Why Sample, and What is Your Soil Test Telling You?

By Dillon Muldoon

After over a decade of trial and error, consulting with experts, and a deep dive down the rabbit hole of soil health, Evan Quigley of The Kitchen Garden Farm in Wilton, Ontario offered some advice and insights in his EFAO-hosted webinar, *Interpreting Soil Tests and Choosing Amendments* in March of 2022. This article is a summary of Evan's webinar, with some additional information added.

This article offers general information on understanding soil tests and possible amendments. Every farm and soil type has its own unique needs. The EFAO recommends accessing additional educational materials and/or consulting with an advisor before making amendment decisions.

Healthy soils are a vital part of ecological agriculture and a resilient food system. They can improve crop yields and quality, help us reduce greenhouse gas emissions, and become carbon sinks. They can act as a sponge, allowing for better infiltration and water holding capacity, leading to greater resilience during droughts and more resistance to erosion.

Soil health can be measured by the optimization of the biological, physical, and chemical properties in a soil. Although both biological and physical function are very important, this article focuses mainly on the chemical properties that can be interpreted from a soil test.

Why should I take soil samples?

Soil sampling is an integral part of a grower's tool-kit when it comes to building soil health and enhancing crop production. Taking soil samples helps you better understand soil fertility, so you can make informed decisions to improve yields and protect the environment.

It is nearly impossible to make accurate nutrient recommendations without a soil test. This information allows you to tailor your fertility programs, which benefits your production systems. It also allows you to reduce nutrient leaching, which benefits the environment. Relying on crop removal numbers alone without knowing your soil nutrient balance can lead to potential yield losses and/or over application of amendments.

What should I sample?

You want your soil test to inform five main soil elements:

1. cation exchange capacity;
2. soil organic matter (SOM) as a surrogate indicator of soil health;
3. percent base saturation;
4. soil pH or buffer pH; and,
5. primary and secondary nutrients as well as micronutrients.

When testing with A&L Labs, Evan recommends getting the **S1B** base soil analysis and also adding the **+S7** for individual micronutrients.

When should I take soil samples?

A soil test is a "snapshot of exchangeable plant nutrients at a given time," and a tool to make amendment and cropping decisions for the next season. This snapshot is usually taken in the **fall after the crop is harvested** when nutrient levels in the soil will be similar to next year's spring planting.

One soil test is good, but more than one over a number of years is ideal. Updated soil tests allow you to understand your current nutrient balance and, alongside with previous soil tests, allow you to identify trends.

When sampling over the years, consistency is key! Taking samples at the same time each year and using the same lab services allows for more accurate comparisons of test results. In the fall after your crop has been harvested is an ideal time to take soil samples. The fall sample collection timing allows you to spread out the workload so it doesn't conflict with the busy spring season, and can help save time on winter crop planning and money on amendments.

What is my soil test telling me?

Cation Exchange Capacity

The cation exchange capacity, or CEC, is a measure of the soil's ability to store positively-charged nutrients such as potassium, calcium, magnesium, and sodium. In general, the CEC correlates with soil texture: the more clay and soil organic matter a soil contains the higher its CEC will be. Soils with a CEC below 10 are usually sandy, from 10-20 are generally a loamy or medium textured, and above 20 have a fairly high clay content.

