The Basis for Turfgrass Nutrition Management

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Among the 16 elements for turfgrass growth and development, 13 enter the plant via the root system. Only carbon and oxygen are derived from air and even much of the oxygen and all of the hydrogen needed comes from water absorbed by the roots. Thus, the nutrition of turfgrass is very much dependent on what happens in the rooting zone.

Mathematical modeling of nutrient uptake by a variety of crops has clearly shown that the quanitites of nutrients taken up are primarily dependent on three factors:

1. The concentrations of nutrient ions in the soil solution at any given moment;
2. The capacity of the soil to replenish ions removed from solution by the plant roots; and
3. The amount of water present in the soil.

Understanding what controls soil solution concentrations of nutrient ions is, therefore, the basis for turfgrass nutrition management. This knowledge allows us to make rational judgments regarding the development and modification of fertilization programs and to anticipate and diagnose nutritional disorders. Let us briefly examine what controls solution concentrations of ions of nutrients of greatest importance in turfgrass management.

Nitrogen

Plant availability of nitrogen applied to turfgrass is controlled by several loss mechanisms and the rate of entry of nitrogen into soil solution in the form of ammonium and nitrate ions. The positively charged ammonium ions are retained in soil by being attracted to negatively charged soil colloid surfaces while nitrate remains entirely in solution and moves with soil water. The latter is the reason why surface application of nitrogen is so effective — nitrate ions readily move downward into the rooting zone of turfgrass.

Losses of fertilizer nitrogen may occur before or after entering the rooting zone of turfgrass. Urea, if allowed to remain on the soil surface for 24 hours or more, is subject to loss via volatilization of gaseous ammonia. The problem arises because urea undergoes enzyme hydrolysis that converts the urea to ammonium carbonate and raises the pH at the site of application. Should the pH exceed about 7.3, ammonium ions are converted to gaseous ammonia and are lost to the atmosphere. The amount of nitrogen lost varies with the moistness of the soil surface, the rate of hydrolysis of the urea, soil pH, and soil surface temperature. Losses of one-half or more of the nitrogen in urea have been reported. Obviously, chances for significant loss are greatest on soils with pH greater than 7.0.

Fortunately, urea is highly water soluble and volatilization loss of ammonia only occurs at the soil surface. Irrigation with one-fourth inch or more of water after fertilization with urea moves the material into the soil where volatilization loss no longer occurs.

Turfgrass utilization of nitrogen from slow-release fertilizers such as ureaformaldehyde (UF), sulfur-coated urea (SCU), isobutylidene diurea (IBDU), and Milorganite primarily depends on rates of release of the nitrogen as ammonium and the fate of the ammonium released. Release of ammonium from IBDU is largely controlled by the solubility of the product, from SCU by the rate of leakage of urea solution through cracks and micropores in the sulfur coating, and from UF and Milorganite by the rate of microbiological decomposition. Moisture supply and soil temperature affect all of these processes to varying degrees.

Once in the soil, ammonium ions are rapidly converted microbiologically to nitrate ions unless the soil is very dry, has a pH of less than 5.5, or is at a temperature substantially below 85°F. Nitrogen in the form of nitrate is subject to loss via leaching and denitrification. Any movement of water deeper than the rooting zone of turfgrass inevitably results in leaching loss of nitrogen. Irrigating to wet no more than three-fourths of the rooting zone is a sound nitrogen management practice.

Denitrification is the chemical and microbiological conversion of nitrate to gaseous forms of nitrogen that are lost to the atmosphere. The process occurs to some extent in all soils, but is greatly accentuated by the presence of excess moisture and the associated lack of aeration. It is for this reason that impeded drainage and soil compaction often greatly reduce the effectiveness of nitrogen fertilizers.

The amounts of fertilizer nitrogen lost from soil by way of leaching and denitrification increase with increasing concentration of nitrate in the soil solution. In contrast to the soluble nitrogen fertilizers, slow release materials generally maintain lower solution concentrations of nitrate. Hence, when leaching or denitrification of nitrogen is a problem, slow release fertilizers typically prove more effective than soluble nitrogen fertilizers.

Phosphorus

Phosphorus enters the soil solution in the form of negatively charged ions. These ions are quickly and extensively adsorbed on soil mineral surfaces. The amount of phosphate ion remaining in solution is very low and it is the adsorbed phosphate that is the major plant available source of the nutrient.

Plant availability of the adsorbed phosphate depends on how strongly the ions are bonded to soil colloid surfaces. This, in turn, relates to the composition of the soil and how much of its phosphate adsorption capacity has been satisfied through fertilization. As a general rule, the finer the texture of soil, the greater its phosphate adsorption capacity and the greater the amount of fertilizer needed to satisfy plant requirements for the nutrient. Soil pH values below 5.5 and above 7.5 further increase soil phosphate adsorption capacities and decrease phosphate availability.

