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# Interpreting a Soil Test Report

Soil Testing is a very important step for growing healthy plants and crops. A soil test will provide information on the quantity of the nutrients or elements in the soil and their availability for plant growth.

The CSU Soil, Water and Plant Testing (SWPT) Lab soil testing packages are soil management tools designed for farmer, gardeners, nurserymen, landscape contractors, golf course caretakers, and anyone interested in diagnosing and correcting soil fertility problems. This guide is provided as a tool to better understand and interpret the soil test reports. The information in the soil test reports should be used to make informed fertilizer and soil amendment choices for healthy plant growth and development.

Soil sampling procedures should be conducted properly to obtain quality soil test results. Each sample should represent the entire field or a specific sampling area. Samples must be taken at the proper depth, 6 or 8 inches (2 or 3 inches for turf and lawns) during the same time frame each year to identify trends over time. Ideally, soil sampling should be done annually in the spring to best estimate nutrient availability for the upcoming growing season. For example, sampling in the fall does not always capture the true amount of nitrogen (N) that will be available at planting in the spring because some N is released from organic matter (OM) during the winter months due to a process known as mineralization or decomposition. While N can be leached in very wet years, fall nitrate-N ($NO_3$-N) levels will be similar to spring $NO_3$-N levels if the fall and winter are cold and dry, because little or no N mineralization and/or leaching occur.

Generally, the soil test results indicate whether a nutrient level is low, medium (moderate) or high (adequate). These levels are known as nutrient ranges or categories. The SWPT Lab has broken these ranges down further to very low, low, medium, optimum, high, and very high for certain nutrients. The cutoff between a medium and high level is sometimes referred to as a **critical level** and provides a value that indicates when a fertilizer should (below critical level) or should not (above critical level) be added (Figure 1). The ranges in the soil test reports are only for the test methods listed.

The interpretation of the soil test values are based on crop yields and production targets. Considering the nutritional status of the soil, ranges are generally based around the critical level required. The critical level is the value where 90-95% of maximum production or yield potential occurs. The confidence interval around the critical value indicates the reliability of the estimate, the narrower the range the more reliable the data. These ranges have being collected from fertilizer trials, where various fertilizer rates are applied and the crop yield response measured. Adequate levels are generally higher than the critical value(level?) to allow for field error and natural variation.

