NUTRIENT MANAGEMENT FOR GROUNDS AND COMMERCIAL TURF

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Introduction

When one look's at the limiting factors in turfgrass growth and development, three factors are more important than fertility. First, there is light. Without adequate quantity and quality of light, nothing else matters. Second is temperature. If the light levels are adequate, yet the temperatures fall outside the optimum for turf, then growth and development cannot be sustained. In the past, turf managers had little control over these factors other than siting of turf areas or pruning of trees. With the use of fans becoming more popular for temperature modification by mechanically inducing air movement, this has changed. However, the main cultural practices of irrigation to supplement natural rainfall and fertilization to overcome nutrient deficiencies are more commonly recognized as part of the art and science of growing grass. Plant nutrition requires that sixteen essential elements be provided. The air and water supply carbon, hydrogen and oxygen. The soil usually supplies the rest which includes nitrogen, phosphorus, potassium, calcium, magnesium and sulfur as macronutrient. The micronutrients, whose tissue concentrations are at least 10 times less (less than 100 ppm) than the macronutrients include iron, manganese, zinc, copper, molybdenum, boron and chlorine.

Nutrient Uptake

Most water and nutrient absorption occurs through the root system. Some uptake can occur through the leaves although it is minimal. Many nutrients are tightly bound in the soil in unavailable forms. However, the root system of grasses is very efficient and effective in uptake. Any factor such as poor aeration from compacted soils which affects the root system can interfere with respiration and therefore nutrient absorption

Functions of Plant Nutrients

Nutrients function in the plant in a number of ways. They are constituents of living cells; catalysts in biochemical reactions; influence cell osmotic pressure; influence plant tissue pH;
influence membrane permeability and play other vital roles in plant metabolism and physiology.
Therefore, deficiencies which need to be corrected by fertilizer applications impact more than just the aesthetics of the plant.

Nitrogen

Nitrogen is the nutrient used most by turf managers. It controls growth and yet is also most potentially damaging to environment if wasted. Nitrogen affects shoot growth and color; root growth; disease susceptibility; stress tolerance; recuperative potential/rate; and turf composition.
Nitrogen availability is dependent on temperature; moisture; solubility; microorganism activity and nutrient movement. Within the shoot tissue, the nitrogen content is typically 3 to 6 % N as dry matter. Nitrogen is mobile within the plant so deficiency symptoms are seen in older portions of the leaf which is the upper parts of the leaf blade.

Increasing nitrogen within the optimum range required for turfgrasses results in a decrease in rhizome internode length; stolon internode length; Cell wall thickness; cell size; seedhead number and a decrease in incidence of certain diseases, particularly dollar spot, rust, and red thread. Some diseases are more prone to occur under high nitrogen levels, including brown patch, leaf spot, melting out, and Pythium blight.

Nitrogen uptake occurs primarily as nitrate (NO_3^-) although some is taken up as ammonium (NH_4^+). Roots absorb nitrogen very efficiently, in the range of 50 to 90 % for grasses compared to 30 to 50 % for other agronomic crops. Large quantities of nitrogen are stored in the soil. The organic N pool of a typical fertile soil may contain from 3,000 to 5,000 pounds N per acre in the top 6 inches. However, the inorganic N is much lower, perhaps 10 to 50 pounds per acre.
Nitrogen conversions are constantly occurring within the environment. Fixation of elemental nitrogen can

occur through microorganisms or chemical reactions such as the following:

$N_2 + 8\ H^+ + 6\ e^- \text{-->} 2\ NH_4^+$

Lightning can cause reactions such as this and formation of oxides up to 0.1 to 0.2 lb N/1000sq.ft./yr. Other nitrogen conversions are also taking place including the following:

Aminization: proteins --> microbes --> amino compounds, $C\text{-}NH_2$

$C\text{-}NH_2$ --> ammonification --> NH_4^+

NH_4^+ --> nitrification --> NO_2^-

NO_2^- --> oxidation --> NO_3^-

Additionally, volatilization can occur and nitrogen can be lost as a gas. This is affected by temperature, moisture, CEC, and pH. Urea-N volatilization can be 20 to 30% of the amount applied. Losses from other sources such as ammonium nitrate (3 to 10%), ammonium sulfate (36 to 45%) can also be very high. Volatility losses can be minimized by using slowly available carriers such as IBDU.

