Understanding Soil Tests

FACT SHEET

Soil tests are a valuable agronomic resource if they are fully used and properly understood.

Plant nutrition and plant to soil interactions are complex mechanism with a number of environmental and external conditions affecting the process. There are 17 elements involved in plant nutrition, three that are supplied naturally that we have little control over and 14 that are supplied by soil and or by fertilizer applications.

Therefore it is important when interpreting soil analysis and designing a fertility program to keep balanced nutrition and proper placement of these nutrients in mind.

There are two basic philosophies in soil test interpretation used today and both have merit and solid scientific support to substantiate these philosophies.

The SLAN Concept "Sufficient Levels of Available Nutrients" originated or resulted from research done by Bray et al in 1944-45. This research monitored crop response to the addition of an element until crop response was zero or negative with additional increments of an element. This concept does not however attribute any affect of the level of availability of one element on another. It does however recognize that the addition of the most limiting element may enhance the efficiency of another element.

The BCSR Concept "Basic Cation Saturation Ratio" originated from research on soils where the cation saturation was varied and the yields and quality of the crops recorded. This work done by Bear and co-workers in 1945 identified optimum saturation levels of the basic cations for an ideal soil at 65% saturation of calcium, 10% saturation of magnesium and 5% saturation for potassium. Other work suggests that 10% saturation of magnesium may be marginal for alfalfa and other crops. Later work done by Bear in 1948 compared ratios in plant tissue with ratios in soils to determine optimum levels.

One major oversight in both of the approaches to under standing soil fertility and the ability for plants to take up nutrients was that they do not differentiate soil type. Sands and clays are different and this should be taken into account when developing a crop nutritional program.

Fisher in 1975 introduced another parameter to express the fertility index where by yield could be predicted from soil test values for both P and K. He substituted an equation of optimum K based on cation exchange capacity that predicts a deficient level of K in different soil types based on the cation exchange capacity (C.E.C.). This new philosophy integrates the SLAN approach with the BSCR concept. This approach uses the key strong attributes of both philosophies using cation exchange capacity to establish the differences in soil type and hence the different optimum levels of nutrients required for that soil. This is the trend used today by a number of respected soil testing laboratories and progressive individuals involved in plant nutrition and crop performance today.

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At A&L Canada we have adopted Fisher's approach using cation exchange capacity to establish soil type and from that information derive what the optimum level of the nutrient for that soil type. From the ppm. reading for the various nutrients found in the soil, a rating is established based on their value before making a recommendation.

Other information such as percent saturation of the cations, are on the report so that the educated crop advisor can use this information to fine tune nutrient inputs and or placement based on their understanding of crop performance in that field or management system.

Any grower can grow a crop in a good year but it take a strong understanding of nutrient availability and management techniques to develop crop input programs that can deliver consistent crop performance under conditions that are not always ideal. Percent saturation of K, Mg, Ca, H, and Na are merely an understanding of the predictability availability of the nutrients in less than ideal condition.

In order to use a soil test adequately the crop advisor or producer must first of all understand what these relationship are, and be able to make judgment calls on placement and amounts of nutrients to ensure each nutrients availability.

To begin with in using an A&L soil test to make a recommendation one needs to understand what the optimum nutrient level in each soil type is, and develop a program to address any deficiencies.

A good fertility program begins with a nutrient balance sheet defining how much of each nutrient will be removed by the harvest per unit of production. This amount should always be returned to maintain strong soil health unless soils are in excess and the goal was to draw the nutrient down.

If a clear understanding of the fields potential has been determined through historical records, based on management zones, a target optimum level of a nutrient for that production system can be established. Once this is clear a producer can make the decision on how much luxury application he can to afford to build these soils to their optimum.

Soil build is an investment in soil health and future crop performance. When we apply N to a crop 50-75% of what we apply that season will be taken up by that crop and this response is easy to see. When we broadcast P, K, Mg, Ca in most soil types only about 15% of what we apply is taken up by that crop in that season, and this response is not often obvious. Most of the P and K a crop takes up first of all is supplied by the starter mix or band in early growth, and later to finish the crop it is supplied by soil reserves. With these nutrients therefore we must not forget that we feed the soil and the soil in turn feeds the plant.

In many cases as I have mentioned already it may not be economically practical to achieve optimum levels and we may have to rely more on placement techniques to achieve crop performance and overcome short comings of the soil type. However all fertility programs should include some build as crops do depend on these soil reserves to finish the crop once the roots move out beyond the band.

