Understanding Soil Sample Analysis

- Soil testing is used to assess what soil amendments are present or may be needed for optimum plant growth and yield potential.
- The results from a soil test list the concentration for specific parameters, an interpretation value (low, optimum, and high), and recommendations for amendment management or nutrient application.

Soil Lab Testing and Results

Soil sampling must be conducted properly to obtain quality soil test results. Each sample should be representative of the entire field or specified sampling unit. Samples must be taken at the proper depth during the same time frame every year. Sample depths can vary by test, but are usually 6 to 12 inches. For more information on best management practices, refer to the Agronomic Spotlight - Soil Sampling.

Soil lab results list the test, the result, and may include interpretation or recommendation. When reviewing lab results, it is important to know what extraction method was used. Labs may report results in parts per million (ppm) or lbs/acre.
To convert ppm to lbs/acre multiply ppm by 2 (lbs/acre = ppm x 2).
To convert lbs/acre to ppm divide lbs/acre by 2 (ppm = lbs/acre ÷ 2).

Soil Parameters

Plants require macronutrients in large amounts. Macronutrients are: Nitrogen (N), phosphorus (P), potassium (K), sulfur (S), calcium (Ca), and magnesium (Mg). Micronutrients are needed for plant function in trace amounts. Plant micronutrients are: copper (Cu), iron (Fe), manganese (Mn), zinc (Zn), boron (B), chloride (Cl), nickel (Ni), and molybdenum (Mo). Other soil characteristics that may be included in soil lab results are organic matter (OM), soil pH, soluble salts (salinity), and cation exchange capacity (CEC).

Nitrogen - An adequate supply of N is associated with high photosynthetic activity, vigorous growth, and dark green plant vegetation. There are two forms of plant available N: nitrate (NO_3^-) and ammonium (NH_4^+). Nitrate is measured most often in soil tests. Soil test results report NO_3^- N in lb N/A. When soil is saturated, nitrate can be lost by leaching and denitrification. It is important to remember that nitrate levels on a soil test reflect what is immediately available and not what will be available in the future from mineralization of organic matter. The Late Spring Nitrate Test, also known as the Pre-sidedress Nitrate Test (PSNT), may be used in-season when corn plants are 6 to 12 inches tall, to determine how much N should be sidedressed. Since nitrate soil test thresholds are regional, consult the nitrate soil test thresholds specific to your geography.

Table 1. Phosphorus recommendations for corn and soybean production when utilizing various extraction methods.

PPM					
	Very Low	Low	Optimum*	High	Very High
Bray P and Mehlich-3 P	0-8	9-15	16-20	21-30	31+
Olsen P	0-5	6-9	10-13	14-18	19+
Mehlich-3 ICP P	0-15	16-25	26-35	36-45	46+
P_2O_5 to apply (lb/acre)					
Corn	100	75	58	0	0
Soybean	80	60	40	0	0

Table 2. Potassium recommendations for corn and soybean production when using the ammonium acetate and Mehlich-3 Extractable K method.

Ammonium Acetate and Mehlich-3 Extractable K - PPM					
	Very Low	Low	Optimum*	High	Very High
Dry	0-120	121-160	161-200	201-240	240+
Field-moist and Slurry	0-50	51-85	86-120	121-155	156+
K_2O to apply (lb/acre)					
Corn					
Fine Textured	130	90	40	0	0
Sandy Textured	110	70	40	0	0
Soybean					
Fine Textured	120	90	66	0	0
Sandy Textured	100	85	66	0	0

Phosphorus - Phosphorus is needed by the plant to store energy created from photosynthesis and carbohydrate metabolism to be used for plant growth and reproductive processes. Phosphorus is not as naturally abundant in the soil as other macronutrients and is relatively immobile because of its negative charge that binds to positively charged particles, such as calcium. The amount of plant available P in the soil solution is related to soil pH. Different P extraction methods are used for lab tests depending on the soil pH: Bray P (acidic soils), Mehlich-3 P (acidic soils), and Olsen P (neutral to alkaline soils). Test results may vary based on the extraction method or test used for measuring P. When interpreting results it is important to know which extraction method and test were used, and how the results were

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reported. Table 1 provides recommendations for corn and soybean production based on soil test results from each of the 3 soil extraction methods.[2]

Potassium - Potassium helps plants activate enzymes, draw water into roots, produce phosphate molecules and CO_2, translocate sugars, and uptake and assimilating N. Most soils contain K in large quantities, although it is not always available. The K cycle is always changing and concentrations will fluctuate seasonally due to differing environmental conditions. Comparing soil tests over time is the best method of evaluating nutrient management decisions. Soil testing in the fall or spring are acceptable for determining K soil concentrations, as long as there is consistency as to when samples are taken. Soil test K recommendations for corn and soybean production can be found in Table 2.[2]

Sulfur - Sulfur has many important functions in plant growth and metabolism. Deficiency symptoms resemble those of N; however, S deficiency is found in young tissue where as N deficiency can be found in both young or old plant parts. Only a small fraction of the total soil S is readily available to plants and that form is sulfate (SO_4^{2-}). Sulfur can be mobile or immobile in soil depending on microbial activity and the quantity of carbon (C), N, and P. S-deficient soils have soluble SO_4^{2-} concentrations less than 5 to 10 ppm[5].

