SOIL TEST REPORT INTERPRETATION FOR NOVA SCOTIA

After taking a soil sample and submitting it to a lab, you will receive a soil test report. The soil test report will look different depending on the lab you are using. Most producers in Nova Scotia use the Nova Scotia Plant and Animal Analytical Lab. This factsheet helps producers interpret a standard soil test report from the Nova Scotia Department of Agriculture Analytical Lab. This factsheet will go through each component of the soil test report in figure 1, with each colour corresponding to each component.

There are many important components of a soil test report including:

- pH
- Organic Matter
- Macronutrients and Secondary Nutrients
- Crop Ratings
- Micronutrients
- Cation Exchange Capacity (CEC)
- Base Saturation (BS)
- Lime Recommendation
- Nutrient Recommendations

PARAMETER	ANALYSIS	RATING	ANALYSIS	RATING
pH (pH Units)	5.14		5.70	
Buffer pH (pH Units)	7.37		7.62	
Organic Matter (%)	3.6		4.2	
P205 (kg/ha)	277	L+	2093	E
K20 (kg/ha)	151	L+	1191	E
Calcium (kg/ha)	327	L-	2226	M-
Magnesium (kg/ha)	60	L-	363	M+
Sodium (kg/ha)	23		47	
Sulfur (kg/ha)	42		40	
Aluminum (ppm)	1569		1160	
Boron (ppm)	< 0.50		0.56	
Copper (ppm)	1.75		2.79	
Iron (ppm)	169		264	
Manganese (ppm)	149		294	
Zinc (ppm)	3.72		26.97	
CEC (meq/100g)	6.3		11.5	
Base sat. K (%)	2.5		11.0	
Base sat. Ca (%)	12.9		48.5	
Base sat. Mg (%)	3.9		13.2	
Base sat. Na (%)	0.8		0.9	
Base sat. H (%)	79.8		26.5	
LR CaCO3 (t/ha to pH 6.5)	8		4	
Required Nutrient (kg/ha)	N	P205	K20	N	P205	K20
	140	225	130	140	0	0

Figure 1. Example soil test report from the Nova Scotia Plant and Animal Analytical Lab.

PH

What is it?

- A measure of soil acidity.
- Measures the active hydrogen ions in the soil solution.
- pH is on a scale of 1-14, where below 7 is acidic, 7 is neutral, and above 7 is alkaline (Figure 2).
- pH is on an inverse logarithmic scale– for every one unit increase in pH, there is a 10-fold decrease in hydrogen ion activity.

Importance

- pH plays a large role in the availability of nutrients to plants in soil.
- At low pH, essential nutrients can get tied up and are not plant available.
- Adequate pH is important for maintaining microbial life in the soil.

CROP	OPTIMAL PH RANGES
Field Crops	5.8-7.0
Forages	5.8-7.0
Blueberry	4.5-5.5
Tree Fruits	5.5-6.5
Vegetables	6.0-7.0
Berries (except blueberry)	6.0-6.5
Grapes (depends on variety)	5.5-7.0
Many crops can grow in wide pH ranges; however, they are likely less productive below or above optimal pH levels.	

What you need to know

- The pH is the first value listed on the soil test report.
- Know your crop's ideal pH range.
- If the pH is below the ideal range, you may need to apply a liming agent such as limestone.
- If your pH is above the ideal range, you may need to apply an acidifying agent such as elemental sulfur.
- Nova Scotia soils are typically acidic, and liming is often required.
- For most crops, a good yield can still be produced if your soils are slightly acidic.

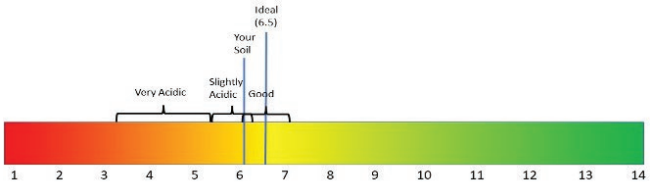

Figure 2. pH scale and the ideal range for most crops (subject to change based on the crop).

BUFFER PH

What is it?

- The amount of acidity in reserve in your soil.
- Indicates the buffer capacity of the soil.

Importance

- The buffer pH helps dictate your lime requirements.
- The higher the buffer capacity, the more lime is required to change your pH. Lower buffer capacity will require less lime but may require it more frequently.

