SOIL PROPERTY DETERMINATIONS POSSIBLE WITH PORTABLE TESTERS

The physical and chemical properties of a soil profile must be well understood in order to institute a management program that will take advantage of characteristics favorable to plant growth and overcome those that limit soil's function as a growth medium. Even the hardiest of plant species will not grow unless basic metabolites are present.

Soil testing, in most cases, is done by technicians in well equipped laboratories. However, companies making soil test kits have simplified them to the point that it is easy for a grounds manager to perform many spot tests and make immediate corrections, or to sleep better, knowing that his plants are growing under optimum conditions.

The sand:silt:clay ratio, types of clay, the physical and chemical nature of the soil separates, aggregate stability, particle and bulk densities,, pore space, and organic matter content of a soil can provide insight into management techniques that take advantage of natural properties and overcome detrimental qualities.

Understanding pH and its relationship to nutrient release in the soil solution is important. Buffer pH must be overcome in initiating any change in pH. Cation exchange capacity can provide insight into a soil's ability to take fertilizer additions into solution and render them into compounds for plant uptake.

Plant tissue analysis can be used to indicate uptake of some nutrients and is probably the best test for nitrogen utilization by plants.

Soil pH

Soil reaction, or pH, is recognized as one of the more critical properties of a soil solution.

Whether a soil is acid, neutral, or alkaline depends upon the ratio of hydrogen ions (H+) to hydroxyl ions (OH—) in the soil solution. As a calculation, pH is expressed in terms of the H+ concentration. The pH value is the logarithmic reciprocal of the hydrogen ion concentration. As a simple formula: pH=log 1 (H+).

In mathematical terms, a pH value of 7 indicates neutral conditions with a 1:1 ratio of hydrogen and hydroxyl ions. Moving in either direction, acidic or alkaline, from a neutral value, the values for pH increase in logarithmic increments.

This can best be understood by realizing that while, at a pH of 6, the hydrogen ions are 10 times more numerous than the hydroxyl, the hydroxyl ions have decreased proportionately and are only one-tenth as numerous.

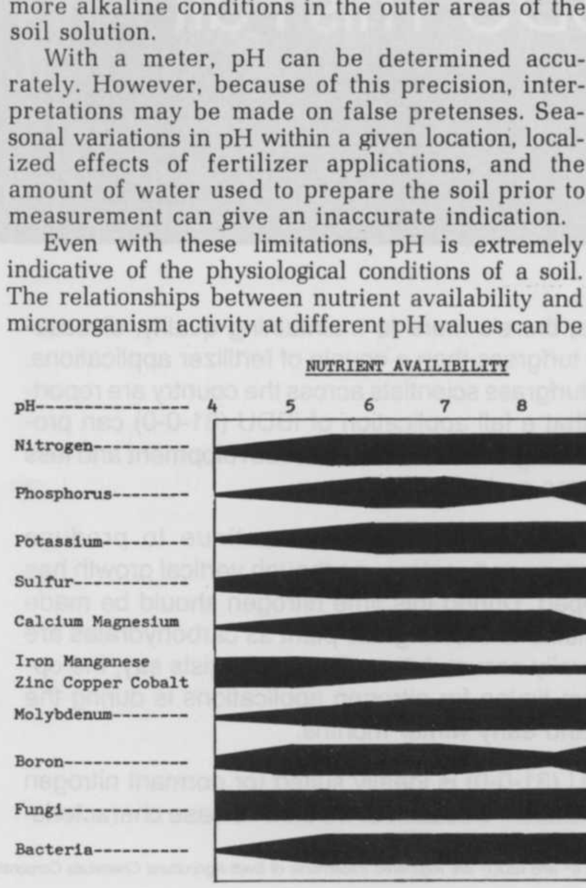
This inverse relationship leads to a 100 times increase in one ion concentration over the other, as pH values move in either direction. At ph, 8, there are 10 times more OH— ions, but only one-tenth as many H+ ions. The concentration of OH— ions is therefore 100 times greater than H+. The solution is alkaline.

However, while establishing a mathematical pH value is a rather stable operation, the value can be distorted if it is not standardized against soil performance.

