PCBFA
PEACE COUNTRY BEEF & FORAGE ASSOCIATION

Understanding Soil Tests

Volume 9
Issue 99
April 2013

Forage Facts

Knowing when and where to get a soil test done and then understanding how to interpret the results can be a challenge. Soil tests can help a land manager develop an efficient soil fertility management program. Monitoring soil conditions over a long period of time can give an indication both of successful management decisions and also where changes may need to be made.

Getting the Soil Tested

Analytical techniques vary from lab to lab, so a farmer should use the same lab every year so that results are comparable. It is also important that the chosen lab uses analytical methods that are tested and appropriate to Albertan soils and climate. For example, the ideal method for phosphorous extraction in Alberta is a 'modified Kelowna' extraction – this method delivers results that are most reflective of our Western Canadian soils and climate conditions.

Soil test results are only as good as the soil sample. Soil samples are typically taken from the 0-6 inch depth. Some labs might require a deeper sample for some tests, so a land manager should check first. A conventional sampling method requires at least twenty samples from random locations throughout the field. These samples are mixed together, and then a sub sample is removed from that mixture. This sub sample is what gets sent away to the lab. If the field in question has at least two areas of different plant performance and these areas are managed separately, twenty samples can be taken from each of these distinct zones. Two or more samples are sent to the lab from that field. Sampling according to zones of performance is called benchmark sampling and is a common practice in precision agriculture where managers can apply variable rates of fertilizer across a field.

The fertilizer recommendations that come with soil tests results are one part science to two parts art. That is why a land manager should give as much background information as possible about the soil and field. Cropping history, previous yields, soil, crop and residue management practices, the date and application rates of fertilizer or manure applications and the depth of the soil sample should all be identified on a paper sent with the soil sample. The crop being seeded in the upcoming season should also be identified. Each sample should be associated with a legal land location, as the lab will use climatic differences such as average precipitation, evapotranspiration rates, soil organic matter and even projected spring soil moisture levels to interpret the results and make nutrient recommendations.

Interpreting the Results

The **nutrient analysis** is the heart of the report. Nutrients are typically reported in parts per million (ppm) in either the top 6 inches or the top 24 inches. For each 6 inches in sample depth, ppm values are doubled to convert ppm to pounds per acre – a unit that makes a lot more sense to most land managers. For example, 10 ppm nitrogen in a 0-6 inch sample corresponds to 20 lbs of nitrogen per acre. For more complicated conversions, a simple equation can be used:

Nutrients (lb/ac) = **Nutrients (ppm)** X **2** X **Sample Depth (inches)** / **6 inches**

Nutrients are typically rated as being deficient, marginal, adequate or in excess. Soils that test deficient for a given nutrient have a high probability of improved yield if the deficient nutrient is increased on site. Soils testing marginal may or may not show a response from a nutrient application. Soils testing adequate are unlikely to show a response.

Most labs will test for nitrogen (N), phosphorous (P), potassium (K) and sulfur (S). A micronutrient analysis usually costs more but will include calcium (Ca), magnesium (Mg), copper (Cu), manganese (Mn), iron (Fe), zinc (Z) and even boron (B) and chloride (Cl).

Nitrogen is expressed as ppm of nitrate (NO_3^-) readily available in the soil up to 24 inches. Less than 30 lb/ac on NO_3^- is typically considered deficient. Extractable phosphorous is expressed as ppm in the top 6 inches and less than 26 lb/ac is considered deficient. Potassium is usually highly available in Albertan soils. Less than 151 lb/ac is considered deficient. Soluble sulfur is considered deficient at less than 16 lb/ac.

A Word On Manure

It is important to get your manure tested if you plan on spreading it onto a field as a fertility management tool. Typical lab analyses report the % in lb/ton of moisture and solids, total nitrogen, ammonium nitrogen (NH_4^-), total phosphorous, phosphate phosphorous (P_2O_5), total potassium, potash potassium (K_20), the EC and Na content.

