 using a 25m x 25m sampling grid (180 separate sampling points over 10 ha). Biological soil N supply was measured using standard laboratory methods (Figure 1) and also predicted using mid infrared technology (Figure 2). This intensive sampling grid was used for assessing the required sampling grid size for farm management application. These spatial maps show the extent of similarity between grid sample points. There was good agreement between measured (Figure 1) and mid infrared predicted (Figure 2) values of biological soil N supply. This data suggests optimal crop yields would require additional fertiliser to be applied to the red and yellow areas. In a good rainfall year, low fertiliser N application would also be of benefit in the light blue area. Fertiliser N may not be economic on the dark blue areas as soil N supply is already sufficient for crop N demand.

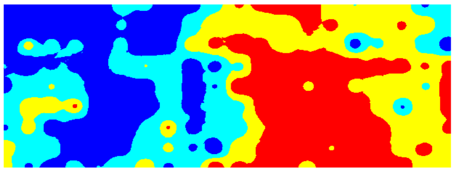


Figure 1. STANDARD LABORATORY DETECTION OF BIOLOGICAL SOIL N SUPPLY - Data from soil samples (0-10 cm) collected on a **25 m x 25 m sampling grid.** Colours represent data categorised into 4 ranges where [red] = very low biological soil N supply, [yellow] = low biological soil N supply, [light blue] = moderate biological soil N supply and [dark blue] = high biological soil N supply.

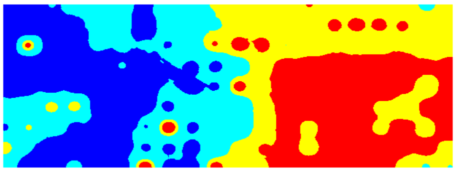


Figure 2. MID INFRARED PREDICTED BIOLOGICAL SOIL N SUPPLY - Data for the same 10 ha area as that shown in figure 1 (i.e. the pattern of colour on figure 2 would be identical to that on figure 1 if the mid infrared prediction was 100% accurate). The same colour groupings apply.

What stage is this mid infrared technology at in Western Australia?

Currently this work is in a research development stage, with mid infrared calibrations being developed for a range of soil properties in Western Australian soils. Future work requires validation of data to test the transferability of calibration curves from one region to the next and also across soil types. We hope to answer these questions over the next 2-3 years. Potential future development could include portable mid infrared machines that would enable in-field application of mid infrared to predict soil properties instead of having to collect samples and transport them to the laboratory.

This research is being funded through the GRDC Farming Systems Program and Soil Biology Initiative. We wish to thank Bill and Ritchie Walker from Dangin, for their ongoing support to our research efforts.