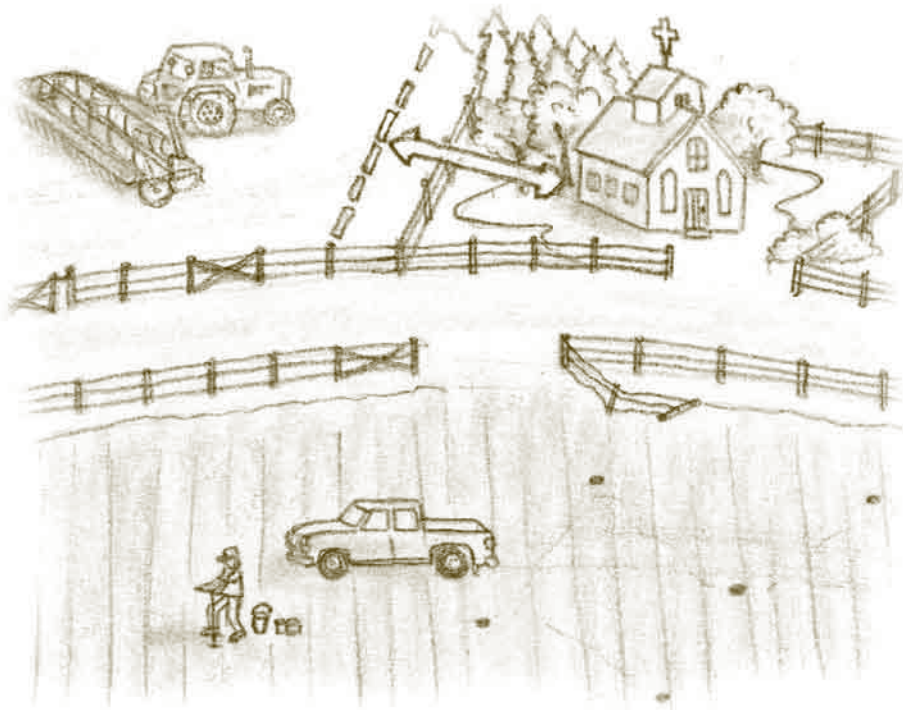
Chapter 3.4
Practical Use of Soil Analysis Results



learning objectives

- Identify analytical results from nutrients, organic matter, pH, EC and CEC from the lab report.
- Interpret soil analysis results for pH and salinity.
- **Describe the significance of soil CEC, soil** organic matter content and soil texture.
- Describe the importance of soil available moisture and how it is characterized.
- Understand why laboratories differ in their analytical results and recommendations.

more info

Refer to Chapter 3.3 for more information on how to collect a quality, representative soil sample from a site.

Important Terms

Table 3.4.1 Key Terms and Definitions

Term	Definition
Atoms	The smallest particle of an element that can exist as a stable entity, either alone or in combination.
Atomic Weight	The average mass of an atom of an element as it occurs in nature. This is made up of the weighted sum of the masses of the protons and neutrons composing the atom.
Labile	Readily or continually undergoing chemical, physical or biological change or breakdown. A substance readily transformed by micro-organisms or readily available to plants.

The soil analysis report provides the information necessary to set nutrient application targets, which are used to calculate manure and fertilizer application rates. Test results from regular field sampling (particularly from benchmark sites) allow monitoring and detection of changes in soil parameters (e.g., nutrients, pH, and salinity) with time.

Soil analysis results must be interpreted within the context of expected yield response for the crop to be grown under specific environmental and management conditions. The interpretations discussed in this chapter are specific to Alberta soils and are based on extensive field and laboratory research. The results of a lab analysis are only as good as the quality of the samples collected and the sampling strategy used. Poor samples that are not representative of field conditions will lead to inaccurate nutrient recommendations.

Address: ❶ ABC Farms Box 123 My Town, AB T0G 0N0	**Grower Name:** Joe Smith ❷ **Client's Sample ID:** 1a **Field ID:** Brown Place **Legal Location:** NW 6-39-29-W4	**Tracking Number:** 200610-01999 ❸ **Date Received:** October 19, 2006 **Report Date:** October 26, 2006 **Disposal Date:** November 30, 2006

Nutrient Analysis (PPM) ❹													**Quality** ❼			
Depth	**N**	**P**	**K**	**SO_4**	**Cl**	**Cu**	**B**	**Ca**	**Mg**	**Fe**	**Zn**	**Mn**	**pH**	**EC**	**OM**	**Texture**
0 - 6"	4	11	175	19	12	0.6	0.7	800	300	3	1.5	2.5	6.7	0.4	5.5	Loam
6 - 12"	1			10												
12 - 24"	1			8												
Total																
Range ❻	D	D	A	A	M	M	A	A	A	M	A	A	Neutral	Good	Normal	
E: Excess **A:** Adequate **M:** Marginal **D:** Deficient																
lb/ac	14	22	350	90									**Cation Exchange** ❽			
Available lb/ac	14	22	350	90									**TCEC:** 44 meq/100g			
❺													**BS:** 100%			
													Ca	**Mg**	**K**	**Na**
													55%	35%	9%	1%

Recommendations (lb/ac) ❾															
Crop	**Conditions**	**Yield**	**N**	**P_2O_5**	**K_2O**	**S**	**Cl**	**Cu**	**B**	**Ca**	**Mg**	**Fe**	**Zn**	**Mn**
Wheat	Excellent	68	125	30	0	0	0	0	0	0	0	0	0	0
	Average	57	100	25	0	0	0	0	0	0	0	0	0	0

Figure 3.4.1 General Appearance of a Soil Analysis Report

sidebar

Nutrient levels are converted from ppm to lb/ac by multiplying by two because a one acre slice of soil, six inches deep weighs approximately two million pounds. In other words, lb/ac is essentially parts per two million. For a soil sample 12 inch deep, multiply ppm by 4.

sidebar

Soil test P and K levels are reported on an elemental basis (i.e., P or K) rather than oxide basis (i.e., P_2O_5 or K_2O).