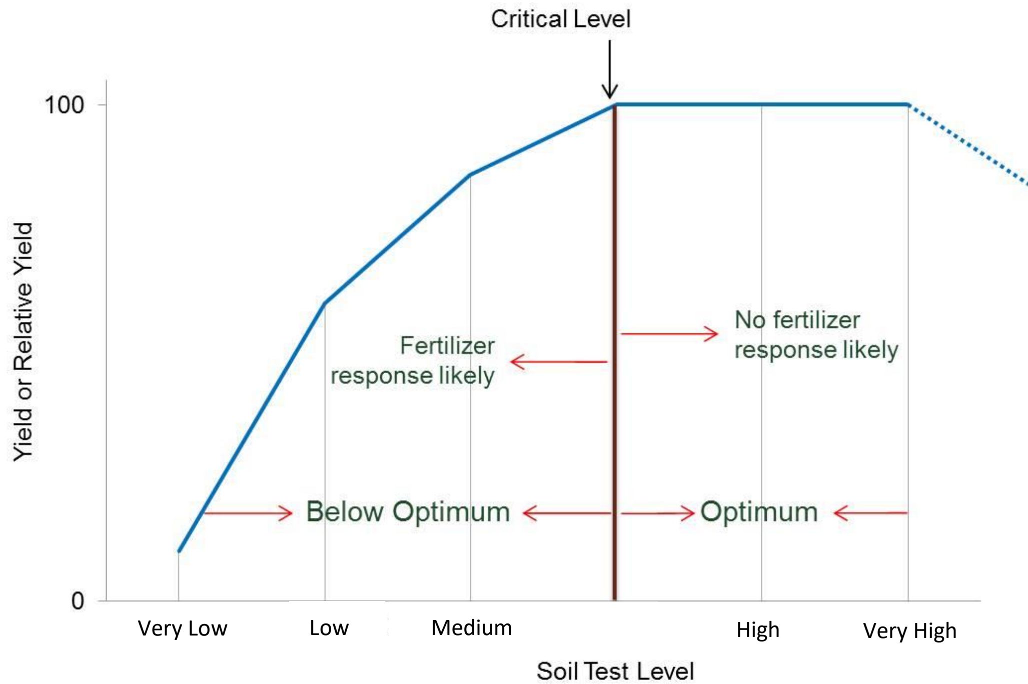


Figure 1. Soil test value vs. probability of crop yield response to nutrient addition. Crop yield increase due to nutrient addition is likely at low soil test values and unlikely at high soil test values

This guide describes each of the soil parameters measured and included in the different soil test packages offered by the SWPTL.

**Soil pH** is a measurement of how acidic or basic a soil is. Soils with pH values below pH 7 are referred as acid and those with pH values above pH 7 as alkaline. Soils at pH 7 are referred to as neutral. Soils can range from a pH of about 3 to 9. Generally, a soil pH between 6.0 and 7.5 is acceptable for most plants as most nutrients become available in this pH range (Figure 2). However, some plants have soil pH requirements about or below this range. Soil pH affects many aspects of plant growth, including availabilities of nutrients (Figure 2) and toxic substances, activities and nature of microbial populations, suppression and enhancement of soil borne diseases, activities of certain pesticides, and soil structure. Decreasing soil pH is difficult. Fertilizing with ammonia-based fertilizers may decrease soil pH over time. Adding elemental sulfur (S) can decrease soil pH but it requires 10,000 lb/ac to lower the soil pH from 8 down to 7.5 in a soil with 1.5 percent calcium carbonate ($CaCO_3$).

**Soluble Salts or Electric Conductivity (EC)** is a measurement of dissolved inorganic solutes. The most common soluble salts in soils are the cations, calcium ($Ca^{+2}$), magnesium ($Mg^{+2}$), and sodium ($Na^{+}$), and the anions chloride ($Cl^{-}$), sulfate ($SO4^{-2}$), and bicarbonate ($HCO3^{-}$). Smaller quantities of potassium ($K^{+}$), ammonium ($NH4^{+}$), nitrate ($NO3^{-}$), and carbonate ($CO3^{-2}$) are also found in most soils. Sources of soluble salts in soils include soil organic matter, commercial fertilizers, animal manures, municipal sewage sludge, runoff from areas where salt or ice-melt products have been used and irrigation water that is high in dissolved salts.