Volatilization is accentuated under certain soil conditions. If the soil pH is >7.0, there is an excess of OH- ions present and the following reaction can occur:

$NH_4^+ + OH^- > NH_3\ (gas) + H_2O$

Volatilization can also occur from applied fertilizers, particularly urea from the following reaction:

Urea

$$\overset{\displaystyle O}{\overset{\|}{H_2N\text{-}C\text{-}NH_2}}\ \xrightarrow[\text{water}]{\text{urease}}\ NH_3\ (\text{gas}),\ \text{or}\ NH_4^+$$

Hydrolysis raises the pH around the urea particle, which can result in pHs greater than 7.0, even though soil or thatch pH is less than 7.0

Volatilization can also occur due to denitrification - particularly under anaerobic soil conditions

$NO_3^- > NO_2^- > NO > N_2O > N_2$

Where does the nitrogen go? A nitrogen recovery study at Michigan found that they could account for from 76 to 109 % of what was applied as follows:

Clippings	Verdure	Thatch	Soil	Leachate	Total %
31	7	25	16	0.003	76
22	23	56	10	0	109

Dealing with nitrogen losses can be handled in several ways. One is through split applications. This keeps the amount of nitrogen free in the soil profile at any one time to a minimum. Another way is to use slowly available materials. Keeping thatch to a minimum is also a concern. Nitrogen loss can be up to 2.5 times greater from thatch than soil.

Nitrogen materials are identified as belonging to one of two broad categories.

Quickly available materials are highly soluble, readily available, short lived, have a high burn potential and relatively inexpensive. These include inorganic salts such as ammonium nitrate, ammonium sulfate, mono- and di- ammonium phosphates. These are easily dissociated when water is available and the nitrogen immediately available for turf uptake. Urea is also a quickly available source despite it being an organic molecule due to its chemical structure. It has a very high nitrogen content (45%) and is commonly used as a cheap nitrogen source.

Slowly available nitrogen carriers have low solubility, are available over a long time, longer lived, have a low burn potential and are relatively expensive.

Slowly available nitrogen sources are sub-divided into three groups:

Slowly soluble materials include

Methylene urea (MU) and

Ureaformaldehyde (UF) - these are manufactured by combining urea and formaldehyde. The resultant mixture has both quickly and slowly available materials, and under the proper controlled chemical conditions, the mixture has a high percentage of slowly available materials. The nitrogen released from the UF material is degraded by microorganims prior to making it available for turf uptake.

Isobutylidenediurea (IBDU) is manufactured by combining butyraldehyde and urea. The resultant material is a uniform chemistry which is dependent on hydrolysis for nitrogen release based on particle size for turf uptake.

Slow release materials are manufactured by coating urea with an impermeable coating such as sulfur or plastic. As the coating is broken down, or as water enters the particle, the nitrogen is released.

Natural organic fertilizers are composed of naturally occurring products such as manures, sewage sludges, feathermeal, soybean meal or other by-products. The nitrogen in these materials is released once microorganisms decompose them. Thus the nitrogen release is highly temperature dependent.

Many turf grade fertilizers combine a quickly and a slowly available nitrogen source in order to take advantage of the desirable characteristics of each.

Balanced nutrition for turf fertilization is critical. Match applications to meet growth demands - this is dependent on season and temperatures. Timing to meeting peak growth flushes when optimum air temperature ranges for shoot growth: cool-season grasses 60 to 75 F; optimum soil temperature ranges for root growth: cool-season grasses 50 to 65 F.

The approach to designing nitrogen programs for cool season grasses has changed over the years. Most specialists suggest that for cool-season grasses: Fall fertilization - 2/3 of total N for the year in the fall and for Spring fertilization - avoid excess N, especially in late spring. At that time, stimulate color, not growth. Iron could be used to do this. For Summer fertilization - 3 possible strategies for N: 1) apply small amounts (0.125 to 0.25 lbs./1000 sq.ft. of N) from a quick release source during the summer when necessary; 2) apply a slow-release fertilizer (1 to 2 lbs N/1000 sq.ft.) early in the summer; or 3) moderately apply a slow-release source at the beginning of the summer, then supplement with quick release as needed. Use foliar applications of Fe to improve color without stimulating excessive growth. Applications of 1 to 2 lbs of actual iron per acre.

Potassium is known to have an influence root growth and stress tolerance. Much has been debated about the ratio of nitrogen to potassium with some agronomists suggesting excessively high potassium rates in order to induce stress tolerance. A summary of the research results finds that potassium fertilization produced positive results on a sandy soil in terms of top and root growth and a higher visual quality. However, it appeared that an N:K fertilization ratio of 1:1 appears optimum. Proper selection of soluble and/or controlled release K sources cuts leaching losses and provides the longevity of the response desired.