Reading Soil Analysis Reports

All laboratories generate reports for each sample submitted for analysis. All reports will contain the same basic information although individual labs may present this information in their own unique format. Figure 3.4.1 is an example of the general layout of information on a soil analysis report.

The report will identify the client (# 1 in Figure 3.4.1) as well as the unique sample identification (#2 in Figure 3.4.1). When reviewing soil analysis reports, verify that the sample identification is correct. Although it may seem of minor significance, the legal land location is often used to identify agro-climatic regions that affect yield expectations and fertilizer recommendations.

The report will usually indicate when the sample was received and when it was processed (#3 in Figure 3.4.1). Review these handling dates to see if there were any unusual delays in shipping that might affect the accuracy of the results. Take note of the length of time the sample will be retained (#3 in Figure 3.4.1). Additional analysis or repeated tests to verify unusual results must be performed while the sample is still available.

The nutrient analysis (#4 in Figure 3.4.1) is the heart of the report but it is often overlooked compared to the fertilizer recommendation. The nutrient analysis is a measurement of the nutrients removed from soil using an extracting solution. These results form the basis for fertilizer recommendations.

Labs use diverse extraction methods so the nutrient analysis of one lab is not directly comparable to another lab unless both are using the same procedures. An individual lab may use various extracts for different nutrients in order to get the most reliable results. Find out what methods a lab follows since some extraction methods may not be suited to western Canadian soils.

For nutrient management purposes, it is useful to use the same lab every year or to use labs that follow the same extraction processes to track nutrient level changes with time.

Nutrient levels are reported in parts per million (ppm or mg/kg). For each 15 cm (6 in) sample depth, these values can be doubled to approximate the nutrient levels on a kilograms per hectare (kg/ha) or pounds per acre (lb/ac) basis (#5 in Figure 3.4.1).

Nutrient (kg/ha) =
Nutrient (ppm) x 2 x sample depth (cm) ÷ 15 cm

Nutrient (lb/ac) =
Nutrient (ppm) x 2 x sample depth (in) ÷ 6 in

A soil analysis report indicates there is 10 ppm N in a 0 to 6 in soil sample. This corresponds to 20 lb N/ac:

Nutrient (lb/ac)

= nutrient (ppm) x 2 x sample depth (in) ÷ 6 in

= 10 ppm x 2 x 6 in ÷ 6 in

= 20 lb N/ac

There is 10 ppm N in a 0 to 12 in sample. This corresponds to 40 lb N/ac:

Nutrient (lb/ac)

= Nutrient (ppm) x 2 x sample depth (in) ÷ 6 in

= 10 ppm x 2 x 12 in ÷ 6 in

= 40 lb N/ac

Examine reported nutrient levels for any unusual values. Soil N levels following average or above average crops should be low (i.e., below 15 ppm and often less than 10 ppm for 0 to 15 cm (6 in) depths). Phosphorus levels for fields that have not received manure should not vary much from year to year and are typically quite low (less than 15 ppm for 0 to 15 cm depth). On fields with a history of manure application, the N and P levels may be considerably higher. Potassium levels of Alberta soils are relatively stable, often quite high (more than 150 ppm in 0 to 15 cm depth) and may exceed 500 ppm on Brown and Dark Brown soils, even without a history of manure application. Sulphur levels are variable and can range from less than 5 ppm to more than 50 ppm for 0 to 15 cm depth. Large year-to-year changes in soil nutrient levels should be investigated to determine the cause (e.g., management changes, change in analytical method, or mishandling of samples).

Excess nutrient levels may be suggested on a soil analysis report when nutrient levels are reported as being greater than a lab threshold (e.g., K is more than 600 ppm). Unless a dilution is performed, the lab will not be able to provide an exact nutrient level. While this has minimal influence on crop production, it can suggest nutrient levels that pose potential environmental risk. If high levels of nitrate (NO_3^-) or P are suspected in a field, ask the lab to dilute the extract to get exact NO_3^- and P levels.

Soil analysis reports often include a subjective rating of nutrient levels (#6 in Figure 3.4.1) based on the probability that a particular nutrient will limit plant growth and production. Often these ratings are depicted as bar graphs for each nutrient. These subjective ratings may also help identify potential environmental risk.

For most soils, micronutrient levels are usually in the marginal range but are occasionally adequate or deficient. The probability of crop response to micronutrient application is not clear in many instances.

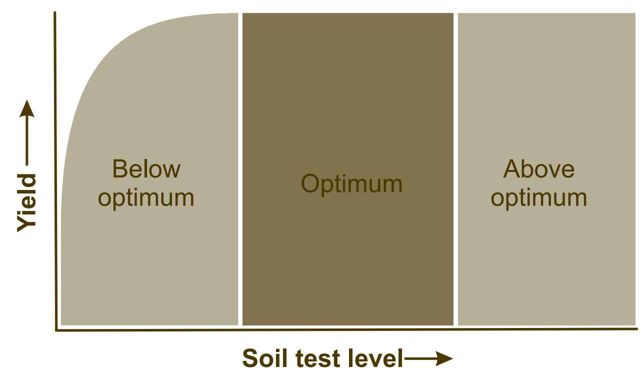
Soil quality factors including pH, salinity, organic matter, and texture (#7 in Figure 3.4.1) provide information useful for the site assessment and crop selection. Often soil quality factors will have a rating system that may flag potential problems.