The buffering capacity of soil is largely dependent on the organic matter and clay content of the soil and can also be indicated by the cation exchange capacity.

Soils can have the same pH and different buffering pH.

pH = Does my soil need lime?
Buffer pH = How much lime does my soil need?

What you need to know

- Buffer pH determines how resistant your soil is to pH change.
- This value is used mainly by the lab and your agronomist to determine the amount of lime required to reach a target pH of 6.5.

ORGANIC MATTER

What is it?

- Combination of living and dead plant and animal matter in soil (Figure 3).
- Organic matter is often an indicator of soil health.

Importance

- Provides nutrients.
- Contributes to soil structure.
- Increases water-holding capacity.
- Reduces the risk of erosion.
- Increases biodiversity.
- Organic matter contains negatively charged binding sites which promote nutrient adsorption.
- Increases cation exchange capacity.

What you need to know

- Organic matter is listed as a percentage on the soil test report and is closely tied to carbon in the soil.
- Ideally, you want more than 3.5% organic matter, but this can change depending on your soil type.
- If your organic matter is below the ideal range, you can add organic amendments such as compost and/or manure.
- Beneficial management practices such as cover cropping, residue retention, and reduced tillage helps build organic matter.
- Organic matter takes a long time to build.

Organic matter is approximately 58% organic carbon and exists within different pools.

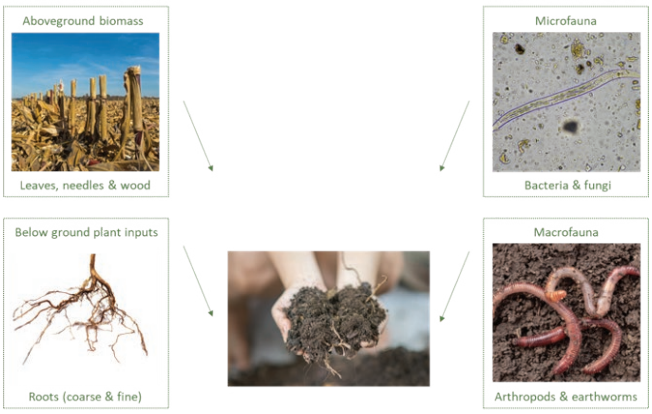

Figure 3. Major sources of organic matter, adapted from Krzic et al., 2021.

MACRONUTRIENTS AND SECONDARY NUTRIENTS

Phosphorous (P_2O_5)

What is it?

Phosphorous (P) is an essential macronutrient and can often be the limiting nutrient to crop growth.

Importance

- Important for seed germination and root growth.
- Important for vegetable and fruit maturity.
- Improves nitrogen absorption.
- Essential for photosynthesis.
- Structural part of cell membranes.

The availability of phosphorous in soil is highly pH dependent (Figure 4).

What you need to know

- Phosphorus is represented in kg/ha of P_2O_5 on the soil test report.
- P_2O_5 = 2.29 X P
- Different crops require different amounts of P; it is important to know your crop requirement.
- Phosphorous occurs in the soil as organic phosphorous, dissolved phosphorous in solution, and insoluble inorganic phosphorous compounds.
- Plants take up P in its soluble form ($H_2PO_4^-$, HPO_4^{2-}); dissolved P can bind with other elements such as aluminum making them unavailable.
- Low P can be compensated for by adding fertilizers or organic amendments.
- It is important not to overapply P because it can be lost from the system through erosion, runoff, and leaching and cause environmental damage.
- Phosphorous can build up in soil over time.

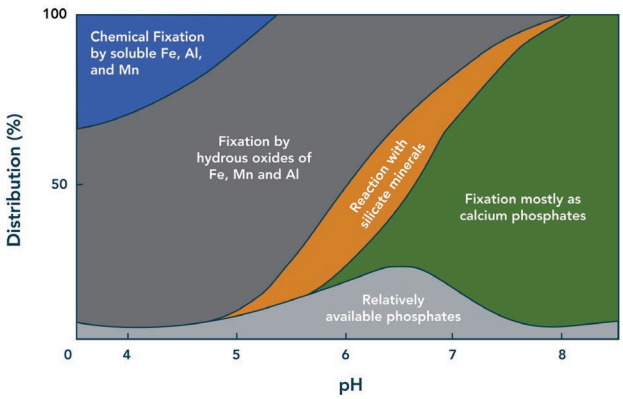

Figure 4. Relative availability of phosphorous at different pH levels, adapted from Schlesinger, 2012.

