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Fertilizer Management To Protect Water Quality Soil Testing And Plant Analysis For Fertilizer Management

Soil testing is not an exact science, but it is the most important Best Management Practice for fertilizer management. Soil test results can be used to determine proper fertilization and liming rates and to monitor soil fertility.

Also valuable in monitoring soil fertility is plant analysis. Plant analysis has been used as a diagnostic tool for many years. It is based on the concept that the concentration of an essential element in a plant or part of the plant indicates the soil's ability to supply that nutrient. Thus, nutrient concentrations in plants are assumed to be directly related to the quantity of that nutrient available in the soil. Plant analysis and soil testing go hand in hand.

How Plants Use Nutrients

Of the more than one hundred chemical elements known today, only certain basic elements play important roles in the growth and development of plants. Not all are required by all plants, but all have been found essential to some.

Many scientists think in terms of there being sixteen essential elements for all higher plants. Carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), and sulfur (S) are the elements of which proteins and protoplasm are made, the living substance of all cells. In addition to these six, there are ten other elements which are essential to the growth of some plants: calcium (Ca), magnesium (Mg), potassium (K), iron (Fe), manganese (Mn), molybdenum (Mo), copper (Cu), boron (B), zinc (Zn), and chlorine (Cl). Sodium (Na), cobalt (Co), vanadium (V), silicon (Si), and nickel (Ni) are also required by some lower plants. When these elements occur in insufficient quantity, plant growth and production are reduced. Other elements may be found to be essential in the future.

Nitrogen, phosphorus, and potassium are called the primary macronutrients because they are required in the greatest amount. Calcium, magnesium, and sulfur are called secondary macronutrients because they

are required in the second largest amount. The other elements are called minor or micronutrients because they are needed in very small quantities. With the exception of carbon, hydrogen, and oxygen, all the elements must be obtained from the soil.

Plants may take up many elements that play no vital role in their own nutrition. Plants can consume high levels of certain elements, some of which are essential and some of which are not. They may accumulate low levels of elements which play no beneficial role in the plants themselves but which are important in the diet of animals that eat these plants. Plants can even take up elements, like heavy metals, which may be extremely toxic when their availability exceeds certain levels in the soil.

Soil Sampling Procedures

While there have been improvements in sampling procedures, one of the ongoing problems in soil testing is failure to collect a sample that truly represents the conditions that are to be measured. Soil sampling techniques are undergoing review because of the changing chemical characteristics of the surface 1 to 2 inches of soil in conservation tillage fields. New techniques may also be required where land is regularly used for waste disposal.

General recommendations for standard row crops, pastures, forage, and small grain crops are that a minimum of one soil sample should be taken for every 30 to 45 acres of harvested crop. More recent research on soil test variability, however, suggests that a sample should not represent more than 2.5 acres and even sampling on a 1-acre grid with at least 5 cores per sample might be needed on small acreage, high-value, intensively managed crops such as vegetables.

Another approach is sampling according to maps of soil types. This approach would allow farm managers to vary fertilizer rates according to soil type. Yet another sampling approach is detailed or grid sampling for all crops. This allows fertilizer applications to be varied according to changes within the field.

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As a minimum, soil tests should be taken once per 3-year rotation for field crops and once every 5 years for pastures. But on sandy soils, especially where rainfall or irrigation rates are high, samples should be taken annually. The same is true if a mobile nutrient form, such as nitrate or chloride, is part of the test.

Deep testing is important in drier climates to determine how much of last year's nitrogen fertilizer remains within the plant's reach. For most dryland crops in the western United States and central Great Plains where residual nitrate tests are used, there is evidence that sampling to 2 feet is sufficient. In the western Corn Belt, sampling depths of 3 to 4 feet are required.

Special field test kits and improvements in analytical methods and micro-electronics will allow for more sophisticated and timely onsite sampling and testing in the future. Devices that monitor fertilizer levels in shallow-rooted field crops may help growers avoid applying too much fertilizer while still feeding their plants for optimum yield and quality. However, all tests must be calibrated to plant growth response or they are of little value.

Standard Soil Tests And Plant Analyses

The tests that are run depend on the lab making the analyses, the nature of the soil and crops to be grown, and the problems that are expected to be encountered with the soil or crop. There is no need to test for all the chemical or mineral elements found in soils and plants. Only certain basic elements, called essential plant nutrients, play important roles in the growth and development of plants.