Labs based in western Canada do not emphasize the total cation exchange capacity or the composition of exchangeable cations (#8 in Figure 3.4.1). These analyses are usually included at additional costs. Other labs may recommend nutrient additions to "balance" exchangeable ions but there is little research evidence to support this practice.

Fertilizer recommendations are usually based on yield response curves or yield expectations (#9 in Figure 3.4.1) for a crop based on soil moisture and growing season precipitation. Some labs will provide more than one set of recommendations to account for different rainfall conditions (e.g., average and excellent). Fertilizer application rates can then be adjusted or selected based on expected rainfall.

Crop Nutrients

One of the basic principles behind formulating fertility requirements relates to the probability of a crop response to nutrient application (Figure 3.4.2).



From Beegle, 2006

Figure 3.4.2 Yield Response in Relation to Soil Nutrient Levels

tip

Contact the soil testing laboratory with specific questions about the analytical techniques used to measure individual soil.

sidebar

Often kg/ha and lb/ac are interchanged and considered to be equal. However, the actual conversion is kg/ha x 0.8924 = lb/ac.

Soils that test in the deficient range for a particular nutrient have a high probability of improved yield if that nutrient is applied. Soils that test in the adequate range are not likely to see an improvement in yield as a result of nutrient application (Table 3.4.2).

Table 3.4.2 Generalized Deficient, Marginal, and Adequate Ranges of Various Crop Nutrients for Alberta Soils

Soil Test Nutrient	Depth, cm (in)	Classification[1]								
		Deficient[2]			Marginal			Adequate		
Nitrate-Nitrogen (Dryland) (lb/ac)	0–60 cm (0–24 in)	< 11	11–20	21–30	31–40	41–50	51–60	61–70	71–80	> 80
Nitrate-Nitrogen (Irrigated) (lb/ac)	0–60 cm (0–24 in)	< 21	21–40	41–60	61–80	81–100	101–120	121–140	141–160	> 160
Phosphorus (lb/ac)	0–15 cm (0–6 in)	< 11	11–20	21–25	26–30	31–40	41–50	51–70	71–90	> 90
Potassium (lb/ac)	0–15 cm (0–6 in)	< 51	51–100	101–150	151–200	201–250	251–300	301–400	401–600	> 600
Sulphur (lb/ac)	0–60 cm (0–24 in)	< 6	6–10	11–15	16–20	21–25	26–30	31–40	41–50	> 50
Copper (ppm)	0–15 cm (0–6 in)		< 0.5			0.5-1.0			> 1.0	
Manganese (ppm)	0–15 cm (0–6 in)		< 1.0			1.0-2.0			> 2.0	
Iron (ppm)	0–15 cm (0–6 in)		< 2.0			2.0-4.0			> 4.0	
Zinc (ppm)	0–15 cm (0–6 in)		< 0.5			0.5-1.0			> 1.0	
Boron[1] (ppm)	0–15 cm (0–6 in)		< 0.35			0.35-0.50			0.50-3.50	
Chloride (ppm)	0–15 cm (0–6 in)		< 15.0			16-30			> 30	

Adapted from Kryzanowski et al., 1988

[1] **Nutrient range for each classification will vary with crop type and soil zone.**
[2] **Boron levels above 3.5 ppm are considered excessive.**
[3] **To convert lb/ac to kg/ha, multiply by 1.1206.**

pH

Soil pH (or reaction) indicates acidity or alkalinity of the soil. Soils below pH 6.7 are acidic and soils above pH 7.3 are alkaline. A pH near 7.0 is considered neutral. A more descriptive classification of soil pH is based on the ranges described in Table 3.4.3.

Table 3.4.3 Qualitative and Quantitative Descriptions of pH for Alberta Soils

3.0–5.6	5.6–6.2	6.2–6.7	6.7–7.3	7.3–7.9	7.9–8.5	>8.5
Strongly Acidic	Moderately Acidic	Slightly Acidic	Neutral	Slightly Alkaline	Moderately Alkaline	Strongly Alkaline

Source: Kryzanowski et al., 1988

Under low pH conditions, some nutrients bind tightly to soil particles and as a result are unavailable to plants. In addition, chemical structures of some nutrients, particularly P, can change under low pH making them less available to crops. Low pH conditions also impact the growth and survival of soil microorganisms, some of which are instrumental in releasing nutrients bound in organic matter for crop use.

Crops vary in their acidity tolerance (Figure 2.2.5) which is strongly influenced by the sensitivity of crops to various levels of soluble aluminum (Al^{3+}). Aluminum solubility increases substantially under strongly acidic conditions. Crops produced in soils more acidic than their tolerance level will result in reduced yields. Fertilizer recommendations should be adjusted for reduced yield potential on the basis of crop type and pH.

To contend with soil acidity, select acid tolerant crop types or consider liming the soil to correct the high pH condition. Before applying lime, request a lime requirement test which will provide a recommendation for an appropriate rate. Liming acid soils can be an extremely costly procedure so the potential return on investment should be carefully assessed. More information about soil pH and acid soil conditions can be found in Chapter 2.2.

Salinity

There are two soil parameters used to characterize soils as saline, sodic or saline-sodic. These are electrical conductivity (EC) and sodium adsorption ratio (SAR). Only EC is part of routine agricultural soil analysis.

