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Managing soil pH for optimum turf quality

by
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TURF LINE NEWS

Soil pH is the foundation of soil fertility and turfgrass nutrition. It is measured on a logarithmic scale, with each pH unit representing a ten-fold change in relative acidity or alkalinity. Cool season turfgrasses prefer a pH range of 6.5-7.0 where nutrients are at their greatest level of availability. Soils with a pH below 5.5 can be toxic to turf growth. Soil pH is driven primarily by climate, parent soil material, irrigation water quality and to a lesser degree, nitrogen fertilization. Acidic soils should be amended with lime. In specific circumstances, alkaline soils can be amended with elemental sulfur.

Defining pH

In soil science, the terms acid, neutral and alkaline refer to the relative concentration of hydrogen ions (H+) and hydroxyl ions (OH-) in the soil solution. An acid soil has a higher concentration of hydrogen ions than hydroxyl ions, while an alkaline soil has the opposite. A neutral soil simply means the two ions are present in offsetting amounts.

In order to distinguish between relative degrees of acidity and alkalinity, a pH scale from 0-14 is used. The middle of the pH scale, 7.0, is neutral. Below 7.0 the soil is acidic and above 7.0 the soil is alkaline. The pH scale is logarithmic, with each pH unit representing a tenfold change in relative acidity or alkalinity. **For example, a soil with a pH of 4.5 is ten times more acidic than a soil with a pH of 5.5 and one hundred times more acidic than a soil with a pH of 6.5.**

Analyzing soil pH is essentially a two step procedure. The primary test determines the pH of the soil solution and is known as the active pH. One can look at active pH as the concentration of hydrogen or hydroxyl ions that are “free” in the soil system. When the active pH is below 6.8, the buffer pH is measured. Buffer pH determines the soil’s potential acidity by measuring the acidifying ions held on soil exchange sites, and their medium term effect on pH. Buffer pH is the analytical tool used to quantify the amount of lime required to neutralize a soil.

Optimum pH

A pH of 6.5-7.0 offers the best environment for turfgrass growth because nutrients are at their greatest level of collective availability. As pH moves away from the ideal range, a number of chemical and biological reactions occur that have a dramatic effect on nutrient availability and turfgrass health.

As soil pH decreases, aluminum (Al) and manganese (Mn) become increasingly soluble. Al toxicity is the most significant growth-limiting factor in soils with a pH less than 5.5. Hydrogen (H) also becomes toxic when pH is below 4.5. In acid soils, phosphorous (P) availability is impaired due to fixation with high levels of soluble Al. Acid soils are usually deficient in calcium, potassium and magnesium due to the dominance of H and Al on soil exchange

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sites. Finally, acid soils tend to have very low microbe populations, which inhibits nutrient conversion as well as organic matter and thatch decomposition. In short, the agronomic problems in acid soils can severely inhibit turfgrass growth and health.

As pH rises Ca becomes increasingly soluble, reacting with P and micronutrients to form insoluble compounds. As a result, P, Iron (Fe), Mn and Zinc (Zn) deficiencies are common in alkaline soils. Though serious, these problems are easier to manage and not quite as deleterious to plant growth as are the problems associated with acid soils. In the case of a high pH induced P deficiency, "build" applications of P fertilizers often produce a dramatic response in turfgrass growth and density. In addition, tissue analysis will reveal the extent of micronutrient deficiencies, which can then be managed with supplemental fertilization.

Factors Influencing pH

The factors that determine soil pH fall into three broad categories, climate, soil type and inputs. The level of annual precipitation plays an important role in soil pH. Water from rain and snow is very pure; the chemical nature of which dissolves calcium carbonate in the soil. In addition, high rates of precipitation leach Ca, K and Mg through the soil profile. Eventually, hydrogen accumulates and the soil becomes acidic – much like the environment in BC's Lower Mainland.

Conversely, low rainfall climates tend to have alkaline soils. Low precipitation levels dissolve much smaller amounts of calcium carbonate and since leaching is kept to a minumum, dissolved calcium salts actually accumulate rather than steadily decline. Calcium levels tend to be relatively high in these soils, reflected with an alkaline pH. The arid South Okanagan is a good example of this type of climate driven soil pH.

