NITROGEN SOURCES FOR TURF FERTILIZATION

NITROGEN: THE 'TNT' OF TURF FERTILIZATION PROGRAMS

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Turfgrass growth is dependent on maintaining an adequate supply of all essential plant nutrients as well as properly managing a multiplicity of other cultural and edaphic factors. There are at least sixteen elements considered necessary for plant growth and development. Nitrogen is the essential element that receives the most attention in turfgrass fertilization programs. Nitrogen is the element to which turfgrass is most responsive. The nitrogen content of the turfgrass plant is usually higher than any other essential element (i.e. 3-6 percent on a dry weight basis). Nitrogen is a very dynamic element in the soil system. The concentration of soil nitrogen is in a constant state of change. Nitrogen depletion in soils may result from leaching, clipping removal, volatilization, denitrification, immobilization, or nitrogen fixation in the lattice structure of certain clays. Thus, nitrogen must be added to turfgrass sites on a routine basis in order to maintain a sufficient soil level for turfgrass growth.

Generally, nitrogen additions to the turfgrass system from clipping return, decomposition of organic matter, topdressing, nitrogen fixation, and rainfall are not sufficient to supply the needs of high quality turf. The main source of nitrogen is added by the application of nitrogenous fertilizers. Nitrogen fertilizer is initially added to the turfgrass system as ammonium (NH_4^+) and/or nitrate (NO_3^-) or some nitrogen carrier that eventually breaks down to ammonium. The turfgrass plant absorbs nitrogen from the soil as either ammonium or nitrate. Nitrate is the predominant form absorbed by the plant since ammonium is rapidly converted to nitrate by soil bacteria. This biological oxidation of ammonium to nitrate is called nitrification. Nitrification is a two-step process in which the ammonium is converted to nitrate (NO_2^-) by Nitrosomonas bacteria and then to nitrate by Nitrobacter bacteria. The process is temperature dependent and increases with soil temperatures from 32°F. to an optimum range of 85-95°F.

Once absorbed into the plant, nitrate can be stored in the cell, or reduced back to the ammonium form. The storage of free nitrate within the plant cells results in a luxary consumption of nitrate (absorption of more than is used). This is likely an inefficient use of nitrogen, especially if clippings are removed. Nitrate must be converted to the ammonium form before it can be further utilized by the plant. The reduction process (NO_3^- to NH_4^+) within the plant requires at least two enzymes (compounds that assist in the reaction). Nitrate reductase is the enzyme involved in the conversion of nitrate to nitrite. Nitrite reductase is the enzyme involved in the conversion of nitrite to ammonium. In grasses, the reduction process predominantly occurs in the shoot or foliar portion of the plant, although some reduction may occur in the roots. The ammonium ion is then readily combined into various complex organic (carbon) compounds within the plant. Chlorophyll, amino acids, proteins, enzymes and vitamins are among some of the organic compounds containing nitrogen. Photosynthesis provides the source of carbohydrates or organic skeletons for the nitrogen assimilation processes.

Carbohydrates produced by photosynthesis are the necessary precursors for the formation of nitrogen-containing amino acids and proteins which are utilized in growth processes. The more turfgrass growth, the greater is the demand for carbohydrate. Carbohydrate is also the key source of energy for maintaining all the various growth and physiological processes within the plant. Carbodydrates are broken down into carbon dioxide and water through a process called respiration, and energy is released. Respiration therefore is a "carbohydrate-utilizing" process. When the rate of photosynthesis exceeds the rate of respiration and the requirement for growth, carbohydrates accumulate as reserves. Carbohydrate reserves are usually stored in the crowns, rhizomes and stolons of cool-season grasses. Carbohydrate reserves are desirable since they serve as an immediate source of energy and carbon skeletons for regrowth and recovery from defoliation or stresses that may injure or thin the turf. A "carbohydrate deficit" may develop when respiration rates are high and/or growth is rapid. Usually any factor that stimulates rapid topgrowth will deplete or drain carbohydrate reserves. The turfgrass manager should manipulate cultural practices so as to maintain an adequate level of carbohydrates within the plant for normal as well as unusual energy and growth demands. In essence, the carbohydrate status of the plant reflects the energy status of the plant.

Nitrogen fertilization has a definite effect on the carbohydrate status of turfgrasses. Nitrogen applications favor turfgrass growth. As nitrogen rates are increased, usually more topgrowth is produced. More topgrowth results in the use of more carbohydrate. Physiologically, under rapid growth conditions shoots take priority over roots and rhizomes for available carbohydrate. Shoot growth will usually continue to respond to higher nitrogen levels causing a distinct suppression in root growth and other growth processes.

These effects are well illustrated from a fertilization study evaluating the response of a Merion Kentucky bluegrass sod to incremental rates of nitrogen (Table 1) (3). Higher nitrogen rates resulted in an increase in clipping yield (topgrowth) and nitrogen content of clippings. In contrast, sod strength (a reflection of root and rhizome growth) and rhizome weight decreased at the higher nitrogen levels. Thus, when most of the plant's carbohydrate was directed toward producing shoot growth, root growth and other plant growth processes suffered accordingly. Agronomists well recognize that a plant is no better than the root system that supports it.