EC

Soluble salts are present in soils at all times; however, when the concentration of salts is high, the soil is considered saline and crop growth can be reduced. EC is a measure of the total soluble salt concentration in a soil (i.e., salinity). It is determined by measuring the ability of a small current to be transmitted through saturated soil between two electrodes of a conductivity meter that are a fixed distance apart. The units commonly used to express EC are decisiemens/metre (dS/m). Soils are classified on the basis of salinity according to the EC ranges specified in Table 3.4.4.

more info

For more information on liming acid soils can be found in the factsheets below, which can be ordered from the AF Publications Office or searched by Agdex number on Ropin' the Web:

- **AF. 1996. Liming acid soils. Agdex 534-1.**
- **AF. 2002. Wood ash: An alternative liming material for agricultural soils. Agdex 534-2.**

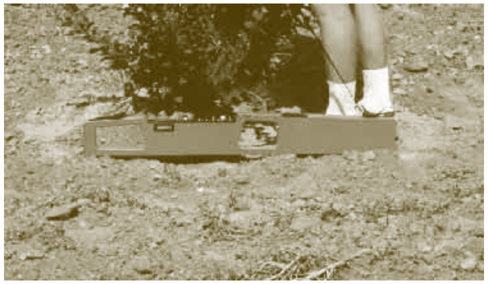


Table 3.4.4 Salinity Ratings for Alberta soils in Relation to Electrical Conductivity Measurements

Soil Depth	Salinity Classifications and EC Measurements (dS/m)				
	Non-Saline	Weakly Saline	Moderately Saline	Strongly Saline	Very Strongly Saline
0–60 cm (0–2 ft)	< 2	2–4	4–8	8–16	> 16
60–120 cm (2–4 ft)	< 4	4–8	8–16	16–24	> 24

Source: Kryzanowski et al. 1988

Crops exhibit a range of tolerance to salt levels in the soil (Table 3.4.5). In general, grass forages tend to have a higher salinity tolerance than field crops.

Table 3.4.5 Salt Tolerance of Selected Crops

EC (dS/m) (Salt Tolerance)	Field Crops	Forages	Vegetables
20 (Very high)		Beardless wildrye, Fulks altai grass, Levonns alkaligrass, Alkali sucatan	
16 (High)	Kochia Sugar beet	Altai wildrye, Tall wheatgrass, Russian wildrye, Slender wheat grass	
8	6-row barley, Safflower, Sunflower, 2-row barley, Fall rye, Winter wheat, Spring wheat	Birdsfoot trefoil Sweetclover Alfalfa Bromegrass	Garden beets, Asparagus, Spinach
Moderate	Oats, Yellow mustard	Crested wheatgrass, Intermediate wheatgrass	Tomatoes, Broccoli
	Meadow fescue, Flax, Canola	Reed canary grass	Cabbage
4	Corn		Sweet corn, Potatoes
Low	Timothy, Peas, Field beans	White dutch clover, Alsike clover, Red clover	Carrots, Onions, Strawberries, Peas, Beans

Excess soil salinity causes poor and spotty crop stands, uneven and stunted growth and poor yields. Salinity restricts plant water uptake, interferes with nutrient availability and can impair germination and root growth because of caustic salt effects. Saline areas also tend to have poor soil structure and are subject to water logging, both of which are harmful to crop growth.

Sodium Adsorption Ratio (SAR)

SAR is a less commonly requested analysis that expresses the proportion of exchangeable sodium (Na^{+}) to exchangeable calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions.

$$\text{Sodium Adsorption Ratio} = \frac{[Na^{+}]}{\sqrt{\dfrac{[Ca^{2+}] + [Mg^{2+}]}{2}}}$$

Soils with SAR values at 13 or higher are considered sodic. Crop growth on sodic soils is very poor. Excess sodium causes soil particles to repel each other, preventing the formation of soil aggregates. This results in a very tight soil structure with poor water infiltration and surface crusting.

As stated previously, SAR is not part of standard soil analysis packages for agricultural applications but is routinely done as part of most testing packages for environmental applications. Characterizing the proportion of exchangeable Na can be useful in identifying solonetzic soils.

The sodium hazard of a soil is determined by factoring in the EC and SAR of a soil. This results in a soil being classified as non-saline, non-sodic, saline, sodic or saline-sodic (Table 3.4.6).

Table 3.4.6 Sodium Hazard Classifications Based on Sodium Adsorption Ratio and Electrical Conductivity

Classification	Sodium Adsorption Ratio (SAR)	Electrical Conductivity (dS/m)[1]	Soil pH	Soil Physical Condition
Sodic	> 13	< 4.0	> 8.5	Poor
Saline-Sodic	> 13	> 4.0	< 8.5	Normal
High pH	< 13	< 4.0	> 7.8	Varies
Saline	< 13	> 4.0	< 8.5	Normal

[1] dS/m = mS/cm

Source: Kryzanowski et al. 1988

Cation Exchange Capacity (CEC)

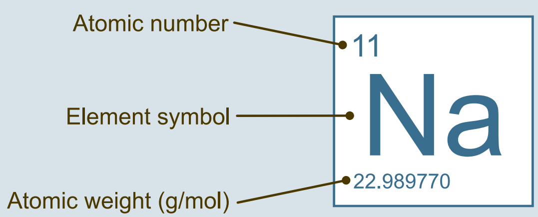
Ion exchange in soils is one of the most important processes influencing crop nutrition. CEC is an estimate of the capacity of soil to hold (or adsorb) positively charged (cation) nutrients. The major soil cations include: calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^+), sodium (Na^+), hydrogen (H^+) and aluminum (Al^{3+}).

