Soil Test Interpretation

By Clain Jones and Kathrin Olson-Rutz, Montana State University

This Soil Scoop explains how to interpret soil test results. For more details, see the MSU MontGuide ***Interpretation of Soil Test Reports for Agriculture***. The Soil Scoop ***Fertilizer Rate Calculations*** explains how to calculate fertilizer rates from soil test results. There are other Soil Scoops on how to get a good sample, what analyses to request from the laboratory, and how to evaluate soil health.

Soil test reports list the property analyzed, a numeric test value, often an interpretation of that value, and sometimes a fertilizer rate recommendation. Table 1 lists the soil properties that can be analyzed and the impact their levels have on plant production. Table 2 provides nutrient levels that are low, and levels considered sufficient in Montana soils. Sufficient is often called the

Table 1. Properties on a soil test report that affect plant health and production.

Property	Value	Impact/consideration
Nutrient content (e.g., N, P, K, Zn)	See Table 2	Too little = hungry plants, too much = hurts uptake of other nutrients, burn plants, contaminate water
Soil organic matter (OM)	≤ 1%	Low soil water holding and nutrient supplying capacity
	> 8%	Risk to surface and ground water from excess N and P
Soil pH	> 8.3	P, K, Fe, Zn, Mn deficiencies
	< 6.0	Poor seedling establishment and legume nodulation
	< 5.0	Aluminum toxicity, stunted plants
	< 4.5	Poor germination, poor growth
	< 4.0	Crop failure
Soluble salts (EC)	> 4 mmhos/cm	Saline = water stress, nutrient imbalance
Exchangeable sodium percent (ESP)	> 15 meq/100 g	Sodic soil = puddling and crusting, shrink/swell, poor aggregation and compaction
Cation exchange capacity (CEC)	> 10 meq/100 g	Adequate
	> 15 meq/100 g > 15%	High nutrient holding capacity
Texture	Loamy sand, Sandy loam	Poor water and nutrient holding capacity
	Medium-textured (e.g., silt loam, clay loams)	Good water and nutrient holding capacity
	Clay, Silty clay	Poor drainage/aeration

'critical level'. Adding a nutrient which is at or above the critical level will likely not increase yield, whereas adding a nutrient when levels are low has a good chance of improving yield.

Nitrogen: Guidelines for soil N levels are provided in ***Fertilizer Guidelines for Montana Crops*** and Extension Bulletins about specific crops such as forage, vegetables and berries. Nitrogen is generally reported as nitrate-N (NO_3-N) in lb N/acre. This value represents what is available at the time the soil was sampled. More may become available during the growing season from decomposition of soil organic matter, or N can be lost to leaching below plant roots by rainfall or irrigation. The Soil Scoop ***Fertilizer Rate Calculations*** provides the math to convert results from ppm to lb/acre if the lab does not.

Phosphorus: Most Montana soils are high in calcium which ties up P, resulting in often low available P levels. Phosphorus levels greater than 30 ppm risk surface water contamination and greater than 60 ppm can tie up Zn.

Potassium: Most Montana soils have medium-to-high available K levels. Highest K levels will be measured in the spring just after the soil thaws and before plant uptake becomes substantial. Plants can continuously absorb K beyond yield requirements ("luxury consumption"), so it is important to test soil for K availability to reduce profit loss from over-fertilization. Alfalfa is especially prone to luxury consumption.

Table 2. Low and sufficient soil nutrient levels for soil collected from the top 0-6" depth.

Nutrient	Low (ppm)	Sufficient = Critical (ppm)
Nitrogen (N)	Crop and yield goal dependent	
Phosphorus (P)	< 8	> 16
Potassium (K)	< 150	> 250
Sulfur (S)		> 40 lb/acre in top 2 feet[1.]
Boron (B)	< 0.5	> 1
Chloride (Cl)		30 lb/acre in top 2 feet
Copper (Cu) and Zinc (Zn)	< 0.25	> 0.5
Iron (Fe)	< 2.5	> 5.0
Manganese (Mn)	< 0.5	> 1.0

1. See notes about S in text

Sulfur: Only a small fraction of the total soil S is readily available to plants and there is generally no clear relationship between soil test S and response to fertilizer. Sulfur deficiencies in Montana have been on the rise. Coarse-textured soils, especially on eroded ridge tops, are most prone to S deficiency. Canola and other brassicas (broccoli, kale, etc.) are most susceptible because they are high S users. Plants with uniformly yellow upper leaves are likely S deficient. Tissue testing for S can help confirm this, however, critical tissue concentrations are not known for all crops.

Micronutrients: There has been little work in Montana to determine crop-specific micronutrient needs, yet general levels are shown in Table 2. Zinc and Cl deficiencies are most common; Zn in crops with high Zn demands (e.g., alfalfa, corn, beans) and Cl largely only in cereals.

Soil organic matter: A 2% SOM content is considered normal but not ideal for Montana annual croplands. See The Soil Scoop ***The Soil Health Gap***, and the MSU Extension bulletins ***Market Vegetable Farms: Soil Characteristics & Testing, Cover Crops: Management for Organic Matter and Nitrogen,*** and ***Soil Nutrient Management on Organic Grain Farms in Montana*** for ways to increase SOM on annual croplands.

Soil pH: Most crops grow best at a soil pH between 6 (somewhat acidic) and 7.5 (slightly alkaline). In eastern Montana, surface soil pH is typically between 7-8, while western Montana soils are generally more acidic. When soil pH is outside of the optimal pH range, nutrients can be less available to plants, potentially resulting in deficiencies. For ways to prevent and correct soil acidity, see The Soil Scoop ***Soil Acidification: Management***. Decreasing soil pH is more challenging. Elemental S can reduce soil pH over time, but it requires 10,000 lb S/acre to lower the soil pH from 8 to 7.5 in soil with 1.5 % calcium carbonate (AGVISE Labs, unpublished data). The best option in acidic soils is to prevent further acidification and select crops suited to low pH.

Soluble salts & exchangeable sodium percent: See Soil & Water Management Module 2 ***Salinity & Sodicity Management*** for management of saline and sodic soils.

Cation exchange capacity & texture: A CEC test value is necessary for ESP calculations. It is very difficult to change CEC or soil texture. Increasing SOM can improve soils that may be limited by low CEC or are high in clay or sand.

For more information:

Resources mentioned can be found at MSU Soil Fertility Extension Bulletins and MontGuides and The Soil Scoop.

MONTANA STATE UNIVERSITY | EXTENSION