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GUIDELINES FOR INTERPRETATION OF SOIL ANALYSES

NITRATE-NITROGEN (NO_3-N)

The NO_3-Nitrogen is determined to assess the nitrogen fertility status of a sample of soil. Nitrate-N and ammonia-N are the most available forms of nitrogen to plants since most of the nitrogen is tied up in organic matter. Nitrogen requirements are different for each crop; therefore the correct evaluation must be done according to the specific crop or symptom of deficiency. Level range is given for reference purposes.

ppm	lb./Acre	Level
< 3	< 6	Very low
4 - 10	7 - 20	Low
11 - 20	21 - 40	Medium
21 - 40	41 - 80	High
> 40	> 80	Very high

PHOSPHORUS (P)

Soil phosphorus is available in very low amounts to plants since most of the total soil phosphorus is tied up in insoluble compounds, and its availability depends on the soil pH. Calcium phosphate is formed in neutral and alkaline soils. Iron and aluminum phosphates are formed in acidic soils. Phosphorus is most available from pH 6 to 7 and is absorbed by plants primarily as orthophosphates.

There are several methods to extract the available phosphorus. The sodium bicarbonate extraction is recommended for neutral and alkaline soils.

ppm	lb./Acre P_2O_6	Level
0 - 3	0 - 14	Very low
4 - 7	15 - 32	Low
8 - 13	33 - 60	Medium
14 - 22	61 - 101	High
> 23	>102	Very high

To convert P to P_2O_5, multiply P by 2.2914
To convert P_2O_5 to P, multiply by 0.4364

EXCHANGEABLE POTASSIUM (K)
Potassium is the third most important plant nutrient along with nitrogen and phosphorus. Soil K exists in three forms: unavailable, slowly available (exchangeable), and available (in solution). The exchangeable form becomes available when the potassium in solution is removed by the crops. This process occurs in one or two days since most crops contain 10 lb/Acre of K or less in solution.

ppm	lb./Acre	Level
< 70	< 140	Very low
70 - 150	140 - 300	Low
150 - 250	300 - 500	Optimum
250 - 350	500 - 700	High
> 350	> 700	Very high

Deficiencies occur when the exchangeable potassium is below 200 lb/acre. Values below 400 lb/acre are considered low for some crops. Total potassium levels above 800 lb/acre indicate a sufficient supply.

Potassium content in fertilizers is expressed as K_2O or potash. To convert from K to K_2O, multiply by 1.2046. To convert from K_2O to K, multiply by 0.8302.

EXCHANGEABLE CALCIUM (Ca)
Calcium deficiencies are rare when the soil pH is adequate. Optimum levels of calcium are around 75% of base saturation. Values 10% above or below can indicate a problem with the water percolation and poor soil aeration on sensitive crops. A calcium:magnesium ratio of 4:1 or 3:1 is appropriate for a good soil structure.

EXCHANGEABLE MAGNESIUM (Mg)
Optimum magnesium levels normally range from 100 to 250 ppm (200 - 500 lb/Acre). The amount of magnesium adequate for crops can be further determined by its base saturation, which should be between 12 -18 %. Soils having a magnesium base saturation in excess of 30 - 35 % may exhibit serious problems, such as soil crusting and restricted root development.

To convert Ca to $CaCO_3$, multiply Ca by 2.50
To convert Mg to MgO, multiply Mg by 1.658

EXCHANGEABLE SODIUM (Na)
This test indicates the degree of which the soil exchange sites are saturated with Na. Exchangeable sodium greater than 2.5% may cause adverse physical and chemical conditions to develop in the soil that may prevent plant growth. High levels of exchangeable sodium affect soil permeability and may be toxic to sensitive plants. Sodium base saturation values over 7% can represent a water permeability problem.

Reclamation of these soils involves the replacement of the exchangeable sodium by calcium or magnesium and the removal of sodium by leaching.

SULFATE-SULFUR (SO_4-S)

Sulfur is part of every plant cell and is an important constituent of proteins. It is absorbed primarily as sulfate (SO_4^{-2}) anion. Values below 7 - 15 ppm are considered low for tomatoes, legume, and sugar beets.

ppm SO_4-S	lb./Acre SO_4-S	Level
0 - 3	0 - 6	Very low
4 - 7	8 - 14	Low
8 - 12	16 - 24	Medium
13 - 17	26 - 34	High
> 18	> 36	Very high

To convert SO_4= to SO4-S, multiply by 0.333

IRON (Fe)

Iron deficiency likely occurs in soils with high pH, poor aeration, excessive phosphorus, or low organic matter. It may be produced also by an imbalance of Mo, Cu, and Mn. In plants, the deficiency shows up as a pale green leaf color (chlorosis) with sharp distinction between green veins and yellow intervenial tissues. Method: DTPA extraction.

ppm	Level
0 - 5	Very low
5 - 8	Low
9 - 12	Medium
13 - 30	High
> 30	Very high

COPPER (Cu)