The unit of measurement used to commonly express CEC is centimoles of positive charge per kilogram of soil (cmol/kg) and is equivalent to the units formerly used to express CEC; milliequivalents per 100 grams (meq/100g).

How Much is a Mole?

A mole is a quantity used in chemistry to describe 6×10^{23} atoms of a particular element. An element's atomic weight, found in a periodic table of the elements, is the equivalent mass, in grams, of one mole of that substance. For instance, the atomic weight for sodium is 22.989770 grams per mole.

One mole of positive charge refers to the equivalent positive charge on 6×10^{23} monovalent (+1 charge) cations.



Basing CEC on centimoles (0.01 moles) of positive charge rather than mass (as the older milliequivalent measure did) makes more sense since the mass and charge of the various exchangeable cations in a soil sample changes, while the number of negatively charged exchange sites do not. Cation exchange capacity in cmol/kg remains the same regardless of which ions occupy the exchange sites in a soil sample.

The CEC of a soil is primarily influenced by soil texture and organic matter content. Among the mineral components of soil, clay particles generally have the highest cation exchange capacity followed by silt and sand (Table 3.4.7).

Table 3.4.7 General Relationship Between Soil Texture and Cation Exchange Capacity

Soil Texture	CEC, Normal Ranges (cmol/kg of soil)
Sand	1–5
Fine sandy loam	5–10
Loams and silt loam	5–15
Clay loam	15–30
Clay	30+

Source: Hausenbuiller 1985

Consequently, CEC increases with increased clay content of soils. The type of clay in soil also has an important impact (Table 3.4.8).

Table 3.4.8 Range of Cation Exchange Capacities of Different Types of Clay

Type of Clay	CEC, Normal Ranges (cmol/kg of soil)
Allophane	100–150
Montmorillonite	60–100
Chlorite	20–40
Illite	20–40
Kaolinite	2–16

Source: Hausenbuiller 1985

Organic matter content of soils also has an important influence on the CEC of soils since it has a CEC range of 100 to 300 cmol/kg of soil. There is potential to increase soil CEC by adopting practices and crop rotations that focus on building soil organic matter content.

Estimating CEC from Soil Texture

Direct measurement of CEC is time consuming and is not part of most basic commercial soil analysis packages. Clay and organic matter are the major soil components that contribute to cation exchange; therefore, it is possible to estimate total CEC of a given soil sample based on the percentage of organic matter and clay content and the CEC estimates of each.

sidebar

Most soils in Alberta have clays similar to montmorillonite. The contribution of the clay fraction of soils towards CEC would be in the 60 to 100 cmol/kg range.

Estimating CEC from Soil Texture

A theoretical soil from the Alberta Peace region contains 40 percent clay and two percent organic matter. Using average values of 80 cmol/kg for clay (i.e., montmorillonite; Table 3.4.8) and 200 cmol/kg for organic matter (Tables 3.4.7 and 3.4.8), the estimated CEC for this soil would be:

CEC contribution by clay	= percent clay ÷ 100 x CEC of clay (cmol/kg)
	= 40 ÷ 100 x 80 cmol/kg
	= 32 cmol/kg
CEC contribution by organic matter (OM)	= percent OM ÷ 100 x CEC of OM (cmol/kg)
	= 2 ÷ 100 x 200 cmol/kg
	= 4 cmol/kg
Total CEC	= CEC contribution by clay + CEC contribution by OM
	= 32 cmol/kg + 4 cmol/kg
	= 36 cmol/kg

Base saturation (BS) is a measure of the proportion of the total CEC in soil occupied by Na^{+}, K^{+}, Ca^{2+}, and Mg^{2+} expressed in percent. While there is no ideal percent BS, these values are sometimes used to make recommendations for K, Ca, or Mg amendments to soils. This approach fails to consider the cost and economics of such an application, nor does it take into account excessively high levels of cations.

