

AGRONOMIC Spotlight



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Interpreting Soil Sample Results - South Dakota

Soil analysis is a great tool to assess what soil amendments are needed for optimum plant function and yield potential. Soil test results list the soil test concentration for specific parameters along with an interpretation value (low, optimum, and high) and a recommendation. This Spotlight will help explain the meaning of each soil test parameter, what the optimum values are for each parameter, and general recommendations based on the soil test values.

Soil Sampling and Lab Testing

To obtain quality soil test results, the soil samples must be taken properly. Each sample must be representative of the entire field or specified sampling unit. The samples must also be taken at the proper depth during the same time frame every year. Sampling depth is 0-6 inches for phosphorus (P), potassium (K), zinc (Zn), soil pH and organic matter (OM). For nitrogen (N) sampling depth is 0-24 inches for most crops, except sugarbeets. Once proper depth is chosen be consistent as this will influence the soil test result. For more detail on soil sampling refer to *Agronomic Spotlight - Soil Testing*.

Lab Results and Conversions

Soil lab results list the soil test interpretation, soil test result, and a recommendation. When reviewing lab results, it important to know what extraction method was used. In addition, using the same lab for annual analysis will help ensure uniformity of year to year comparisons.

The recommended nutrient rates shown on a soil test result are the actual amount of nutrient and not the amount of fertilizer. A lab may report these results in parts per million (ppm) or lbs/acre. To convert ppm to lbs/acre multiple ppm by 2 and to convert lbs/acre to ppm divide lbs/acre by 2⁵:

$$\begin{aligned} \text{lbs/acre} &= \text{ppm} \times 2 \\ \text{or} \\ \text{ppm} &= \text{lbs/acre} \div 2 \end{aligned}$$

To determine the amount of fertilizer needed, find the fertilizer grade listed on the fertilizer bag or bill of sale, which is listed like this: N-P-K. The grade is the percent of total N, available phosphorus (P₂O₅) and soluble potassium (K₂O). If any additional nutrients are included in the fertilizer it will be listed as a fourth value with the abbreviation of the

nutrient in parentheses. Figure 1 gives an example of how to determine a fertilizer blend rate based on a phosphorus recommendation.

Soil Parameters

Macronutrients are needed in large amounts by plants and are the most common fertilizers applied to the soil. Nitrogen, P, K, sulfur (S), calcium (Ca), and magnesium (Mg) are all macronutrients. Micronutrients are needed in trace amounts for plant function. The micronutrients are: copper (Cu), iron (Fe), manganese (Mn), Zn, boron (B), chloride (Cl), nickel (Ni), and molybdenum (Mo). Other soil characteristics that play a role in nutrient availability may also be analyzed and reported. These may include OM, soil pH, soluble salts (salinity), and cation exchange capacity (CEC). More detailed definitions of each soil parameter follow.

Nitrogen

An adequate supply of N is associated with high photosynthetic activity as well as the vigorous growth and dark green color of plant vegetation. There are two forms of plant available N: nitrate (NO₃⁻) and ammonium (NH₄⁺). Nitrate is measured most often in soil tests. Soil test results report NO₃⁻ N in lb N/ acre. Nitrate can be leached through the soil and lost to denitrification during periods of soil saturation. Nitrate is also produced by microbial decomposition of organic matter. Consequently, nitrate levels reflect what is immediately available and not what will be available in the future. Nitrogen fertilizer can be applied as a pre-plant, during planting, or as a side-dress application when corn plants are 6-12 inches tall. The test is useful for determining if significant amounts of nitrate have leached after excessive rain early in the season. The University of Minnesota reports fields with medium textured soils (glacial till or loess) and corn following corn have the greatest potential for residual NO₃-N to be left for the following year's crop². South Dakota State University (SDSU) recommends using the following equation to determine the N recommendation = (1.2 x yield goal) - soil test NO₃- N in top 2' of soil - previous crop credit³. SDSU also recommends the following tips regarding N fertilizer³:

- Nitrogen plus K₂O application in contact with the seed should be limited to 10 lb/acre for 30 inch rows.
- Nitrogen as urea, UAN and ammonium thiosulfate (12-0-0-26) should not be in contact with the seed.
- Reduce seed placed fertilizer rate by 50% when soil conditions are dry or sandy.
- Reduced or no-tillage systems can apply 30 lb/acre of N in addition to the N recommendation above.

