_*3*_ Soil pH and Percent Base Saturation

Soil pH is one of the most important characteristics of soil fertility because it has a direct impact on nutrient availability and plant growth.

The pH scale is a logarithmic expression of hydrogen ion [H+] concentration in the soil solution. Mathematically, pH equals -log [H+] (the negative logarithm of the hydrogen ion concentration). The pH scale ranges from 0 to 14. A soil pH value of 7.0 is neutral. At pH 7.0, the hydroxyl ion [OH-] and the hydrogen ion [H+] concentrations exactly balance one another. At pH values below 7.0, soils are acidic because the [H+] ion concentration is greater than the [OH-] ion concentration. At pH values above 7.0, soils are basic because there are more [OH-] than [H+] ions. Most agricultural soils in Maryland have a pH range between 4.5 and 7.5. Although there are some exceptions, the preferred pH range for most plants is between 5.5 and 7.0. Legumes prefer higher pH's (pH values of 6.2-7.0) than do grasses (pH values of 5.8-6.5).

Because the pH scale is logarithmic rather than linear, the difference in acidity between each pH value varies by a factor of 10, not 1. Therefore, a soil with a pH of 5.0 is 10 times more acid than a soil with a pH of 6.0. A soil with a pH of 4.0 will be 100 times more acid than a soil with a pH of 6.0 and 1,000 times more acid than a soil at pH 7.0. This is an extremely important factor to consider when developing liming recommendations to correct acid soils.

Soil pH also reflects percent base saturation (% BS) of the CEC. This term refers to the relative number (percentage) of the CEC sites on the soil colloids that are occupied by bases such as calcium (Ca++), magnesium (Mg++), and potassium (K+). In general, at pH 7.0 the base saturation is 100 percent. By rule of thumb, for every one-half unit drop in soil pH, the % BS declines by about 15 percent (pH 6.5 = 85 percent BS, pH 6.0 = 70 percent BS, pH 5.5 = 55 percent BS, and so forth). This information can be useful to calculate the approximate amounts of available nutrients present in a soil at a given pH. Ag-Lime Recommendations

To predict how much liming material (calcium and/or magnesium carbonate) will be necessary to change the pH of a soil from one level to another, other information is needed in addition to the soil's pH. It is also necessary to estimate the soil's buffering capacity, that is, the soil's ability to resist a change in pH.

There are several ways to estimate a soil's buffering capacity so that a liming recommendation can be developed. One of the simplest techniques for Maryland soils is to determine soil texture. Research has shown that, with just a few exceptions, for soils within a particular physiographic region, a positive direct relationship exists between soil texture and the CEC. Thus, as soil texture varies from coarse to fine on the Coastal Plain (for example, from sand to silt loam to loam to clay loam), CEC and buffering capacity increase. Simplified tables and equations have been developed to estimate the amount of liming material needed to achieve a desired pH goal when the current soil pH and texture are known.

Another technique that some soil-testing laboratories use to develop an ag-lime recommendation is known as the lime requirement test. With this procedure, in addition to determining the normal water pH, a second pH measurement, known as the buffer pH, is required. For a normal water pH reading, the soil is allowed to equilibrate in distilled water. A pH meter is used to measure how much the soil changed the pH of the unbuffered distilled water. The buffer pH differs in that the soil is allowed to equilibrate in a specially prepared solution that has previously been buffered to a known pH. The buffer solution, as well as the soil, resists changes in pH. A pH meter is used to determine how much the soil was able to overcome the resistance of the buffer solution to a change in pH.

The buffer pH technique directly reflects the soil's buffering capacity and the result can be used in a formula to calculate the amount of ag-lime required to achieve the desired change in pH.

Nutrient Availability and Soil pH

Nutrient availability is influenced strongly by soil pH. This is especially true for phosphorus, which is most available between pH 6.0 and 7.5. Elements such as iron, aluminum, and manganese are especially soluble in acid soils. Above pH 7.0, calcium, magnesium, and sodium are increasingly soluble.

Phosphorus is particularly reactive with aluminum, iron, and calcium. Thus, in acid soils, insoluble phosphorus compounds are formed with iron, aluminum, and manganese. At pH levels above 7.0, the reactivity of iron, aluminum, and manganese is reduced, but insoluble phosphorus compounds containing calcium and magnesium can become a problem. To maximize phosphorus solubility and hence availability to plants, it is best to maintain soil pH within the range of 6.0 to 7.5. Over liming can result in reduced phosphorus availability just as quickly as under liming.

In general, the availability of nitrogen, potassium, calcium, and magnesium decreases rapidly below pH 6.0 and above pH 8.0. Aluminum is only slightly available between pH 5.5 and pH 8.0. This is fortunate because, although plants require relatively large quantities of nitrogen, phosphorus, and potassium, aluminum in appreciable quantities can become toxic to plants. If managed properly, soil pH is a powerful regulator of nutrient availability. Manganese, zinc, and iron are most available when soil pH is in the acid range. As the pH of acid soil approaches 7.0, manganese, zinc, and iron availability decreases and deficiencies can become a problem, especially on those soils that do not contain appreciable amounts of these elements. These micronutrients frequently must be supplemented with fertilizers when soil levels are low, when over liming has occurred, or when soil tests indicate a deficiency. There is a delicate balance between soil pH and nutrient availability. It is important that soils be tested regularly and that the pH be maintained in the recommended range to achieve maximum efficiency of soil and fertilizer nutrients.