Concentration of the ions occurs at different areas within the soil solution. Hydrogen ions tend to concentrate at the soil colloidal surfaces creating more alkaline conditions in the outer areas of the soil solution.

With a meter, pH can be determined accurately. However, because of this precision, interpretations may be made on false pretenses. Seasonal variations in pH within a given location, localized effects of fertilizer applications, and the amount of water used to prepare the soil prior to measurement can give an inaccurate indication.

Even with these limitations, pH is extremely indicative of the physiological conditions of a soil. The relationships between nutrient availability and microorganism activity at different pH values can be



broadly correlated within an optimum range for a plant species.

Addition of lime to raise the pH value, or sulfur to lower it, are probably the most generally recognized methods to manage soil pH. In limited cases, addition of acid organic compost to a soil can also be used to lower pH.

The reserve acidity, or buffer pH, provides resistance to immediate pH change in the soil solution. If other factors remain equal, the buffering capacity of a soil solution will remain at a capacity consistent with the exchange capacity of the soil.

To affect a pH change in an acidic soil, both active and reserve acidity must be considered. Active acidity is the obvious pH resulting from a measurement of the soil solution. Reserve acidity is more complex. It consists of hydrogen and aluminum ions held on the soil colloidal surfaces. As the hydrogen ions making up the active acidic portion are neutralized, these colloidal ions move outward and become active. Reserve acidity is generally much greater than active acidity and plays a greater role in deciding the amount of material to apply to affect a change in pH.

Cation exchange capacity

Cation exchange capacity, as well as clay type and content, and organic matter content can be interpreted to give an idea of the buffering capacity of a soil.

Cation exchange capacity (CEC) is a measure of positively charged ions that are held to the organic and clay colloidal surfaces. The CEC varies with the amount of organic matter and the amount and type of clay. Soils with more clay and organic matter tend to have higher CEC's.

CEC is measured in milliequivalents per 100 grams of soil or material being measured. A milliequivalent is one milligram atomic weight of hydrogen or the amount of another ion that will displace that amount of hydrogen. A soil with a CEC of one milliequivalent will exchange one mg of hydrogen or its equivalent for every 100 grams of soil. A hectare (2.47 acres) of soil to a depth of 15 centimeters (6 inches) could absorb 22 kilograms (48.5 lbs.) of exchangeable hydrogen or its equivalent.

Calcium has two positive charges compared to one for hydrogen. Its atomic weight is 40. Twenty (40 /2) milligrams of calcium are thus required to replace one milligram of hydrogen. 22 kilograms (a factor of 1,000,000) would require 1100 kilograms of calcium carbonate ($CaCO_3$, ordinary limestone).

When applying limestone to established turf, it is recommended that no more than 25-50 pounds of finely ground material, more if coarse, be applied. On highly acidic soils with established turf, it is recommended that limestone be added over a period of two, three or more years to avoid the detrimental effects of a large amount at once.

While limestone application rates are generally recommended according to soil texture, there can be extreme variation between soil types with similar textures. Sands and sandy loams can have a CEC ranging from 2-17 milliequivalents. Loams and clays can range from 8-60 milliequivalents.

A county soil survey map, available from the Soil Conservation Service (if your county has been mapped) will indicate the soil series and expected CEC. Management practices will have affected the rate.

Humus and clay

Clays make up the inorganic portion of soil and humus makes up the organic portion. Together they make up the colloidal portion of the soil.

The amount of humus in a soil can significantly influence its characteristics. Humus contributes directly to better physical properties, improves nutrient availability, and imparts a higher cation exchange capacity.

Humus is made up basically of two types of complex compounds: those resistant to further decomposition; and those that have been synthesized by microorganisms and are held as part of their tissue structure. Because of the relative resistance to microbial breakdown, the nutrients held in the humus are resistant to ready solution and provide a long term release of nutrients.

The cation exchange capacity of humus can range from 150 milliequivalents per 100 grams to 300 milliequivalents. Thus the greater the humus content of a soil, the greater its influence will be on CEC.

Clays play a significant role in determining CEC of a soil. The silicate clays are more typical of the temperate regions and of the more productive agricultural soils.