Figure 1. Determining amount of a fertilizer blend to apply based on a phosphorus recommendation

Fertilizer blend of 10-50-5:

Fraction of fertilizer = 10% N (0.10 lb N/lb fertilizer), 50% P₂O₅ (0.50 lb P₂O₅/lb fertilizer) and 5% K₂O (0.05 lb K₂O/lb fertilizer)

APPLICATION AMOUNT:

To apply 10 lb P₂O₅ using a fertilizer blend of 10-50-5: Fertilizer Needed ÷ Fraction of Fertilizer = Fertilizer Blend Applied (10 lb P₂O₅/acre) ÷ (0.50 lb P₂O₅/lb Fertilizer) =
20 lb Fertilizer/acre

Source: Montana State University Extension¹

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Phosphorus

Phosphate compounds store energy created from photosynthesis and carbohydrate metabolism that will be used for plant growth and reproductive processes. Phosphorus is not as naturally abundant in soils compared to N and K. There are two P extraction methods used for lab tests. The extraction methods are: Bray P (acidic soils) and Olsen P (neutral to alkaline soils). The Olsen P extraction method is recommended, when soil pH is above 7.4. It is important to know which extraction method and test were used because test results vary for each method. Phosphorus recommendations for corn and soybean production based on soil test results from two extraction methods can be found in Table 1. In addition, South Dakota State University recommends an application of 20-30 lb/acre of P₂O₅, regardless of soil test, as starter fertilizer when the previous crop was potatoes or the field was fallow³.

Potassium

Potassium plays a role in many functions in the plant including: activating enzymes, drawing water into the roots, producing phosphate molecules and CO₂, providing energy for the translocation of sugars, and taking up and assimilating N. The K cycle is always changing and soil test K concentrations will fluctuate seasonally due to differing environmental conditions. Due to the seasonality of K availability, selecting the proper time to test can be difficult. Comparing soil tests over time is the best method of evaluating nutrient management decisions. Soil testing in the fall or spring is acceptable for determining K soil concentrations. However, sampling should occur at the same time each year for comparisons over time. Soil test K recommendations for corn and soybean production can be found in Table 2.

Sulfur

Sulfur has many important functions in plant growth and metabolism. Deficiency symptoms resemble those of N: stunting, chlorosis, thin stems,

and spindly plants. Sulfur deficiency is found in young tissue where as N deficiency can be found in both young or old plant parts. Sulfur deficiencies can occur in soils that have reduced mineralization of organic-S to sulfate-S due to lower soil temperatures or lower soil OM levels. In South Dakota, S deficiencies are generally found in no-till soils with an OM content of <2.5%⁴.

Table 1. Phosphorus (P₂O₅) recommendations for 200 bu/acre corn and 60 bu/acre soybean production in South Dakota.

Phosphorus Soil Test (ppm)			Corn P ₂ O ₅ to apply lb/acre	Soybean P ₂ O ₅ to apply lb/acre
Category	Bray	Olsen		
Very Low	0-5	0-3	127	80
Low	6-10	4-7	92	47
Medium	11-15	8-11	56	13
High	16-20	12-15	21	0
Very High	21+	16+	0	0

Source: ³ South Dakota State University Extension

- Corn recommendations are based on a 200+ bu/acre yield target and soybean recommendations are based on a 60+ bu/acre yield target.
- For corn, use the equations below to calculate P recommendations based on a specific corn yield target and specific test value:
 - P₂O₅ Recommendation = [0.700 - 0.035 (Bray P, ppm)] (Expected yield)
 - P₂O₅ Recommendation = [0.700 - (0.044 (Olsen P, ppm)] (Expected yield)
- In corn, phosphate fertilizer is not recommended if the soil test for P is higher than 25 ppm (Bray) or 20 ppm (Olsen).
- For soybean, use the equations below to calculate P recommendations based on a specific yield target and specific test value:
 - P₂O₅ Recommendation = [1.752 - (0.0991) (Bray P, ppm)] (Expected Yield)
 - P₂O₅ Recommendation = [1.752 - (0.1321) (Olsen P, ppm)] (Expected Yield)

Table 2. Potassium (K₂O) recommendations for 200 bu/acre corn and 60 bu/acre soybean production in South Dakota.

Potassium Soil Test (ppm)		Corn K ₂ O to apply lb/acre	Soybean K ₂ O to apply lb/acre
Category	Soil Test (ppm)		
Very Low	0-40	204	110
Low	41-80	146	66
Medium	81-120	87	22
High	121-160	60	0
Very High	161+	0	0

Source: ³ South Dakota State University Extension

- Corn recommendations are based on a 200+ bu/acre yield target and soybean recommendations are based on a 60+ bu/acre yield target.
- For corn, use the equations below to calculate K recommendations based on a specific corn yield target and specific test value:
 - K₂O Rec = [1.166 - 0.0073 (Soil Test K, ppm)] (Expected yield)
- In corn, potash fertilizer is not recommended if the soil test for K is 175 ppm or higher
- For soybean, use the equations below to calculate P recommendations based on a specific yield target and specific test value:
 - K₂O Rec = [2.200 - (0.0183) (Soil Test K, ppm)] (Expected yield)

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Calcium and Magnesium

Calcium enhances NO₃-N uptake and also regulates the uptake of cations, such as K⁺ and sodium (Na⁺). Calcium saturation results in a high pH or alkaline soil. In addition, high concentrations in the soil typically result in low concentrations of undesirable cations, such as aluminum (Al³⁺) in acidic soils and Na⁺ in saline soils. Conversely, a low Ca content in the soil can result in a low pH or acidic soil.