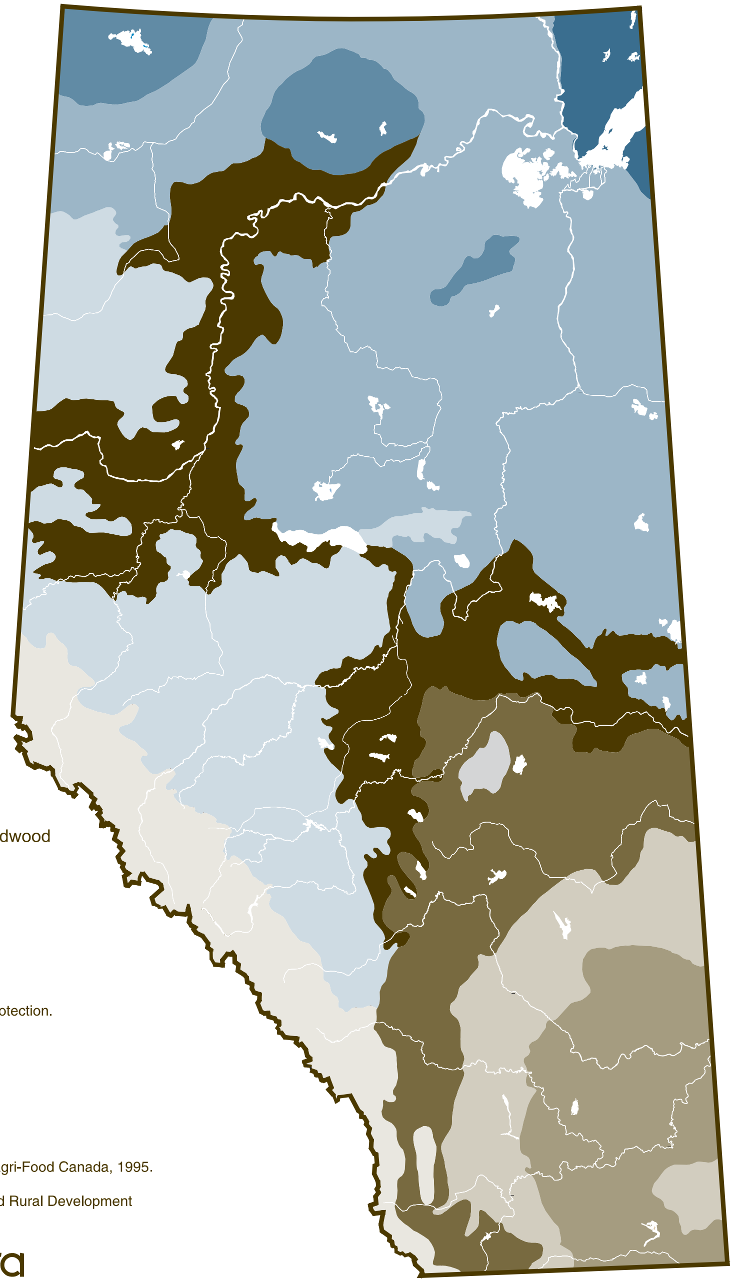
Soil Organic Matter

Soil organic matter is a measurement of the amount of plant and animal residue in the soil. It has several important implications for soil fertility. Organic matter acts as a revolving nutrient bank account, which releases crop available nutrients over an extended period. As discussed in the previous section, it also has an important impact, together with clay content, on CEC of the soil. Soil structure, tilth, and water infiltration are also improved by building soil organic matter.

Organic matter content is the distinguishing characteristic of Alberta's soil zones (Figure 3.4.3). The Brown soil zone has the least organic matter having developed beneath a drier, short grass prairie.

Soil Group Map of Alberta

0 200 km
0 100 mi



Soil Groups*
Natural Subregions**

Brown Chernozemics Dry Mixed Grassland	
Dark Brown Chernozemics Mixed Grassland, Northern Fescue Grassland	
Black Chernozemics Foothills Fescue, Foothills Parkland, Central Parkland	
Dark Gray Chernozemics, Dark Gray - Gray Luvisols Dry Mixedwood, Peace River Parkland	
Brunisols, Gray Luvisols Montane, Subapline, Alpine	
Gray Luvisols Western Alberta Uplands	
Gray Luvisols, Organics Peace River Lowlands, Boreal Highlands, Wetland Mixedwood	
Organic Cryosols, Gray Luvisols Sub-arctic Northern Alberta Uplands	
Brunisols Athabasca Plain	

*Alberta Soil Survey information.

**Natural Regions and Subregions of Alberta Map, 1994, Alberta Environmental Protection.

Map compiled by Alberta Land Resource Unit, Research Branch, Agriculture and Agri-Food Canada, 1995.

Produced by Conservation and Development Branch, Alberta Agriculture, Food and Rural Development

Agriculture and
Agri-Food Canada

Alberta

From AF

Figure 3.4.3 Alberta's Soil Zones

In contrast, the Black soils developed under a cooler, moister aspen parkland condition resulting in greater production of vegetation and organic matter accumulation. Dark Brown soils developed in the transition zone between the Black and Brown zones and has an intermediate organic matter content.

In parts of the province where trees have been the natural, dominant vegetation, Dark Gray or transitional soils developed. In regions where forest cover dominated for longer periods, Luvisolic (forest) soils developed.

Organic or peat soils are found in low-lying areas throughout the Black, Dark Gray and Gray soil zones. These soils formed where organic residues accumulated at a greater rate than they decomposed. These areas are characterized by waterlogged conditions for much of the year.

Typical soil organic matter levels for Alberta cultivated soils range from two to 10 percent (Table 2.2.2, Chapter 2.2). Specific soil organic matter levels will vary based on management history and landscape position.

The most common laboratory procedure for determining organic matter content is through loss on ignition whereby organic matter is incinerated and only the ash residue remains. Organic matter content is the difference in weight before and after the procedure.

More precise methods are used to determine organic carbon content. This involves correcting total carbon content in a sample for the presences of non-organic carbon (e.g., carbonate). Organic carbon is then used to calculate C to N ratios in the sample.

Estimated Nitrogen Release

Organic matter content is an important source of several key crop nutrients including N. Estimated N release (ENR) is an estimate of the amount of N expected to become available from organic matter (i.e., mineralized) over the growing season. This estimate takes into account soil organic matter level, soil moisture, and temperature during the growing season. These are the major factors influencing the rate of mineralization from organic matter (refer to the discussion of organic matter in Chapter 2.2).

Typical ENR values for cultivated Alberta soils are provided in Table 3.4.9 and are based on typical soil organic matter levels for each area. Testing labs use ENR when developing N fertilizer recommendations. Consequently, labs may recommend lower N fertilization rates for individual situations where soil analysis ENR is higher than the expected typical range for that soil zone.

Table 3.4.9 Expected ENR Values for Alberta Soil Groups.

Soil Group	Cultivated Soil			
	kg/ha		lb/ac	
	Mean	Range	Mean	Range
Brown	31	30–33	28	27–29
Dark Brown	38	34–47	34	30–42
Black	56	39–81	50	35–72
Dark Gray	45	43–47	40	38–42
Dark Gray (Peace River Region)	41	34–54	37	30–48

Source: AF Field Research, Kryzanowski & Kelbert (2005)

Variability in growing season nitrogen release (mineralization) will exist from field to field depending on management history. Management practices such as direct seeding, rotation with forages or livestock manure application tend to build the more labile (easily decomposable) fraction of soil organic matter. This helps to improve the nutrient supplying power for a specific field situation. The average ENR's in Table 3.4.9 may underestimate the actual field values.