The silicate clays are broken down into classifications based upon the relationship of aluminum and silicon layers within the clay structure. A 1:1 type clay, such as kaolinite or halloysite, lends the least to soil properties. CEC of kaolinite is expected to range within 3 to 15 milliequivalents. Montmorillionite, a 2:1 (two aluminum layers sandwiching a silicon layer) expanding type of clay commonly ranges between 80 and 100 milliequivalents and lends substantial character to a soil due to its swelling and shrinking capabilities. Ilite is a 2:1 non-expanding type of clay and falls within an intermediate range, commonly having a CEC of 15-40 milliequivalents.

Organic matter (humus) and nitrogen availability share a close relationship. Carbon is a significant part of organic matter. Because both plants and microorganisms maintain a rather definite carbon:nitrogen ratio, it is important to consider the balance when making an addition of organic matter to improve a soil's condition.

Some manures can have a C:N ratio as high as 100:1, compared with a normal soil ratio in the range of 10:1. When such a manure is added to a soil, general decay organisms become more active. Organisms responsible for nitrification become relatively inactive.

The decay organisms utilize nitrogen and produce carbon dioxide. As a result of the decay organisms demand for nitrate, little is available for uptake by plants.

As decay of the soil additive continues, carbon is lost and nitrogen retained in the tissues of the organisms until a stable C:N ratio is once again achieved.

Nitrifying organisms resume activity as the decay organisms demand for nitrate falls off. Meanwhile, the soil has become richer in both nitrogen and humus.

Duration of the process depends upon conditions which might favor or prolong decay.

Optimum temperature range for decay organisms is between 40 and 50 degrees C. Moisture is necessary, but must be balanced against an adequate oxygen supply. Soil reaction should be at a near neutral pH.

If an organic substance to be added is poor in nitrogen content, it may be necessary to supply more nitrogen as a substrate for the decay organisms. Legume tissues are rich in nitrogen, but certain straw residues are poor. In such a case, addition of supplemental ammonium or nitrate will enhance the rate of decomposition.

Nitrogen

Nitrogen is the most widely applied element, yet application is often based on color characteristics, root or shoot growth, or other general indications of less than optimum plant growth. However, nitrogen will not lend as great an effect if other essential nutrients are limited. Growth is generally limited by the contributing factor present to the least degree.

Nitrogen has in the past been recognized as the nutrient required in the greatest amounts, with the exceptions of carbon, hydrogen, and oxygen. Trends have been, however, to reduce the amount of applied nitrogen in relation to the amount of applied potassium. It has been recently suggested that nitrogen be applied on a 1:1 ration basis with potassium. Twenty-some years ago, a 4:1 ration was recommended.

Nitrogen is absorbed from the soil primarily in the nitrate form, although turfgrasses can absorb the ammonia form. The amount of available nitrogen in the soil is usually not a true measure because availability can change rapidly.

Tests are available, however, for nitrates present in plant tissues, and nitrate, ammonia, and organic forms of nitrogen in the soil. It would seem that these tests might be correlated to give an accurate indication of the amount of nitrogen readily available and taken up by the plant.

A large supply of organic nitrogen and a small supply of nitrate and ammoniacal nitrogen would indicate that another factor, beside nitrogen, is limiting its conversion to readily available forms. Supplemental fertilization with a quickly available form of nitrogen could offset these effects while a program to manage the overall soil for better microorganism activity could be instituted.

There are variations due to climate, soil types, testing procedures, etc. The purpose of the above is merely to suggest that an overall picture of nitrogen in the plant and soil would give a definite insight to management techniques.

Phosphorus, potassium, sulfur, calcium, iron, magnesium, boron, manganese, copper, zinc, molybdenum, and chloride are essential nutrients. Soil and tissue tests generally provide an accurate indication of the supply of these.

There are also many other soil properties that might be tested for and integrated into a management program. Some properties lend themselves only to an understanding of the productivity of a soil and are not economical to try to change. Soil function and plant growth are dynamic and rapidly change in relationship to their qualities and needs. Understanding them allows a grounds manager to cope with them and satisfy those needs to achieve the goals of a management program. *Ron Morris*