Potassium (K_2O)

What is it?

Potassium (K) is a macronutrient and can often be the limiting nutrient to crop growth.

Importance

- It is involved in the activation of enzymes that are responsible for many physiological plant processes.
- It plays a role in nutrient, sugar, and water transport within the plant.
- It is essential for the winter hardiness of legumes.
- Improves fruit size, colour, and taste.
- Helps adapt to environmental stresses.

What you need to know

- Potassium is represented in kg/ha of K_2O on the soil test report.
- K_2O = 1.2 X K
- Different crops require different levels of K; it is important to know your crop requirement.
- Potassium is often outcompeted by other nutrients through antagonistic relationships such as calcium.
- Poor aeration can reduce the uptake of K, and more K is often available in moist soil conditions.
- Potassium can be taken up in plants in luxury amounts.
- Potassium can build up in soil overt time.

There are no known environmental damages from K leaching; however, K losses can result in reduced yield and decreased fertilizer use efficiency.

Sulfur (S)

What is it?

Sulfur (S) is a secondary nutrient and can often be the limiting nutrient to crop growth.

Importance

- Helps form amino acids and proteins.
- Essential part of plant structural components.
- Essential part of nitrogen fixation.
- Essential for photosynthesis.

What you need to know

- Sulfur is represented in kg/ha on the soil test report.
- Different crops require different levels of S; it is important to know your crop requirement.
- Sulfur is often overlooked because Nova Scotia received "free" sulfur from acid rain for a long time. However, more recent studies have shown S deficiencies in many crop.
- Sulfur can acidify soils.
- Sulfur deficiencies are more common in sandy soils with low organic matter.
- Sulfur can be leached.

Calcium (Ca)

What is it?

Calcium (Ca) is a secondary nutrient and can often be the limiting nutrient to crop growth.

Importance

- Helps regulate cellular functions.
- Important component of cell wall structure.
- Important for animal health.
- Helps with environmental stress response.

What you need to know

- Calcium is represented in kg/ha on the soil test report.
- Calcium deficiency in a plant is often closely tied to water availability.
- Calcium is often mobile in soil and can be easily leached.
- Calcium is often needed in large amounts.
- Calcium often has a positive relationship with pH; therefore, low pH soils are often deficient in Ca.
- Calcium is not mobile within the plant.

Liming is a good way to increase your calcium levels; however, pH will also increase. Gypsum can be used to increase Ca levels, but not pH.

Magnesium (Mg)

What is it?

Magnesium (Mg) is a secondary nutrient and can often be the limiting nutrient to crop growth.

Importance

- Essential for photosynthesis.
- Involved in the formation of lipids and proteins.
- Important for animal health.
- Essential component for cellular respiration.

What you need to know

- Magnesium is represented in kg/ha on the soil test report.
- Different crops require different levels of Mg; it is important to know your crop requirement.
- Magnesium is often mobile in soil and can be easily leached.
- Magnesium is mobile within the plant.
- Can help with P movement in soil.

CROP RATINGS

Crop ratings are available for phosphorous, potassium, calcium, and magnesium; however, **crop ratings will only be available if you listed a crop on your soil sample submission form**.

These ratings indicate how much of the nutrient in the soil is plant available and are used to gauge how responsive a crop will be to supplemental fertilizer beyond soil supply. The ratings are based on the tables below but do not account for variety or yield goals.

These ratings should be used cautiously, and you can consult with other references (OMAFRA, Quebec) for nutrient recommendations.

TABLE 1.
AVAILABLE PHOSPHORUS (P_2O_5) SOIL INTERPRETATION RATINGS FOR NOVA SCOTIA CROPS.