Soil testing labs may also make an adjustment for pulse crop stubble or manure application in the previous one or two years. Depending on yield, residues from previous pulse crops can release between 20 to 30 kg/ha of available N to the following crop. Likewise, release from the organic portion of the manure will increase the soil's nitrogen supplying power for one or two years after application. This underscores the importance of providing complete information about management and manure application history for a field when submitting samples for analysis.

Soil Texture

Soil texture is the relative proportion of sand, silt and clay in a soil. As discussed in Chapter 2.1, texture directly affects soil water holding capacity, water infiltration rate and indirectly affects soil fertility through CEC.

Soils can be placed into groups (Table 3.4.10) based on textural class, which is determined using a mechanical analysis or the "hand feel" method (Figure 3.1.5, Chapter 3.1). The soil textural triangle is useful for classifying a sample based on the percent sand, silt and clay (Figure 3.1.4, Chapter 3.1).

Table 3.4.10 Soil Texture Group Based on Soil Texture Class

	Soil Texture Group				
	Very Coarse	Coarse	Medium	Fine	Very Fine
Soil Texture Classes	Sand Loamy Sand	Sandy Loam Fine Sandy Loam	Loam Sandy Clay Loam Sandy Clay Clay Loam	Silt Loam Silty Clay Loam Silt	Clay Silty Clay Heavy Clay

Source: Kryzanowski et al. 1988

Table 3.4.11 Classifications for Organic Soils Based on Organic Matter Content

Classification	Organic Matter Content (%)
Muck	30–45
Peaty Muck	45–65
Mucky Peat	65–85
Peat	85–100

Source: Landva et al. 1983

Available Soil Moisture

The amount of soil moisture available at the time of planting is an important consideration when making cropping and fertility decisions. Crop yield potential is directly related to stored soil water and growing season rainfall or irrigation. Low moisture availability will limit crop yield and reduce nutrient requirements. Soils are characterized as being dry, average or wet according to the depth of moist soil and texture class (Table 3.4.12).

Table 3.4.12 Qualitative Interpretation of Available Soil Moisture

Soil Texture Group	Depth of Moist Soil (cm)		
	Dry	Average	Wet
Very Coarse	30–60	60–120	120+
Coarse	30–50	50–100	100+
Medium	15–30	30–60	60+
Fine & Very Fine	15–30	30–60	60+

Adapted from Brady and Buckman 1969

Determining Soil Available Moisture

Soil moisture can be assessed at the same time that fields are being soil sampled. The same rules regarding representative sampling apply to assessing soil moisture. Areas such as depressions, slopes, and knolls can be assessed separately for site-specific crop planning. Sample a minimum of 15 to 20 sites per field and record the average depth of moist soil. Spring sampling may require more sites within a field because of increased variability caused by snow trapping, snow drifting, water runoff, moisture migration within the soil and variations in ground frost, etc.

Soil moisture can be determined by:

- using the "feel test" (Figure 3.1.5, Chapter 3.1)
- subjective visual evaluation
- measuring the depth of moist soil in a collected soil core
- brown soil probe (Figure 3.4.4)

Using the Brown Soil Probe to Determine Soil Moisture

To assess soil moisture depth, vigorously push the probe into the soil in one motion without turning and while applying weight to the handle. The probe will penetrate the soil and will stop when dry soil is reached. Record the depth into the soil that the probe was able to penetrate. Refer to Table 3.4.12 to determine available soil moisture. Stones, frozen soil or a dry surface layer may stop the probe as well, but these are easily detected.

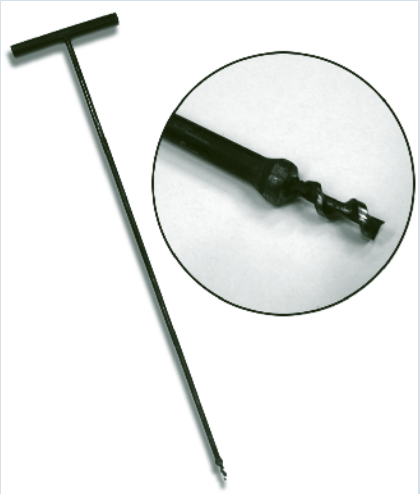


Photo courtesy Crystal Korth and Len Kryzanowski, AF

Figure 3.4.4 Brown Soil Probe

The probe has a short section of a wood drill-bit welded to its end. When the probe is twisted clockwise, a small sample of soil can be obtained. This soil sample can be used to determine texture class and moisture by feel (see method in Chapter 3.1). To construct a soil moisture probe, weld a three-quarter inch steel ball on one end of a one metre long half-inch rod and weld a handle on the other end.

Fertilizer Recommendations

Fertilizer recommendations are usually based on yield response curves or yield expectations for a crop based on soil moisture and growing season precipitation. Recommendations may vary considerably between labs because of different analytical methods, yield response models, yield predictions, expected precipitation and fertilizer use efficiency.

A good soil sample and an accurate soil analysis interpretation are not the only considerations for good yields and maximum profit in crop production. Even if the recommended fertilizer rate is applied, other factors may override the fertilizer effects by limiting crop yield potential. These factors include:

- soil type and stored soil water at time of planting.
- pest control.
- irrigation water quality and management.
- other agronomic and cropping system factors (e.g., seeding date, rate, planting system, fertilizer application method, crop rotation, variety selection, etc.).