Soil Organic Matter

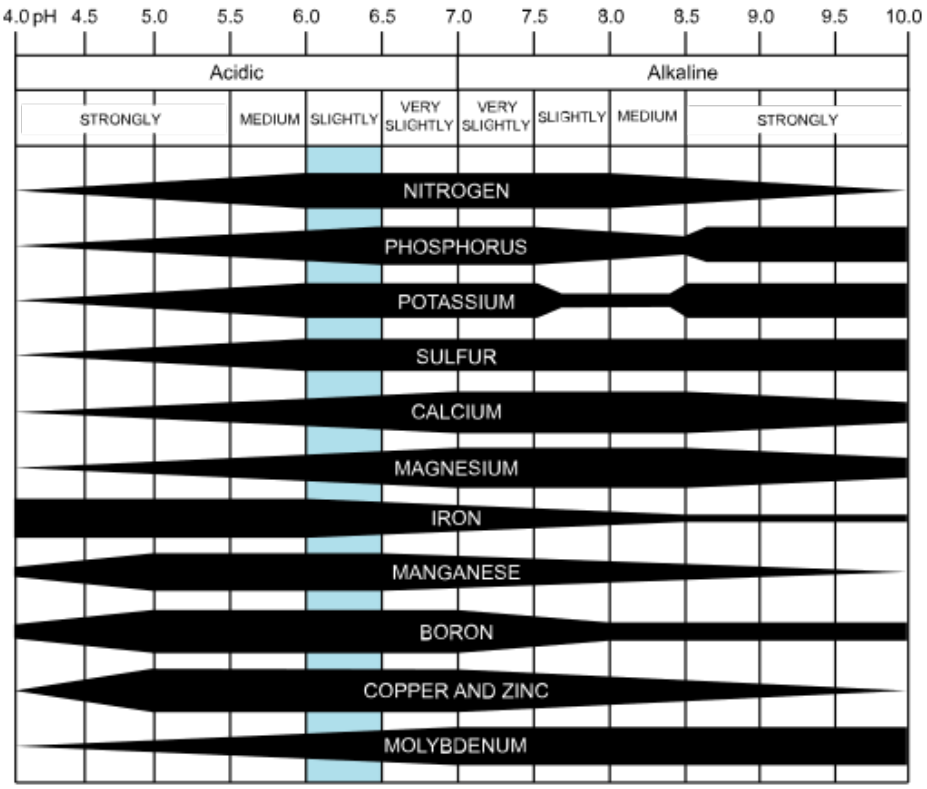
Soil organic matter, or SOM, is the fraction of the soil that consists of plant, animal, and microbial cells and tissue in various stages of decomposition. SOM is approximately 68% carbon, and microbial necromass (i.e. dead microbes) can make up more than half of the SOM of soil. The higher your SOM the better. OMAFRA offers recommendations for minimum SOM by soil texture: sandy soils should be around 2.5%, sandy loam 3.5%, loam 4%, and clay loam and clay soils at 4.5%.

Percent Base Saturation

Base saturation is the ratio of calcium, magnesium, potassium, hydrogen, and sodium in the soil. When these nutrients are balanced with one another, and in optimal ranges, they provide the ideal environment for microbial activity, and help form good soil structure and water holding capacity. The ideal ranges for calcium are 70-80%, magnesium 12-18%, hydrogen 0-15%, potassium 3-5%, sodium less than 1%.

pH

pH is the acidity or alkalinity of a solution on a scale from 0 (extremely acidic) to 14 (extremely alkaline). 7 is neutral. A soil's pH has a direct effect on nutrient availability. Evan suggests that soil pH becomes self adjusting when the base saturations of calcium, magnesium, potassium, sodium, and hydrogen are in balance. A soil pH anywhere between 6.2 and 7.0 is ideal for nutrient uptake and soil biology.



Nitrogen

Nitrogen (N) is an essential element for plant growth and development including chlorophyll, enzymes, amino acids, and contributes to increased yields and protein content. Most base soil tests done in Ontario don't include nitrate analysis, as it is a very mobile nutrient in the soil due. Most crops have a N recommendation based on yield goals, but when adding N it is important to account for residual N and N credits from previous crops or cover crops. Nitrogen needs for an organic system can all be supplied by cover crops when the right array of legumes and termination strategies are used. Other amendment options include manure, compost, meals, and fish products.

Phosphorus

Phosphorus (P) is an important nutrient for plant growth at all stages and soil microbial communities. There are two common lab analyses for phosphorus and your soil pH will influence which one you use to calculate applications. For soils with a pH less than 7, the Bray P1 test will be used, and for soils with a pH greater than 7, the Olsen bicarbonate test. Some amendment options to add phosphorus are bone meal, soft or hard rock phosphate, and compost or manure.

Potassium

Potassium (K) is important to plant growth and helps with drought resistance and enhanced water uptake. It is critical for plant quality and yield, especially in fruits and vegetables. Total K requirement is affected by CEC. To achieve 4-5% from base saturation Evan offers the following calculation to determine total required K in ppm: **CEC * 780 * 4%)/2**. Some amendment options to add potassium are potassium sulfate, KMag, and wood ash.

IMPORTANT: Mind your Ps and Ks! Many amendments list P as available phosphate (P2O5) and K as available potash (K2O). To convert P to P2O5 multiply by 2.29 or to convert P2O5 to P divide by 2.29. To convert K to K2O multiply by 1.21 or to convert K2O to K divide by 1.21.