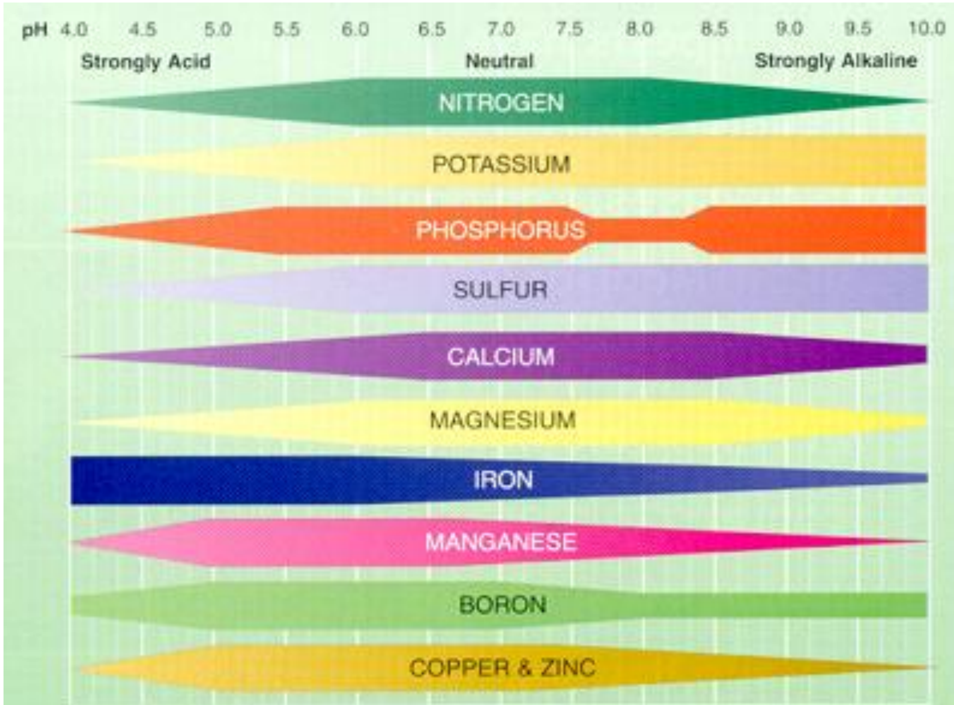


Figure 2. Soil pH effects on nutrient availability (Adapted from Truog, USDA Yearbook of Agriculture 1943-1947

At low levels, soluble salts generally do not harm plants. Excess soluble salts burn foliage, damage roots and lead to problems with water uptake. Wilting, yellowing, and marginal and tip burn of leaves, (scorching), are symptoms of excess soluble salts. Plant species vary markedly in their tolerance to soluble salts. Therefore, the values must be interpreted in relation to a specific plant species.

**Soil Organic Matter (SOM)** is composed of materials containing carbon. These materials include plant and animal remains (including bacteria and fungi) in various stages of decomposition, root and microbial exudates and humus. Soil OM is affected by several factors such as soil texture, tillage, parent material, crop productivity, drainage, and other management factor. Soil OM is important for water and nutrient holding capacity. Overall, SOM in Colorado is low (<3%).

**Nitrogen (N)** is an essential nutrient for plant growth and development. There are two forms of plant available N, nitrate ($NO_3^-$) and ammonium ($NH_4^+$). Nitrate-N is the only N form reported as ammonium-N ($NH_4$-N) levels are typically significantly lower than $NO_3$- N levels. Nitrate-N values reported are in part per million (ppm). The value reflects what is immediately and not what will be available from mineralization or decomposition of OM or lost from leaching and denitrification.

Nitrogen recommendations are based on crop requirements and expected yields, with the assumption that very small amounts of available N remain in the soil after a growing season. . Nitrate, the mobile form of nitrogen, is primarily used to identify plant-available soil nitrogen.

Soil nitrogen content is calculated as:

$$\text{lb N/ac} = \text{ppm } NO_3\text{-N} \times \text{sample depth increment} \times 0.3$$

Sample depth increment is the depth from the top to the bottom where the sample was collected. For example, the sample depth increment for 0-8 inches is 8 inches and from the 8-24 inches increment is 16 inches. The factor to convert $NO_3$-N to N is 0.3

**Phosphorous (P)** is involved in many vital plant growth processes. The most essential function is in energy storage and transfer. Phosphorous soil test is an index of availability and is reported in parts per millions (ppm). The quantity of total P in the soil has little or no relation to the availability of P to plants as it is relatively immobile in soil. The phosphorus application rate necessary to correct P deficiencies varies depending on soil properties and crop grown. Phosphorus availability decreases in cool, wet soils. Phosphorus applications are not recommended when test results are high or excessive.

**Potassium (K)** is taken up by plants in large amounts compared to any other nutrient except nitrogen. Although total soil K content exceeds plant uptake during a growing season, in most cases only a small fraction of it is available to plants. Soils in Colorado generally have medium to high available K levels low amount of leaching. It is recommended that soil be tested for K in the spring to provide the most accurate estimate of available K for crops that season. Potassium is involved in water relations. It is important in many crop quality characteristics due to its involvement in synthesis and transport of photosynthates to plant reproductive and storage organs (grains, fruits, tubers, etc.). In fruits and vegetables adequate K enhance fruit size, color, and taste.

**Sulfur (S)** is a secondary macronutrient required in relatively large amounts for plant growth. Sulfur reactions in soil are very similar to N reactions. Like P and K, only a small fraction of the total soil S is readily available to plants.

**Calcium** is closely related to soil pH. Calcium deficiencies are rare when soil pH is 6.2 to 7.2. The level for calcium will vary with soil type, but optimum ranges are normally in the 65% to75% of cation saturation range. Calcium saturations above 85% may indicate a calcareous soil.