Many of these factors are under direct control of the producer; therefore, a favourable fertilizer response is usually related to crop management. Critically examine fertilizer recommendations, yield predictions and growing season precipitation to ensure they are realistic for the area.

Figure 3.4.5 illustrates how all of these considerations are assembled into a decision-making model used to develop a fertilizer recommendation. This model is used by the AFFIRM software package. For more information, see Chapter 7.2.

tip

If a recommendation on a lab analysis does not appear reasonable, request an explanation from the testing lab, seek advice from a qualified agronomic consultant (e.g., Certified Crop Advisor), or contact AF's Ag-Information Centre, toll-free at 310-FARM (3276).

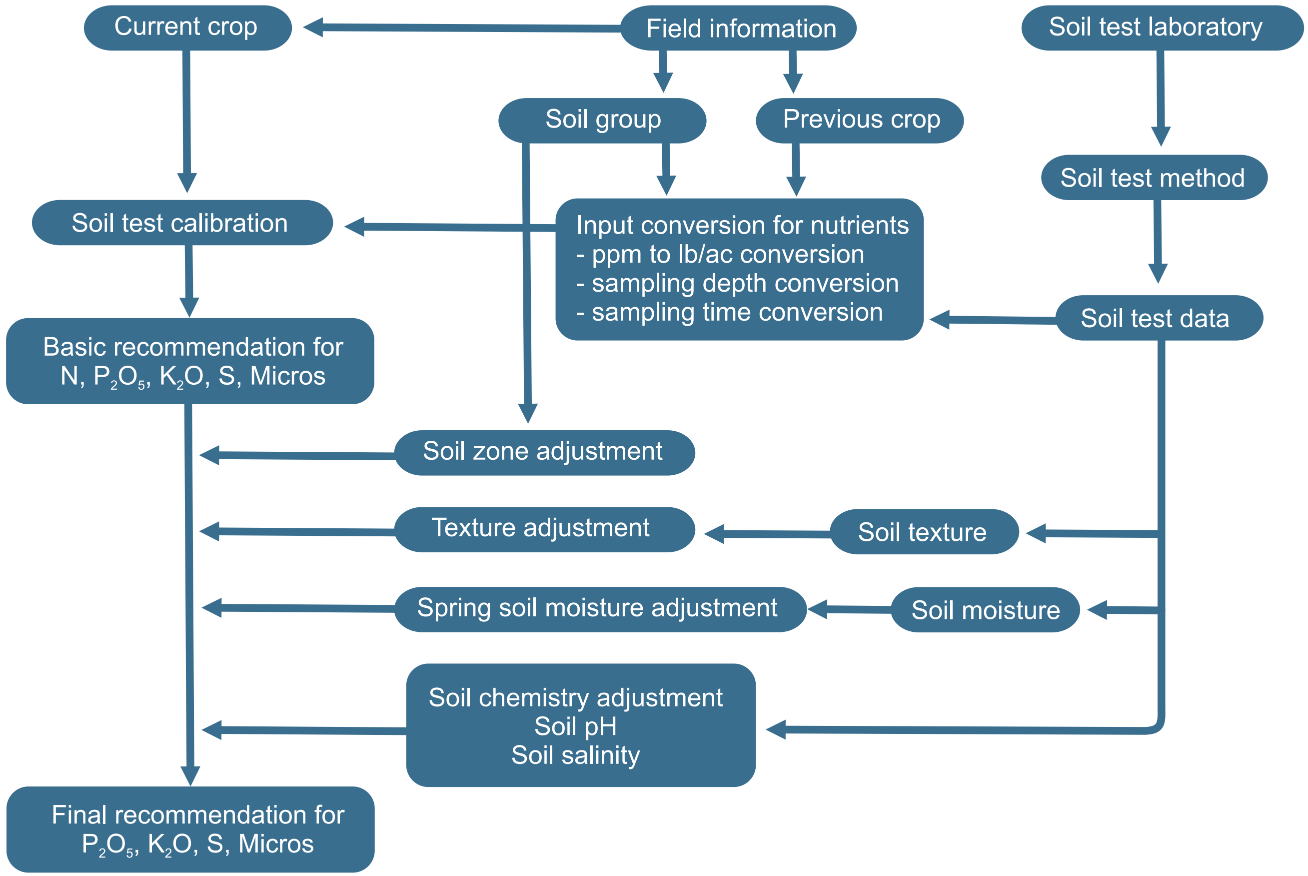


Figure 3.4.5 Decision Making Model Used by AFFIRM to Develop Fertilizer Recommendations

summary

- Key information in a soil analysis report includes: client information, sample identification, date sample was received and processed, nutrient analyses, soil quality parameters (e.g., pH, organic matter, EC) and fertilizer recommendations.
- Soils with pH near 7.0 are considered neutral. Extremes in pH will affect crop productivity. Fertilizer recommendations are adjusted for reduced yields.
- High soil salinity causes poor and spotty crop stands, uneven and stunted growth, and poor yields. Fertilizer recommendations are adjusted for reduced yields.
- Cation exchange capacity indicates the ability of a soil to retain nutrients in the root zone. It can be estimated from the clay and organic matter content of soil.
- Organic matter acts as a revolving nutrient bank account by releasing crop available nutrients over an extended period.
- Soil texture directly affects soil water holding capacity and water infiltration rate, and indirectly affects soil fertility through CEC.
- Crop yield potential is directly related to stored soil water plus growing season rainfall or irrigation.
- Fertilizer recommendations may vary considerably among labs because of different analytical methods, yield response models, yield predictions, expected precipitation and fertilizer use efficiency.