The greater the extent of satisfaction of the phosphate adsorption capacity of soil, the more readily available the phosphate is to plants. However, except in sands with their typically low phosphate adsorption capacities, it is generally impractical, ill-advised, and unnecessary to load

up a majority of the adsorption sites with phosphate.

Three principles govern the management of phosphorus for turfgrass. First of all, soil testing is the only means for accurately assessing how much phosphate a particular soil needs. Secondly, it is soil reactions that control plant availability of fertilizer phosphate. As long as more than 50 percent of the phosphorus applied is water soluble (true of most turf fertilizers now on the market), it makes no difference what source or chemical form is applied and whether it is applied dry or in liquid form. Finally, because soil solution concentrations of phosphate are generally so low, the nutrient is highly immobile in soil. Even with repetitive surface applications phosphate typically does not penetrate soil more than a fraction of an inch. This stratification of phosphate has important implications regarding sampling of turf soils for analysis and establishment of new turf. Incorporation of phosphate into soil to a depth of six inches or more prior to seeding or sodding is the only way of assuring an adequate phosphorus supply in at least a major portion of the rooting zone.

Potassium

All potassium fertilizers readily dissolve in water, releasing the potassium as a positively charged ion that quickly distributes itself among three forms in soil. A small portion remains in solution, some may become strongly bonded on so-called potassium fixation sites on minerals, and the remainder is attracted to negatively charged cation exchange sites. It is the latter that constitutes the bulk of plant available potassium in soil.

Fixed potassium is not readily available to plants and soil fixation capacity must be satisfied before exchangeable potassium levels can be increased and plant needs for the nutrient satisfied. Soil potassium fixation capacities vary from essentially zero to several hundred pounds and depend upon the types and amounts of minerals present. As in the case with phosphorus, soil testing is the only efficient means for addressing how much fertilizer potassium is needed in a given soil to saturate potassium fixation sites and build exchangeable potassium to levels

appropriate for turfgrass.

Potassium is intermediate between nitrogen and phosphorus in terms of its mobility in soil. With repetitive surface applications, fertilizer potassium eventually moves downward in soil into the rooting zone of turfgrass. The rate of downward movement of potassium varies with the cation exchange capacity of soil, whether or not this exchange capacity resides primarily on mineral or organic colloids, and soil pH. High pH, sand-based golf greens are notorious for the rapid rate of potassium movement through them. On the other hand, movement in fine textured soils is slow and amendment with potassium to depth of several inches prior to the establishment of turfgrass is an important management practice.

Secondary Nutrients

Calcium, magnesium, and sulfur constitute this group of essential plant nutrients. Calcium and magnesium are of concern only when turgrasses are grown on sandy, low organic matter, low pH soils. Sulfur, on the contrary, can be limiting and impart poor color to turfgrass.

Sulfur resides in soil primarily in the organic fraction. Microbial decomposition of the organic matter releases sulfur in the form of the negatively charged sulfate ion. Sulfate, in a manner analogus to nitrate, is very mobile in soil and leaches easily. Natural inputs of sulfur continuously occur in the form of sulfates and sulfuric acid in rain and snow. The amounts involved vary widely, but are notably higher at locations downwind from urban or industrial centers. Additional sulfur comes as a minor or trace constituent of various fertilizers and pesticides.

Due to the multiple sources and highly variable quantities of sulfur that turf may receive during any given year, it is very difficult to predict when and where deficiencies may occur. The soil conditions typically associated with sulfur deficiency include sandy texture, low organic matter content, and isolation from urban or industrial centers.

Micronutrients

The essential micronutrients include iron, manganese, copper, zinc, boron, molybdenum, and

chlorine. Of these, only iron is of broad concern and this concern pertains mainly to high pH soils. Plant availability of iron is lowest in the pH range of approximately 7.2 to 8.5. In this pH range, iron deficiency is most likely to occur under one of two sets of circumstances. One instance is on soils with low organic matter content, low total iron content, and high aeration. These conditions promote formation of highly insoluble iron oxides. The second circumstance is poorly drained soils that contain calcium carbonate. Here the problem is accumulation of bicarbonate ions that interefere with plant uptake of iron.

Deficiencies in turfgrasses of manganese, copper, zinc, and boron are rare to non-existent in Wisconsin. Low soil content is a prerequisite for deficiency and must be in combination with soil conditions that minimize the plant availability of the small amounts present. Soil pH near neutrality and high organic matter content are two such soil conditions. Molybdenum and chlorine deficiencies have never been confirmed in turfgrass.