**Magnesium** is affected by the same factors affecting calcium levels in the soil. Adequate magnesium levels range from 30 to 70 ppm (60 to 140 lbs/ac). The cation saturation for magnesium should be 10 to 15%. Magnesium saturations above 20% can adversely affect soil structure, water-infiltration, soil drainage and aeration.

**Sodium** is not a plant nutrient and therefore is not necessary for plant growth. High levels of sodium are detrimental to soil structure and plant growth. Sodium levels are evaluated based on exchangeable sodium percentage (ESP). The ESP is the percent of the cation exchange capacity (CEC) occupied by Na. ESP values above 10 percent are of concern. Excessive sodium levels can occur naturally or can result from irrigation with high-sodium water.

**Cation Exchange Capacity (CEC)** refers to the amount of positively charged ions (cations) a soil can hold. When dissolved in water, the nutrients are either positively charged or negatively charged. Examples of positively charged ions (cations) include: calcium ($Ca^{++}$), magnesium ($Mg^{++}$), potassium ($K^{+}$), sodium ($Na^{+}$), and ammonium ($NH4^{+}$). Soils have a slight negative charge due to the presence of clay particles and organic matter. Thus, the higher the clay content and organic matter content, the higher the CEC of the soil. Soils with a high CEC will tend to hold on to nutrients better than soils with a low CEC. The CEC of a soil can be increased somewhat by increasing the SOM content.

**Base Saturation** is defined as the percentage of the soil exchange sites (CEC) occupied by basic cations, such as potassium ($K^+$), magnesium ($Mg^{++}$), calcium ($Ca^{++}$), and sodium ($Na^+$). The base saturation percentages are calculated for each cation then added up to determine base saturation.

The percentage saturation for each of the base cations are commonly within the following ranges: calcium 40 to 80%; magnesium 10 to 40%: potassium 1 to 5%. Many consider an ideal base saturation ranges to be: calcium 65 to 80%; magnesium 10 to 20%; potassium 2 to 7%; and sodium less than 1%.

**Micronutrients** or trace minerals are essential to plants, but are required in very small amounts. **Zinc (Zn)**, **iron (Fe)**, **manganese (Mn)**, **copper (Cu)**, and **boron (B)** are reported. Micronutrient deficiencies generally occur in sandy, low organic matter soils. Deficiencies of **Zn** and **Fe** are commonly observed in Colorado due to high soil pH. Availability of most micronutrients is largely pH-dependent; availability decreases as pH increases [except for molybdenum (**Mo**)], which becomes more available as pH increases (figure1). Deficiencies rarely occur in soils with pH below 6.5. If a micronutrient deficiency is suspected, plant tissue testing may be a better diagnostic tool than soil testing.

A **Zn** soil test above 1.5 ppm using the DTPA extraction method is sufficient for most crops. Values of **Cu** above 0.6 ppm using the DTPA extraction method are sufficient. Copper deficiencies are extremely rare, regardless of soil test results. Adequate soil test **Mn** varies with plants, but soil test values between 1 and 5 ppm using the DTPA extraction method are usually sufficient. Manganese deficiencies generally occur only when soil pH is 8.0 or above. Low levels of **B** may limit plant growth, while high concentrations can be toxic. When applying B, apply it uniformly as a broadcast application and mix it thoroughly with the soil

**Chloride (Cl)** testing is not a common practice, and little data exist for interpretation of test results. Wheat sometimes benefits from a Cl application. Little information exists on Cl soil test values and recommended rates in Colorado. Chloride is supplied with irrigation water and from organic sources such as manure and compost.

**Soil Texture** is dependent on how much sand, silt and clay is present. Soil texture will influence the physical and chemical properties of the soil. Soils with a light texture (sandy soils) and low CEC are more susceptible to leaching and should be managed by applying smaller quantities of nutrients more frequently.

**Soil Salinity**

The terms salt and salinity are often used interchangeably, and sometimes incorrectly. A salt is simply an inorganic mineral that can dissolve in water. Many people associate salt with sodium chloride or common table salt. In reality, the salts that affect soils often are a combination of Na, Ca, K, Mg, Cl, $NO_3$, $SO_4$, bicarbonates ($HCO_3$) and carbonates ($CO_3$). These salts result from weathering, in which small amounts of rock and other deposits are dissolved over time. Fertilizers and organic amendments also add salts to the soil.