Magnesium is a major part of the chlorophyll molecule and without it photosynthesis can not take place. Magnesium is also imperative in many other physiological and biochemical functions within the plant. Magnesium and Ca have some behavioral similarities in soil. Both Mg and Ca ions can easily be exchanged or taken off of negative soil colloids. One difference is that Mg can only become fixed to certain clays. Magnesium deficiencies are not widespread but can occur.

Micronutrients

The micronutrients needed in trace amounts for plant function are: 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. Soils with low levels of Zn typically have a soil pH >7.5⁶. South Dakota State University recommends applying Zn fertilizer as starter fertilizer and not using Zn chelates due to the high cost. Plant tissue and soil analyses should be used together to assess the need for the application of the other micronutrients.

Organic Matter

Organic matter affects many soil biological, chemical, and physical properties that influence nutrient availability. Organic matter content is related to productivity and soil tilth. Some roles of OM in the soil include: storage for nutrients, energy for microbial activity, increasing water holding capacity, and providing a buffer against changes in pH and salinity. On many soils, suitable physical properties occur at relatively low levels of OM ranging from 2 to 4%; however, increasing soil OM can generally increase productivity⁴. When OM levels are higher than 2%, more N will be mineralized. A general guideline is to reduce fertilizer recommendations by 20 lb/acre for soils with > 3% OM and increase N recommendations for soils with < 1% OM¹. 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 – 14. A reading of 7 is neutral, lower values are acidic and higher values are alkaline. 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; therefore, caution in interpretation

should be made. For example, a soil with a pH of 6 is 10 times more acidic than a soil with a pH of 7, and a soil with 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 and can result in crop nutrient deficiencies.

Soluble Salts

High soluble salt content (or salinity) can cause water stress and nutrient imbalances in plants, as well as affect nutrient uptake. Seedlings are more sensitive to higher than normal soluble salts in soil compared to older plants. Soil labs measure electrical conductivity (EC_e) of a soil extract to determine salt concentrations in soil. EC_e measurements can be taken by using a saturated paste or a 1:1 by weight soil-to-water slurry method. The saturated paste is precise but time consuming and expensive, while the 1:1 slurry is quick and inexpensive. North Dakota State University reports, the corn threshold for a 1:1 slurry is 1.3 decisiemens/meter (dS/m) and 1.7 dS/m for a saturated paste⁷. The thresholds for soybean are 2.4 dS/m for a 1:1 slurry and 5.0 dS/m for a saturated paste. Decisemens/ meter (dS/m) are equivalent to millimhos/cm (mmhos/cm) and values may be reported either way. These thresholds do not take into account other stresses; therefore thresholds may be lower if other stresses are present.

Cation Exchange Capacity

Cation Exchange Capacity (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 adequate⁴. Cation Exchange Capacity can also be reported as centimoles per kilogram (cmols/kg), and may be interchangeable between units reported. A high CEC is sought because it indicates a high capacity for the soil to hold cations (positively charged particles), such as, K⁺, NH₄⁺, Cu²⁺, Fe²⁺, and Mn²⁺.

Region Specific Information

The soil parameter descriptions and optimum values provided within this Spotlight can help assess your soil fertility program and help reach optimum yield potential. 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.

Sources: ¹C.P. Dinkins, et al. July 2007. Interpretation of Soil Test Results for Agriculture. Montana State University Extension. MontGuide. Publication no. MT200702AG; ²G. Rehm, et al. 2009. Using the Soil Nitrate Test in Minnesota. University of Minnesota Extension. Publication no. WW-07310; ³South Dakota State University. 2011. Crop Specific Nutrient Recommendations. Available On-line: www.sdstate.edu; ⁴J. Lickacz and D. Penny. May 30, 2001. Soil Organic Matter. Government of Alberta. Agriculture and Rural Development; ⁵Purdue University. Conversion Formulas. Purdue University Agriculture. www.agriculture.purdue.edu; ⁶South Dakota State University. 2011. Nutrient Management for Corn. Available On-line: www.sdstate.edu; ⁷D.W. Franzen. 2007. Managing saline soils in North Dakota. circular SF-1087, North Dakota State University Extension, Fargo, ND Additional references used to create this publication: S.L. Tisdale, et al. 1993. Soil Fertility and Fertilizers Fifth Edition. MacMillan Publishing Company; J. E. Sawyer, et al. July 15, 2003. Interpretation of Soil Test Results. Iowa State University Extension. Publication No. PM1310; J. E. Sawyer, et al. April 2011. A general guide for crop nutrient and limestone recommendations in Iowa. Iowa State University Extension. Publication No. PM1688; L. Espenosa, et al. 2007. Understanding the numbers on your soil test result. University of Arkansas. Division of Agriculture. Cooperative Extension Service.

Individual results may vary, and performance may vary from location to location and from year to year. This result may not be an indicator of results you may obtain as local growing, soil and weather conditions may vary. Growers should evaluate data from multiple locations and years whenever possible. **ALWAYS READ AND FOLLOW PESTICIDE LABEL DIRECTIONS.** Technology Development by Monsanto and Design® is a registered trademark of Monsanto Technology LLC. ©2011 Monsanto Company. AMB101811