Soil Analysis: A Key to Soil Nutrient Management

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High yields of top-quality crops require an abundant supply of 16 essential nutrient elements (table 1). In addition to providing a place for crops to grow, soil is the source for most of the essential nutrients required by the crop. Our soil resource can be compared to a bank where continued withdrawal without repayment cannot continue indefinitely. As nutrients are removed by one crop and not replaced for subsequent crop production, yields will decrease accordingly. Accurate accounting of nutrient removal and replacement, crop production statistics, and soil analysis results will help the producer manage fertilizer applications.

A soil analysis is used to determine the level of nutrients found in a soil sample. As such, it can only be as accurate as the sample taken in a particular field. The results of a soil analysis provide the agricultural producer with an estimate of the amount of fertilizer nutrients needed to supplement those in the soil. Applying the appropriate type and amount of needed fertilizer will give the agricultural a more reasonable chance to obtain the desired crop yield.

Objectives of Soil Analysis

- To provide an index of nutrient availability or supply in a given soil. The soil extract is designed to evaluate a portion of the nutrients from the same "pool" used by the plant.

- To predict the probability of obtaining a profitable response to fertilizer application. Low analysis soils may not always respond to fertilizer applications due to other limiting factors. However, the probability of a response is greater than on a high analysis soil.

- To provide a basis for fertilizer recommendations for a given crop.

- To evaluate the fertility status of the soil and plan a nutrient management program.

Chemical analysis of plant composition indicates chemicals or elements present in a crop at maturity or when it is harvested. For example, 1,250 lb of lint cotton contains approximately 125 lb of nitrogen (N), 20 lb of phosphorus (P), and 75 lb of potassium (K). The essential question in fertilization is, "How much nutrient must be added to the soil as fertilizer for a given amount to be taken up by the growing plant?" The crop utilizes only a portion of the available nutrients in the soil. This means that more nutrients must be present than are removed by the crop. The amount added varies according to the level already present in the soil and the crop's need for the nutrient involved. The soil analysis is the starting point, since it measures the level or content presently in the soil.

The soil analysis along with the information provided in the information sheet, is interpreted and reported in terms of the nutrients needed to supplement those in the soil. With this information, producers can add sufficient nutrients for the correct balance to obtain high yields.

Limiting Factors

Crop yields are determined by a variety of factors including crop variety selection, available moisture, soil fertility, crop adaptation to the area, and the presence of diseases, insects, and weeds. The soil analysis and its interpretation deal only with the fertility level (plant nutrients) of the soil. Recommended fertilizer will provide sufficient nutrients for the best possible yields. Other factors of production or management may still cause low yields, even though nutrients are adequate.

Carryover

If yields are only partial in relation to a large amount of fertilizer applied, many of the nutrients are carried over for use by the next crop. It is this carryover, or residual effect, from one year to the next that makes heavy fertilizer applications practical in the face of other limits to yield.

Yields to Expect

A certain fertilizer application cannot be expected to produce a specific yield such as two bales of cotton or nine tons of hay. It is more realistic to assume that a balanced fertilizer program assures that nutrients are not the limiting factor in yields obtained. Research has shown that producers who use a balanced fertilizer program obtain consistently better yields than those who don't.

The Soil Analysis Report

After the soil is analyzed, fertility recommendations are made based on amounts of actual nutrients in the soil, not on the amount of any particular fertilizer or mixture. For example, if 100 lb of N were recommended, that amount could be supplied by approximately 300 lb of ammonium nitrate (33%N), 220 lb of urea (45%N), or 120 lb of anhydrous ammonia (82%N). Likewise, a recommendation of 60 lb of P_20_5 per acre could be added as 133 lb of 45% triple superphosphate.

Fertilizer Labeling

The analysis of complete fertilizers is expressed in percentages (by weight) of N, P_20_5, and K_20. In the fertilizer formula, the first figure represents the percent of N (nitrogen); the second figure, the percent of P_20_5 (phosphate); and the third, the percent of K_20 (potash).

Nitrogen is expressed on the elemental basis as "total nitrogen" (N). Phosphorus is expressed on the oxide basis as "available phosphoric acid" (P_20_5). Potassium is expressed as "soluble potash" or potassium oxide (K_20).

In reality, there is no P_20_5 or K_20 in fertilizers. Phosphorus exists most commonly as monocalcium phosphate, but also occurs as other calcium or ammonium phosphates. Potassium is ordinarily in the form of potassium chloride or sulfate. Furthermore, P_20_5 and K_20 are not absorbed by plants. Plant roots absorb most of their phosphorus in the form of orthophosphate ions, $H_2P0_{4^-}$, and most of their potassium as potassium ions, K^+. For these reasons, the elemental expression (N-P-K) is used in all of the recent research publications. Conversions from one form of P and K to another can be made using the following formulas.

$\%P=\%P_20_5\times0.437$ $\quad$ $\%K=\%K_20\times0.826$

$\%P_20_5=\%P\times2.29$ $\quad$ $\%K_20=\%K\times1.21$

Interpretation of the Soil Analysis Report

The soil analysis report contains two parts: characterization and fertility status of the soil, and fertility recommendations. Soil characterization (pH, texture, percent exchangeable sodium, percent organic matter, and salinity expressed as electrical conductivity) is explained in the report. The fertility status is reported as nutrients available to the plant. The second part, fertility recommendation, contains the suggested amounts of fertilizer to apply. These amounts are based on the crop requirements, management practices affecting the crop (as shown in the information sheet), the present fertility level of the soil, and the yield goal desired by the producer. Special notification is given if the tests indicate that a salt or sodium hazard exists or if the information provided shows any other specific problems.

Soil amendments or treatments to reduce a sodium or salt hazard will be recommended if requested. In general, application of gypsum is suggested for reducing a sodium hazard, and leaching is recommended in most cases to lower salt content in the soil. Gypsum or leaching requirements are calculated and reported if requested.

Where to Get Soil Analyzed

There are many soil testing laboratories in New Mexico, Texas, Colorado, and Arizona. Basic soil testing packages vary in price and number of analyses. Many labs are participating in the Western Region Soil Testing Proficiency Program. Program participants share identical soils and compare results quarterly. This process assures the clients that the lab is striving for consistency and accuracy in lab analyses. Recommendations will undoubtedly vary from lab to lab. Often the best recommendation will come from the local Extension service. The choice of labs is at the client's discretion but should be based on report readability, result accuracy, turn-around time, and cost factors. New Mexico specialists can assist with many questions regarding plant health. Remember, a soil analysis is only as good as the soil sample taken.

Table 1. Essential nutrient elements.

Nutrient	Symbol	Form available	Category
Carbon	C	CO_2, H_2O	Non-fertilizer elements supplied through air, water, and soil components
Hydrogen	H	H_20	
Oxygen	O	CO_2	
Nitrogen	N	$N0_3^-$, NH_4^+	Macronutrients required by plants in large amounts
Phosphorus	P	$PO_4^=$	
Potassium	K	K^+	
Calcium	Ca	Ca^{++}	Secondary nutrients required by plants in moderate amounts
Magnesium	Mg	Mg^{++}	
Sulfur	S	$SO_4^=$	
Boron	B	HBO_4^-	Micronutrients required by plants in small amounts
Chlorine	Cl	Cl^-	
Copper	Cu	Cu^{++}	
Iron	Fe	Fe^{++}, Fe^{+++}	
Manganesse	Mn	Mn^{++}	
Molybdenum	Mo	$M_o0_4^=$	
Zinc	Zn	Zn^{++}	

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