Copper deficiency is most likely in organic soils. Cu is not always available even though the soil has plenty of Cu. Sandy soils with low organic matter also are deficient because of leaching losses. In plants Cu deficiency shows up as leaves losing turgor and developing a bluish-green shade before becoming chlorotic and curling. Method: DTPA extraction.

ppm	Level
0 - 0.3	Very low
0.3 - 0.8	Low
0.9 - 1.2	Medium
1.3 - 2.5	High
> 2.5	Very high

ZINC (Zn)
Zn deficiency most often is present in sandy soils with neutral or alkaline pH, or with low organic matter. Total zinc may be high but the availability depends on other factors. Method: DTPA extraction.

ppm	**Level**
0 - 0.5	Very low
0.5 - 1.0	Low
1.1 - 3.0	Medium
3.1 - 6.0	High
> 6.0	Very high

BORON (B)
There is a very narrow range between deficiency and toxicity in boron. Deficiencies are more often when the organic matter is low and the dry weather slows the decomposition. Uptake of boron is reduced at pH levels higher than 7.0. Plant toxicity symptoms manifest as leaf tip and marginal chlorosis. Boron toxicity occurs in dry areas and is generally associated with the irrigation water. Method: hot water extraction.

ppm	**Level**	
0 - 0.3	Very low	Deficient
0.4 - 0.5	Low	Sufficient
0.6 - 1.2	Medium	May be harmful
1.3 - 2.0	High	Toxic
> 2.0	Very high	Highly toxic

pH (pH Units)
The pH is the degree of acidity or alkalinity in the soil and refers to the relative concentration of hydrogen ions (H^+) and hydroxyl ions (OH^-) in the soil solution. It ranges from acidity (below 7.0), neutrality (pH 7.0), and alkalinity (above 7.0). Soil pH is important, because it controls nutrient availability, solubility of toxic ions, and microbial activity. Soil pH from 6.0 to 8.0 is suitable for a wide range of crops. Determination of soil pH is made in a 1:1 soil:water ratio by volume.

pH	Level	
< 4.5	Very strongly acidic	Too acidic for most crops
4.5 - 5.2	Strongly acidic	Too acidic for many crops
5.3 - 6.0	Moderately acidic	Too acidic for some crops
6.1 - 6.9	Slightly acidic	Satisfactory for most crops
7.0 - 7.5	Slightly alkaline	Optimum for most crops
7.6 - 8.2	Moderately alkaline	Too alkaline for some crops
8.6 - 9.0	Strongly alkaline	Too alkaline for many crops
> 9.0	Very strongly alkaline	Too alkaline for most crops

Soils with a pH lower than 6.0 may be improved with lime for good crop production. Soils with pH higher than 8.0 may be improved by applying gypsum or sulfur to drop the pH.

ELECTRICAL CONDUCTIVITY (mmhos/cm at 25°C)
EC expresses the total soluble salts in the soil. The EC is determined on 1:2 soil:water ratio by volume.

mmhos/cm	**Level**	
< 0.40	No salinity effects	Optimum for all crops
0.40 - 0.80	Very slightly saline	Affects only very salt sensitive crops
0.81 - 1.20	Moderately saline	Salt sensitive crops are restricted
1.21 - 1.60	Saline soil	Most crops are restricted
1.61 - 3.20	Strongly saline	Only for salt tolerant crops
> 3.2	Very strongly saline	Very few salt tolerant crops yield

ORGANIC MATTER (%)
Although accounting for only a small part of the total soil mass in mineral soils, organic matter influences physical, chemical, and biological activities in the soil. Organic matter in the soil is plant and animal residue which serves as a reserve for many essential nutrients, especially nitrogen. Determination of organic matter helps to estimate the nitrogen which will be released by bacterial activity for the next season depending on the climatic conditions, soil aeration, pH, type of organic material, and other factors.

% O.M.	**Level**
< 0.7	Very low
0.7 - 2.0	Low
2.0 - 3.5	Medium
3.5 - 4.5	High
> 4.5	Very high

CATION EXCHANGE CAPACITY (CEC)
Cation Exchange Capacity is a measure of the amount of cations which the soil can absorb or hold. Soil particles and organic matter are negatively charged, and the cations present as sodium, calcium, magnesium, hydrogen and ammonium are positively charged. This means that the positive charges are attracted and held by the soil particles. The common expression for CEC is in terms of meq/100 g of soil.

The CEC on most soils range from 5 to 35 meq/100 g depending upon the soil type, amount or combinations of clay minerals. Soils with high CEC will generally have

higher levels of clay and organic matter. Some crops respond to low levels (below 15 meq/100 g) during the season when nutrients are retained in the root zone.

PERCENT BASE SATURATION

The percent base saturation of calcium, magnesium, sodium, and potassium in the soil may indicate if there is a deficiency or excess in the balance of cations. The percent base saturation for each of the following cations for optimum crop performance will usually be within the following ranges:

Base	**Percentage**
Potassium	2 - 5
Magnesium	12 - 18
Calcium	65 - 75
Sodium	< 2.5

References

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