Research has shown that a considerable amount of root initiation and root growth of cool-season grasses occurs in the spring (2). Liberal nitrogen fertilization in the spring will have a tendency to restrict root growth. The turfgrass plant will go into the summer with a shorter root system than where moderate rates of nitrogen fertilizer are used. Furthermore, high amounts of nitrogen will increase topgrowth and increase the need for more frequent mowing in the spring. The rapid topgrowth may result in the removal of large amounts of clippings at each mowing. The removal of excess foliage (i.e. more than a third of the foliage at any one mowing) is known to retard both tiller and root development. Thus, mismanagement of nitrogen during the spring can have a dramatic effect on the root system under the turfgrass going into the summer.

Liberal nitrogen fertilization also causes a lush, succulent plant growth that is characterized by decreased cell wall and cuticle thickness, increased cell size, and an increased level of plant tissue hydration. The thinner plant cell walls are most like the result of more rapid plant growth and the production of condition increases the severity of plant disease and lowers the hardiness of the plant to heat, cold, and drought. Lush, succulent tissue also contains high concentrations of nitrogen-rich storage compounds. The nitrogen-rich compounds accumulate in guttation fluid (leaf exudates). The guttation fluid serves as an ideal medium for the enhancement of many turfgrass diseases. Thus, mismanagement of nitrogen in the spring can take the plant into the summer in a soft growth condition in which it is more vulnerable to disease, heat, and drought.

Liberal nitrogen fertilization is known to increase the severity of Pythium, brown patch, Fusarium blight, stripe smut, snow mold, and Helminthosporium (leafspot) diseases (5). Leafspot, a serious disease of both Kentucky bluegrass and bentgrass in the midwest, is much more serious at high nitrogen levels, especially in the spring. Kentucky bluegrass varieties like Park, Kenblue, and Delta are very susceptible to leafspot. Many lawns and older turfgrass areas have been established to these common-type Kentucky bluegrass varieties. Research at the University of Illinois (4) has shown the incidence of Fusarium blight in the summer to be greater with increasing nitrogen application rates in the spring. Nugget, Merion, Fylking, and Pennstar were highly susceptible to the disease when more than a total of two pounds of soluble nitrogen per 1,000 ft. was applied in the spring. Kenblue was affected by the disease at all the fertility levels. This information lends support to moderate levels of nitrogen fertilizer in the spring. It more specifically suggests a critical limit of no more than two pounds of total soluble nitrogen in the spring.

Liberal nitrogen fertilization is also critical during the summer (1). As seasonal temperatures increase, photosynthesis of cool-season grasses decreases and respiration increases. As mentioned earlier, carbohydrates are consumed during respiration. Respiration is known to increase with increasing nitrogen fertility levels. Thus, during periods of high temperature, liberal nitrogen fertilization may reduce carbohydrate reserves due to rapid growth and high respiration. Additional stress may result from lower photosynthetic rates. Because carbohydrates are produced at a slow rate and respiration is high during the summer, nitrogen should be applied at low rates for cool-season grasses.

Nitrogen is a necessary component of turfgrass fertilization programs. High quality turf exhibiting acceptable green color and density requires periodic application of nitrogen. Nitrogen however, is frequently referred to as the "TNT" of turfgrass fertilization programs. It can be just as detrimental as beneficial, if mismanaged. Proper timing and rate of application are important in successful long-term programs. Always remember! Greener is not always better. A happy medium must be met between agronomics and aesthetics.

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Table 1. Nitrogen treatment effects on a Merion Kentucky bluegrass sod (3).

Nitrogen Rate	Annual Clipping Yield (dry wt.)	Nitrogen Content in Clippings	Sod Strength	Rhizomes
lb/A/month	lb/A	%	lb to tear	grams
0	463	3.0	146	99
15	1807	3.3	188	89
30	2555	3.6	130	120
60	5676	4.5	97	43
120	8447	5.4	67	14

Literature Cited

1. Beard, J. B. 1973. Turfgrass: Science and Culture. Prentice-Hall, Inc., Englewood Cliffs, N.J. 658 pp.
2. Beard, J. B. and W. H. Daniel. 1966. Relationship of Creeping Bentgrass (*Agrostis palustris* Huds.) Root Growth to Environmental Factors in the Field. AgronomyJournal 58:337-339.
3. Rieke, P.E. 1975. Turfgrass Fertilization — Nitrogen. 16th Illinois Turfgrass Conference Proceedings. 81-85.
4. Turgeon, A. J., and W. A. Meyer. 1974. Effects of Mowing and Fertilization Level on Disease Incidence in Five Kentucky Bluegrasses. Plant Disease Reporter 58:514-516.
5. Vargas, J. M. 1975. Turfgrass Disease — Nitrogen Relationships. 16th Illinois Turfgrass Conference Proceedings. 90-02.