Crops that use potassium late in the season, (soybeans, pulse crops) and crops that have a high demand for potassium such as alfalfa or potato rely on soil potassium reserves to meet these needs. In season potassium application can not deliver enough potassium.

At one of our research locations in Ontario where we were looking into fertility and management techniques that could influence soybean yields. We observed that regardless of what the treatment was within the treatment, yields would double in the treated and in the check. Comparing the yield data to soil health we found that when ever the % K exceeded 4%, yields would double. The soybean has a large demand for K, but this need is different than many crops as it is required later in the season as this crop is finishing pod filling. This demonstrated that the easiest way of providing potassium to the soybean is through soil reserves.

High potassium demand crops also require attention to K:Mg balance and as we increase potassium application we must pay attention to Mg balance. The ideal K:Mg ratio in meq is 0.2 to 0.35 for most crops and crops such as potato 0.3 to 0.4. Often times in trying to satisfy a crops K requirements yield loss is experienced with over application of K by inducing Mg deficiency. Percent saturation levels of K and Mg in the soil are key to understanding when Mg needs to be applied with K to avoid this K:Mg imbalance in a fertility program.

The ratio of magnesium to potassium should be greater than 1.5:1 (in other words, this amount of magnesium should be more than on and a half times greater than the amount of potassium). A magnesium-to –potassium ratio of less than 1.5:1 indicates an increased chance of grass tetany.

An example of how percent saturation should be used in this case is; if the exchangeable magnesium is more than 20% of the cations, lead to a calcium and potassium deficiency and soils tend to become tight and anaerobic . Conversely if the exchangeable poat of the cations, lead to a calcium and potassium deficiency and soils tend to become tight and anaerobic and crop performance drops off dramatically. Conversely if the exchangeable potassium is more than 10% or the cations or the K:Mg is > 0.5, it may cause magnesium deficiency. Exchangeable K should be maintained in the range of 3-8%.

The value of potassium in relationship to magnesium and calcium should be less than 0.07. A result of 0.07 or higher indicates a greater chance of grass tetany. A result of less than 0.07 indicates a minimal chance of grass tetany. This formula is a good quick test for milk fever but animal symptoms and a blood test are more accurate. To determine this availability use the following formulas;

meq.K / (meq Ca + meq Mg)

example soil test showed 0.47 meq/100g K
7.85 meq/100 g Ca
1.33 meq/100 g Mg

0.47 / (7.85 + 1.33) = 0.0511 which is well under the grass tetany danger level of 0.07 or greater.

Simply restricting K in the fertilizer program only reduces the stand, and overall yield of the hay and may not reduce the problem of grass tetany or milk fever. Often we find that maintaining the K fertility and addressing the Mg and Ca deficiency corrects the problem and maintains the yield and stand of the hay.

These are just a few examples on how to interpret cation exchange and use this information to manage a soil condition more effectively.

Maintaining the proper balance between calcium and magnesium requires understanding the difference between soil types and predictable availability of the cations. In soils with C.E.C. < 7 a Ca:Mg in meq. should be 3:1; and in soils with C.E.C. between 7-25 Ca:Mg in meq should be 5:1; and soils with C.E.C. > 25 Ca:Mg in meq should be 6:1. Always maintaining a K:Mg in meq between .2-.35 which is not always that easy.

This understanding of Ca:Mg helps identify many production issues with crops that are paid for based on quality and shelf life more than total yield.

In many cases correcting these levels of K,Mg, and Ca becomes difficult and it becomes a matter of managing these soils. One such management of such soils often requires low-level application of calcium materials to supply calcium regardless of pH.

Often there are heated debates over recommendations based on differences in philosophy. There is no such thing as a bad recommendation if the recommendation has been made based on some performance objective and cropping system. If a soil test is taken properly and defines what the management zones are, and the person using the soil test understands how to interpret all the items that differentiate that soil type, the agronomics should be solid. The key to managing fertility is to understand what the limiting factor is, and know how to address it. Therefore a soil test should be complete and have all the information available for the crop advisor to make the call.

For further understanding of how to use the soil test refer to fact sheets
-Understanding Cation Exchange Capacity and % Base Saturation fact sheet no. 54
-Calcium Nutrition in Plants fact sheet no. 121
-% P fact sheet no. 79
-Soil Optimum Levels based on C.E.C. fact sheet no. 55
-Soil pH and crop response fact sheet no. 01

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