The parent material of a soil also has a profound impact on its pH. Soils comprised primarily of calcium carbonate, such as those in the East Kootenays, naturally tend to have a high pH. Needless to say, these soils are not significantly altered by attempts at acidification. On the other hand, peat soils and other soils with very high organic matter tend to be acidic, as these compounds release hydrogen upon decomposition. In such cases lime has a minimal medium-term effect on soil pH.

The external input with the greatest potential impact on soil pH is irrigation water. Relatively pure irrigation water (very low in soluble salts) acts much like rain, dissolving and leaching calcium carbonate and thereby creating the conditions for an acidic soil. As mentioned previously, irrigation water moderately high in dissolved calcium salts will deposit calcium carbonate and create an alkaline soil. Effluent irrigation water tends to be high in sodium and bicarbonates, the accumulation of which can create a high pH, sodic soil.

Nitrogen fertilizers have an acidifying effect in soils, but their potential impact is small when compared to that of irrigation water. Urea (46-0-0) and Ammonium Sulfate (21-0-0-24S) acidify soil because they both contain hydrogen, the ion that ultimately drives acidity. Ammonium sulfate acidifies the soil more than urea because for each pound of actual N applied ammonium sulfate deposits the most hydrogen. It's commonly assumed that the sulfur in ammonium sulfate acidifies the soil, but sulfate itself actually has no impact on soil pH. Take potassium sulfate and K-Mag as an example. Both are sulfate fertilizers but they have no effect on soil pH.

Changing pH

In order to produce the healthiest turf possible, one that is able to thrive under today's stressful maintenance regimes, acidic soils should be amended with lime. Soils primarily low in only calcium should be limed calcium carbonate, while soils low in both calcium and magnesium should be limed with dolomite limestone. Due to its inherent insolubility, lime must be ground into a fine powder in order to be effective. Prilled limestone, which consists of finely ground lime powder in the form of a water dispersible prill, is not only effective but is also easy to apply. Though not practical on established turf, incorporating lime in the soil enhances its effectiveness. Small particles of insoluble limestone rock are essentially inert and should not be used for liming acid soils.

The amount of lime required to neutralize a soil depends on a combination of the soil's Cation Exchange Capacity (CEC) and its hydrogen base saturation. Lime applications should always be based on soil test results and should not exceed 20 pounds per 1000 square feet in a single application. The following formula provides a rough guideline for the amount of calcium carbonate required to neutralize the top six inches of soil:

$$\text{Limestone (tons / acre)} = 0.5 \text{ X } (\text{CEC X hydrogen base saturation \%})$$

Elemental Sulfur is a powerfully acidifying fertilizer amendment, converting to sulfuric acid through the action of soil microbes. It is a widely available and low cost method of lowering soil pH. Alkaline soils that are not derived from calcium carbonate parent material are the best candidates for pH lowering elemental sulfur applications, particularly if the site's irrigation water is not high in dissolved calcium salts. Much like lime, incorporating elemental sulfur in the soil prior to establishment increases the speed with which a pH change occurs. In order to avoid leaf or crown damage, individual elemental sulfur applications shouldn't exceed 5 pounds / 1000 square feet on fairways and 0.5 pounds / 1000 square feet on greens.

Amount of elemental sulfur required (lbs. / 1000 ft^2) to lower soil pH to approximately 6.5, based on soil type or texture

Existing Soil pH	**Sand to Loamy Sand**	**Loam**	**Clay**
8.5	30-50	50-60	60-70
8.0	15-25	25-35	35-50
7.5	10-15	15-20	20-25
7.0	2-5	3-6	5-10

Source: Turfgrass Soil Fertility and Chemical Problems. Carrow, Waddington, Rieke.

Conclusion

We've all heard the expression "healthy turf can only come from a healthy soil". The origin of this term probably comes from trying to explain the importance of soil pH in practical terms. When pH is optimized, soil chemistry is simply no longer a limiting factor in turfgrass growth. Nutrients are utilized at their peak efficiency and the microbial life that we all recognize as critical to plant health is enhanced. In essence, a pH in the range of 6.5-7.0 creates the foundation for vigorous growth.

It's important to note that a non-optimal pH doesn't automatically impair turf health. In other words, a pH of 6.4 isn't bad for turf growth just because it's not in the optimal range. Rather, the farther soil pH departs from optimum range, the greater likelihood of pH induced agronomic problems.

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