Primary nutrients (N, P, K) and secondary nutrients (Ca, Mg) are the elements most commonly tested for in soil samples, whereas, deficiencies of the others are usually tested through plant analyses.

Many labs also determine organic matter, cation exchange capacity (CEC), and percent base saturation. Other determinations are optional with some labs. These include sulphate-S, nitrate-N and total N, Cl, and micronutrients such as Zn, Mn, Cu, B, and Fe. In arid and semi-arid regions, it may be necessary to run tests for sodium and soluble salts. Virtually all labs in humid regions run pH, lime requirement, P, and K.

The most reliable tests are generally assumed to be for pH and lime requirement and for N, P, and K. There is more research information behind the interpretation of these tests and, hence, more confidence in them.

Plant analysis usually refers to the quantitative analysis for the total amount of essential elements in

plant tissue. It should be distinguished from rapid (qualitative) plant tissue tests, which may be made in the field.

Using Test Results

Soil testing and plant analysis can provide much valuable information about soil fertility and plant health.

Soil tests can be used to monitor soil fertility rather than just to make a recommendation for a particular crop in a particular year. Soil test records can be used to determine if soil fertility is being depleted, maintained, or built-up.

Soil tests can be used to determine residual nitrogen. The distribution and carryover quantities of nitrate nitrogen are drastically affected by climate, tillage practices, and irrigation practices. Determining residual nitrogen may help farmers fine tune their nitrogen application rates and reduce nitrate carryover in their fields. The wide scale adoption of this practice can have a significant influence on decreasing fertilizer's potential role in groundwater nitrate levels and improving the efficiency of nitrogen fertilizer use.

Soil tests can be used to maintain plant nutrients at optimum levels, where the supply will not limit plant growth at any stage from germination to maturity. The soil test of the future may be used to determine the optimum level of a nutrient required to reach high yields, the amount to be applied to reach this level, and the amount needed to maintain it. By providing optimum fertility for crops, the farmer can maximize profit and minimize potential danger to the environment.

Soil tests can be used to diagnose micronutrient problems. Micronutrient soil tests are not very reliable for diagnosing deficiencies because of the low levels normally found in soil, but they may be used to diagnose micronutrient levels for some crops. These micronutrient tests, however, may be more valuable for avoiding over-application in the future. Zinc, Cu, Mn, and non-nutrient elements such as Cr, Cd, Hg, and Pb cannot be removed from the soil once they are applied. Information on pH, organic matter content, irrigation water quality, soil depth, soil compaction, and liming history may be more valuable in diagnosing micronutrient problems than soil testing.

Soil tests may be used to make recommendations for lime application. Many determinations help arrive at soil lime requirements: pH and buffer pH, CEC and percent base saturation, Ca and Mg levels, organic matter, and soil texture.

Plant analysis may be used to diagnose or confirm diagnoses of visible symptoms. Nutrient deficiencies are often difficult to identify because a num-

ber of different factors may cause similar symptoms. Often, analyses are used to compare normal and abnormal plants.

Plant analysis may be used to identify “hidden hunger.” Sometimes a plant may be suffering from a nutrient deficiency but show no symptoms. A plant analysis looks beyond the appearance of a crop.

Plant analysis can be used to indicate if applied nutrients entered the plant. If no response was obtained to applied nutrients it might be concluded that the nutrients were not lacking. However, such factors as pests, unfavorable placement, soil chemical properties, or moisture stress might have prevented the nutrient from being taken up by the plant.

Plant analysis can be used to indicate interactions or antagonism among nutrients. Sometimes the addition of one nutrient will affect the amount of another taken up by the plant. For example, metal cations including Cu^{2+} , Fe^{2+} , and Mn^{2+} inhibit plant uptake of Zn^{2+} , and a Zn deficiency can enhance phosphorus accumulation to toxic levels under certain conditions.

And, finally, **plant analysis can be used to study trends during the year or over the years.** Periodic sampling during the season may help to determine if a nutrient is becoming deficient. Sampling a crop over the years monitors trends in the levels of fertility in the soil. Many of the more common nutrient deficiencies are the result of long-term improper lime and fertilizer practices. Plant nutrient deficiencies or excesses can be detected before they appear as visual symptoms or reduce yields and quality.

Conclusion

Soil testing can help a grower realize maximum returns for his fertilizer investment by using the value of residual fertility. The grower can also avoid plant toxicities and deficiencies inadvertently created by over-applying some nutrients. Soil testing and plant analyses are established best management practices, which have an additional benefit of protecting the soil and water quality from excessive nutrients and metals.

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