**Alkalinity** is associated with the **presence of sodium carbonate ($Na_2CO_3$) or sodium bicarbonate ($NaHCO_3$) in the soil**, either as a result of natural weathering of the soil particles or brought in by irrigation and/or flood water.

**Sodium Absorption Ratio (SAR)** is a measure of the amount of Na relative to Ca and Mg in the water extracted from a saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration. Soils that have values for SAR of 13 or more may have an increased dispersion of organic matter and clay particles, reduced saturated hydraulic conductivity and aeration, and a general degradation of soil structure.

**Fertilizer Recommendation**
The recommended nutrient rates shown on the soil test report are for the actual amount of nutrient, not the amount of fertilizer. To determine fertilizer amounts, you will need to know the fertilizer grade, the three numbers on every fertilizer (Figure 3). Grade or number equates to the percentage of total N, available phosphorus ($P_2O_5$) and soluble potassium ($K_2O$) present. For example, if a fertilizer is labeled 5-

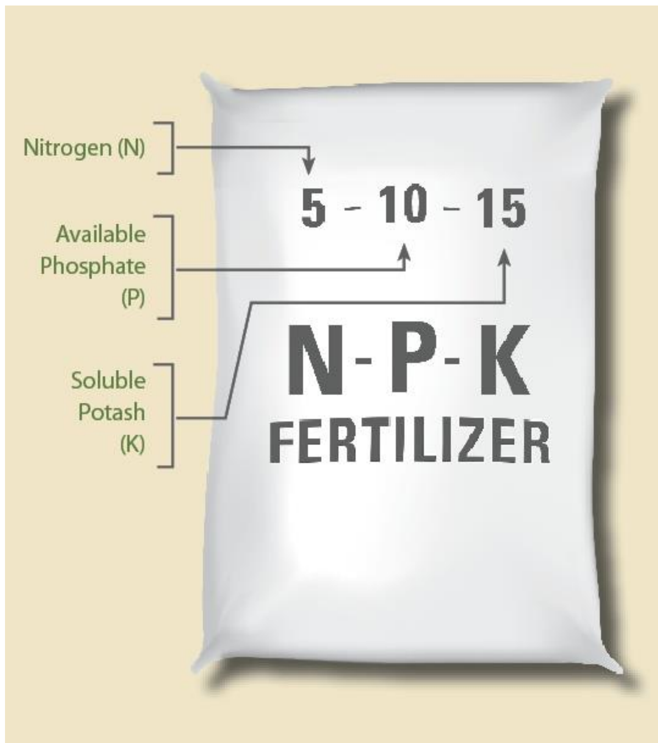


Figure 3. Fertilizer grade

10-15, it contains 5% N, 10% $P_2O_5$ and 15% percent $K_2O$. If a significant source of a particular nutrient, other than N, P or K, is in the fertilizer, it is typically labeled as a fourth value. This is most often seen with fertilizers containing sulfur (e.g., 21-0-0- 24).

Recommended fertilizer rates may need to be adjusted based on climate and soil properties at your specific location due to the high degree of variability throughout the state of Colorado. Please contact your local Extension agent or crop adviser for specific recommendations regarding your soil test results.

An example of the fertilizer calculation based on a recommended P rate using a fertilizer blend is as follows:

**Soil Test Report Recommendation 0.4 lb $P_20_5$/100 sq. ft.**

**Using a fertilizer blend 5-10-15**

**Fertilizer fraction** 5% N (0.05 lb N/lb fertilizer); 10% P $P_2O_5$ (0.1 lb $P_2O_5$/lb fertilizer); and 15% $K_2O$ (0.15 lb $K_2O$/lb fertilizer)

**Fertilizer needed = Fertilizer fraction = Fertilizer applied**

0.4 lb $P_2O_5$ /100 sq. ft. = 0.1 lb $P_2O_5$/lb fertilizer = 4 lb fertilizer/100 sq. Ft.

This sample calculation could also be used to determine the amount of fertilizer to apply to reach a specific N or K recommendation.

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