The nitrogen reported as NH_4^- is plant available. However, it can be lost to the air, especially if the manure is not incorporated, or if warm and wet weather persists immediately after it is applied. Retention can vary anywhere from 90-25% in best and worst case scenarios! In addition, organic nitrogen can be calculated as total nitrogen minus NH_4^-. Approximately 25% of this organic nitrogen will become available to plants in the first growing season after application. Thus, estimated crop available N = Available Organic N (year 1) + Retained NH_4^-. Similar principles apply for phosphorous and potassium. Bottom line is: get it tested and then work with an agronomist to understand exactly what you are applying to you land—big savings can result!

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Sometimes, the report may indicate that a nutrient exceeds a certain level, but it will not give an exact number. For example, the report might state that potassium is ">60 ppm". This is because potassium content exceeding 60 ppm is more than adequate for plant growth, so the exact level is considered irrelevant. There are situations in which a land manager may want to know exactly how much nutrition is in the soil, to more precisely track nutrient additions from management practices such as spreading manure or extensive winter grazing. In this case, a **dilution** must be ordered for the nutrients of interest. A dilution analysis will provide exact numbers, but it will likely cost more.

A very important concept in understanding soil fertility is that of the **cation exchange capacity (CEC)** of soil. The CEC is an estimate of the ability of the soil to hold onto positively charged (cation) nutrients. Major soil cations include calcium (Ca^{++}), magnesium (Mg^{++}), potassium (K^+), sodium (Na^+), hydrogen (H^+) and aluminum (Al^{+++}). The CEC is measured in centimoles of positive charge per kilogram of soil (cmol/kg). It is affected by the amount of clay and soil organic matter in the soil. That is because both clays and organic matter tend to carry a negative charge, contributing to the ability of a soil to attract and hold these positively charged nutrients. Soils with high CEC will have a higher yield potential and therefore higher fertility recommendations. **Percent base saturation** is a measure of the proportion of the total CEC occupied by Ca^{++}, Mg^{++}, K^+ and Na^+, expressed as percentages. It can be tested for at an additional cost.

The report will often include soil quality factors such as **pH**, **salinity** and **soil organic matter**. These quality factors are considered along with the nutrient analysis to create fertility recommendations and are usually included in any package.

The **pH** of a soil indicates acidity or alkalinity of the soil. Soils testing below 6.7 are considered acidic whereas those above 7.3 are considered alkaline. Most crops grow well within a pH of 6-7.5. At low pH, soluble aluminum is released from the cation exchange, and it is toxic to many plants. Phosphorous becomes more tightly bound and therefore less available. A very low pH will result in lower fertilizer recommendations, as the yield potential for certain crops will be reduced.

There are two soil parameters which characterize soils as either saline, sodic or saline-sodic and these are together indicators of its total **salinity**. *Electrical conductivity* (EC) indicates total soluble salt concentration in decisiemens per metre (dS/m). Grass forages tend to have a higher salinity tolerance, with some species surviving at greater than 16 dS, which is considered very strongly saline. Field crops often require less than 8 dS, which is considered moderately saline. The *sodium adsorption ratio* (SAR) gives an indication of the proportion of exchangeable sodium (Na^+) to exchangeable calcium (Ca^{++}) and magnesium (Mg^{++}) sitting on the cation exchange. Soils with an SAR of 13 or higher are considered sodic. Sodium causes soil particles to repel each other, preventing soil aggregate formation. The result is a very tight soil structure with poor water infiltration and surface crusting. Getting an SAR test is usually an additional cost, but it can be useful if a land manger suspects the soil is sodic, as specific management techniques can then be employed to remediate these soils.

Soil organic matter (SOM) is a measure of the amount of plant and animal residue in the soil, by percent weight. It acts like a nutrient bank account, as it slowly releases crop available nutrients to the soil over time as it degrades. As stated, it contributes to the CEC of the soil and also improves soil structure and water infiltration. Typical SOM in Alberta can range any where from 2-10%.

In a basic soil test, nutrient analysis, pH, salinity and SOM are all reported. Dilutions, base saturation and SAR cost extra. A soil lab considers these results and develops yield response expectations for the future crop based on climatic conditions and reported management. All of these factors contribute to the final fertility recommendations. As a land manger understands more about the way these factors contribute to the fertility recommendations, these numbers become much more important than the recommendations themselves, which are useful guidelines, but hardly gospel!

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