Sulfur

Sulfur (S) is an important plant nutrient for protein synthesis and chlorophyll formation and is a key part of the compounds imparting flavour and aroma to many plants, particularly the allium family. The recommended level of sulfate is 20-35ppm. Some options to add sulfur to the soil include, elemental sulfur, gypsum, potassium or magnesium sulfate, and KMag.

Micronutrients

Although micronutrients are needed in small amounts, these do not reflect their relative importance to the growing plants. They often serve as catalysts and work in conjunction with major nutrients. They can be essential for disease and pest resistance. When applying, caution must be taken as excess application can quickly become toxic to the plants and soil.

Important micronutrients include:

- boron – recommended to be around 2ppm in a soil test; can be amended with solubor or borax;
- zinc – recommended to be between 5-10 ppm in a soil test; can be amended using zinc sulfate;
- copper – recommended to be between 2-3 ppm and can be amended using copper sulfate;
- iron – recommended to be greater than 50 ppm in a soil test and can be amended by iron sulfate; and,
- manganese – recommended to be between 40-80 ppm on a soil test and can be amended using manganese sulfate.

What do I do with my soil test?

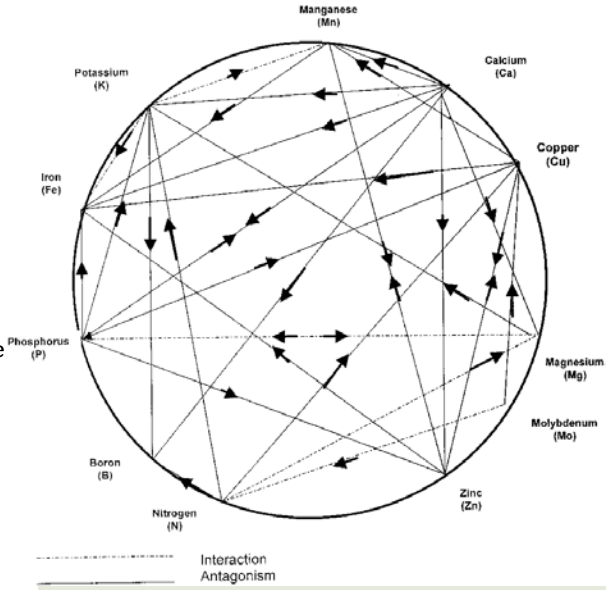
After receiving your soil test it is important to interpret and understand the results, remembering that this test is just a snapshot in time.

To do this, Evan has created a spreadsheet that can help you take the information provided in a soil test and choose and balance amendments for field applications. Hyperlinks to these tools can be found in the digital version of this magazine.

When using this tool, it is important to keep in mind the potential antagonisms and synergies between any two nutrients (see Mulder's chart). It's all about balance. An excess or deficiency of one nutrient can have a huge impact on another nutrient's availability. Knowing these interactions can help us make more informed decisions on how to amend the soil.

After you understand your results, it's time to design a fertility program based on your soil, soil tests, and cropping plan.

Evan recommends always applying amendments within a carbon source (compost, humates, or biochar). Less is often more. Doing split applications over a number of years, especially for micronutrients and trace elements, is recommended. Remember that this isn't a one and done thing — don't expect to fix everything in one go. Keeping the soil balanced and productive is an ongoing process and needs to be assessed continually. Finally, Evan suggests making major corrections in autumn, especially with things like calcium. ■



Mulder's chart shows some of the interactions between plant nutrients.
Source: Researchgate.net.

Soil Amendment Tools:

- Evan's Soil Spreadsheet – thekitchengarden.ca/soil
- OSCIA's Soil Test Manager – soiltestmanager.ca
- OMAFRA's AgriSuite – agrisuite.omafra.gov.on.ca

Other helpful conversions:

- mg/L = mg/kg = ppm (parts per million)
- P in ppm multiplied by 4.6 = P2O5 in lbs/ac
- K in ppm multiplied by 2.4 = K2O in lbs/ac
- Other elements in ppm multiplied by 2 = element in lbs/ac
- Results in kg/ha multiply by 0.455 = ppm

Dillon Muldoon *is EFAO's Research and Soil Health Program Manager. He is passionate about agriculture and food systems and has a broad range of research interests including agroecology, sustainable production, soil health, community food systems, integrated pest management, and agricultural education and outreach.*