SOIL RATING	SOIL TEST LEVELS (kg/ha)					
	Forages	Grain	Vegetables	Small Fruits	Tree Fruits	Turf
Low (L-, L, L+)	0-141	0-141	0-336	0-231	0-239	0-336
Medium (M-, M, M+)	142-215	142-215	337-582	232-360	240-383	337-582
High (H-, H, H+)	216–411	216–411	583–1144	361–558	383–598	583–1144
Excessive (E)	411+	411+	1145+	559+	599+	1145+

TABLE 2.
AVAILABLE POTASSIUM (K_2O) SOIL INTERPRETATION RATINGS FOR NOVA SCOTIA CROPS

SOIL RATING	SOIL TEST LEVELS (kg/ha)					
	Forages	Grain	Vegetables	Small Fruits	Tree Fruits	Turf
Low (L-, L, L+)	0–121	0–121	0–179	0–121	0–179	0–179
Medium (M-, M, M+)	122–236	122–236	180–330	122–236	180–330	180–330
High (H-, H, H+)	237–514	237–514	331–703	237–514	331–703	331–703
Excessive (E)	515+	515+	704+	515+	704+	704+

TABLE 3.
AVAILABLE CALCIUM (Ca) SOIL INTERPRETATION RATINGS FOR NOVA SCOTIA CROPS

SOIL RATING	SOIL TEST LEVELS (kg/ha)					
	Forages	Grain	Vegetables	Small Fruits	Tree Fruits	Turf
Low (L-, L, L+)	0–1883	0–1883	0–1883	0–1187	0–1883	0–1883
Medium (M-, M, M+)	1884–4157	1884–4157	1884–4157	1188–3083	1884–4157	1884–4157
High (H-, H, H+)	4158–7012	4158–7012	4158–7012	3084–5434	4158–7012	4158–7012
Excessive (E)	7012+	7012+	7012+	5435+	7012+	7012+

TABLE 4.
AVAILABLE MAGNESIUM (Mg) SOIL INTERPRETATION RATINGS FOR NOVA SCOTIA CROPS

SOIL RATING	SOIL TEST (kg/ha)					
	Forages	Grain	Vegetables	Small Fruits	Tree Fruits	Turf
Low (L-, L, L+)	0 – 80	0 – 80	0 – 80	0 – 80	0 – 80	0 – 80
Medium (M-, M, M+)	81 – 432	81 – 432	81 – 432	81 – 329	81 – 341	81 – 432
High (H-, H, H+)	433 – 1048	433 – 1048	433 – 1048	330 – 563	342 – 714	433 – 1048
Excessive (E)	1049+	1049+	1049+	564+	715+	1049+

MICRONUTRIENTS

The soil test report provides concentrations for various micronutrients, mostly in ppm. Producers should look up specific crop requirements for micronutrients to evaluate whether the amounts in their soil are within a suitable range.

Some micronutrients can be toxic in abundant amounts, so it is important not only to evaluate these values for sufficiency, but also for toxicity ranges.

- Sodium (Na) – beneficial to salt-adapted crops; most NS soils are not deficient.
- Iron (Fe) – Most soils in Nova Scotia have plenty, becomes more available at low soil pH
- Manganese (Mn) – Most soils in Nova Scotia have plenty, becomes more available in low soil pH.
- Zinc (Zn) – Can be made unavailable by high P.
- Copper (Cu) – Sandy or low OM soils might see a response to a Cu application.
- Boron (B) – NS soils may benefit from additional B applications dependent on crop.
- Aluminum (Al) – Most soils in Nova Scotia have plenty, can be damaging in excess amounts, becomes more available at low soil pH.

There are other micronutrients which are not on the NS soil test report which are often important, such as cobalt (Co), silicon (Si), molybdenum (Mo), and selenium (Se).

In addition, heavy metals such as cadmium (Cd) and arsenic (As) can cause decreases in production. Other labs can offer these as an analysis.

CATION EXCHANGE CAPACITY

What is it?

- Cation exchange capacity (CEC) is the total amount of exchangeable cations that a soil can adsorb.
- A cation is a positively charged molecule such as Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, and H^{+}.

Importance

- Contributes to the buffering capacity of the soil.
- Dependent on the number of negative exchange sites found on soil organic matter and clay particles.
- May be difficult to alter.

What you need to know

- Knowing your cation exchange capacity can alter your management practices.
- Soils with low CEC may need to have more frequent fertilizer applications at lower rates because of its lower ability to retain nutrients.
- Sandy soils have inherently low CEC, you can increase the CEC by building organic matter in your soils.