Calcium and Magnesium - Calcium enhances NO_3-N uptake and also regulates the uptake of cations, such as K^+ and sodium (Na^+). High Ca concentrations typically result in low concentrations of undesirable cations, but a low Ca content can contribute to soil acidity. Magnesium is needed for photosynthesis and in many other physiological and biochemical functions within the plant. Both Mg and Ca ions can easily be exchanged or taken off of negative soil colloids. Mg deficiencies are not widespread, but can occur. Concentrations of Mg^{2+} in the soil are commonly 5-50 ppm in temperate soils but can be much higher.[5]

Micronutrients - Plants require micronutrients in trace amounts for function: Cu, Fe, Mn, Zn, B, Cl, Ni, and Mo. Although many of the micronutrients are reported on soil test reports their levels do not currently affect fertilizer recommendations, with the exception of Zn. Soil test Zn recommendations for corn are shown in Table 3.

Organic Matter - Organic matter affects many soil biological, chemical, and physical properties that influence nutrient availability. A general guideline is to reduce N recommendations by 20 lb/A for soils with >3% OM and increase N recommendations for soils with <1% OM.[4] Consult your regional guidelines for a more precise influence of OM on nutrient availability.

Soil pH - Soil pH is an indicator of the level of acidity or alkalinity of the soil, ranging from 0 to 14. A reading of 7 is neutral, crops typically grow best when pH is between 6 (slightly acidic) and 7.5 (slightly alkaline). Results of soil pH are reported on a logarithmic scale; a soil with a pH of 6 is 10 times more acidic than a soil with a pH of 7, and a pH of 5 is 100 times more acidic than a pH of 7. Nutrient availability may be hindered if soil pH is not within the optimum range.

A buffer pH (BpH) test is used to determine lime rate requirements.[5] The amount of lime needed to increase soil pH to a desirable level can be estimated by mixing a buffer solution (with a known pH) to soil and then measuring the change in pH. If the change in pH is large after the buffer is added, the soil pH is easily changed and a low lime recommendation rate will be made and if the change is small it means the soil pH is difficult to change requiring a larger lime recommendation.

Table 3. Zinc recommendations for corn production utilizing the DTPA Extractable Zn extraction method.

	Zn Soil Test	Zn application	
	PPM	broadcast	band
Low	0-0.04	10	2
Marginal	0.5-0.8	5	1
Adequate	0.9+	0	0

Soluble Salts - High soluble salt content (or salinity) can cause water stress, nutrient imbalances in plants, and affect nutrient uptake. Seedlings are more sensitive to higher than normal soluble salts compared to older plants. High soluble salt levels above 4 mmhos/cm (or 'dS/m') can potentially damage plants.[4] Salinity levels in soil can change rapidly due to leaching; therefore, sampling should take place periodically within the growing season.

Cation Exchange Capacity (CEC) - The CEC is not always part of soil analysis. If it is included on a lab result, a CEC above 10 milliequivalents per 100 grams (10 meq/100g) is considered adequate.[4] A high CEC is sought because it indicates a high capacity for the soil to hold cations (positively charged particles), such as, K^+, NH_4^+, Cu^{2+}, Fe^{2+}, and Mn^{2+}.

Summary

The soil parameter descriptions and values provided within this spotlight can help assess soil fertility programs. Due to variability in soil, lab analysis, and reporting, guidelines specific to your region may exist. A local agronomist or extension specialist can provide information specific to your area.

Source:
[1] Mallarino, A. P. and Sawyer, J.E. 2013. Interpretation of soil test results. Iowa State University Extension. Publication No. PM1310. [2] Mallarino, A. P. and Sawyer, J.E. 2013. A general guide for crop nutrient and limestone recommendations in Iowa. Iowa State University Extension. Publication No. PM1688. [3] Lickacz, J. and Penny, D. 2001. Soil organic matter. Government of Alberta. Agriculture and Rural Development. http://www1.agric.gov. [4] Dinkins, C.P. and Jones, C. 2013. Interpretation of soil test results for agriculture. Montana State University Extension. MontGuide. Publication no. MT200702AG. [5] Pagani, A., Mallarino, A.P., and Sawyer, J.E. Soil pH and lime management for corn and soybean: an ongoing on-farm project. Iowa State University; [6]Tisdale, S.L., Nelson, W.L., Beaton, J.D. and Havlin, J.L. 1993. Soil fertility and fertilizers, fifth edition. Web sources verified 8/20/15. 140728141718.