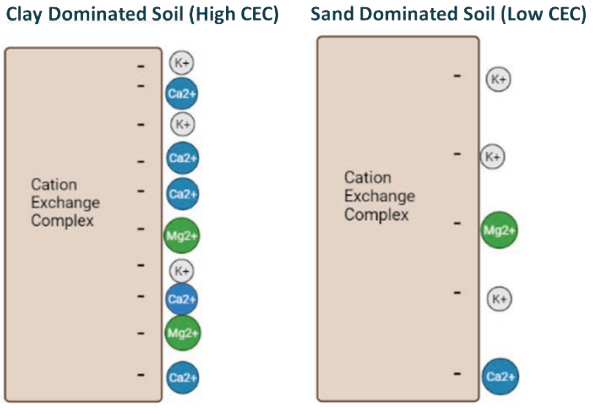

Figure 6. Representation of high and low cation exchange capacity.

Soil Texture	*CEC (meq/100g)*
Sand	1-5
Fine Sandy Loam	5-10
Loam	5-15
Clay Loam	15-30
Clay	>30
Organic Matter	200-400

Table 1. Cation exchange capacity of different soil textures and organic matter Base Saturation.

BASE SATURATION

What is it?

- The ratio of Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, and H^{+} on the cation exchange complex.
- Closely related to pH.

Importance

- Base saturation can be used as an indicator of soil acidification (i.e., if %H is high); however, nutrient ratios are not typically used to make fertility recommendations.

What you need to know

- Fertility recommendations should not be made based on base saturation.
- Base saturation does not indicate total amounts of nutrients, only the amounts relative to each other.
- Does not account for all acidic cations and therefore may misrepresent the base saturation values.

The Albrecht Method is a commonly referred to method for nutrient recommendations, in which nutrient ratios are used; however, there are the following limitations:

- The method is outdated.
- Many crops can tolerate a wide range of nutrient ratios.
- There are few to no studies which show changes in yield from manipulations in Ca:Mg ratios.
- Ideal ratios do not necessarily mean that the nutrient is sufficient. For example, you can have an ideal Ca:Mg ratio, but both nutrients could be deficient.

LIME RECOMMENDATION

The lab provides lime recommendations based on the pH and buffer pH of your soil. These lime recommendations are the amount of calcium carbonate ($CaCO_3$) required to increase your pH to 6.5.

- The lime recommendations are in metric t/ha, you must convert to t/ac if that is the desired unit. The lab reports in metric tonnes; a conversion must be made to US tons.
- Typically, you wouldn't want to apply more than 5 metric t/ha (2 metric t/ac) at one time. If your soils are very acidic, you may need to apply some in the spring and some in the fall or over multiple years.
- Lime application will be more effective if it is incorporated.
- Depending on coarseness, and soil type, lime can take 2-3 years to become fully effective.
- The rates required to increase pH may be different if a different amendment is used such as wood ash.

NUTRIENT RECOMMENDATIONS

- The lab provides nutrient recommendations based on general crop requirements, that are not based on variety or yield goals.
- These recommendations are often very broad, and it is recommended to also review other regional recommendations associated with this method.
- Recommendations change based on soil levels for P and K. Nitrogen recommendations are based on the crop to be grown, because the lab does not test for N, unless specifically requested, and nutrient recommendations for those tests are not available.
- To optimize nitrogen-use efficiency and reduce greenhouse gas emissions, split applications of nitrogen are highly recommended.
- Timing is a crucial factor in nutrient application that is not accounted for in these recommendations.
- You can consult with your local agrologist for more specific nutrient recommendations.

RESOURCES

Krzic, M., Walley, F.L., Diochon, A., Paré, M.C., & Farrell, R.E. (Eds.) 2021. Digging into Canadian soils: An introduction to soil science. Pinawa, MB: Canadian Society of Soil Science. **https://openpress.usask.ca/soilscience/**

Magdoff, F., & van Es, H. (2021). Building Soils for Better Crops: Ecological Management for Healthy Soils (4th ed.). Sustainable Agriculture Research and Education Program. Retrieved from **https://www.sare.org/wp-content/uploads/Building-Soils-for-Better-Crops.pdf**

Nova Scotia Department of Agriculture Analytical Lab Information: **https://novascotia.ca/agri/programs-and-services/lab-services/analytical-lab/**

Ontario Ministry of Agriculture and Rural Affairs Soil Fertility Handbook: **https://files.ontario.ca/omafra-soil-fertility-handbook-en-2022-10-13.pdf**

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