# Nitrogen Sources For Turf Fertilization

Turfgrass managers have many alternatives when it comes to choosing a source of nitrogen for turfgrass fertilization. For many years, only soluble sources and natural organic materials were available for nitrogen fertilization, according to Donald V. Waddington, associate professor of soil science at Pennsylvania State University.

"Ureaform became commercially available in 1955 and soon found a place in many turfgrass fertilization programs," Waddington told WEEDS TREES & TURF. "The choice of slow-release nitrogen sources was limited to natural organics and ureaform until recently when IBDU, plastic-coated fertilizer and sulfur-coated urea became commercially available."

He said the choice of a nitrogen source is not limited to these materials alone. Also to be considered are the combinations available in many mixed fertilizers, which may differ widely in the source and amount of slowly available nitrogen. Good turfgrass can be produced and maintained using any of these materials, provided they are used properly. Proper use must meet the needs of the turfgrass and should be based on the properties of the material and the factors that affect the release and availability of nitrogen from the material.

**Classification.** Nitrogen sources can be divided into two major groups, Waddington said. The two groups are quickly available sources and slowly available sources. Quickly available sources may also be called readily available, quick-release, quick-acting, soluble or other terms that indicate rapid availability of nitrogen after application. Quickly available sources include urea, a synthetic organic, and inorganic salts containing ammonium or nitrate.

Slowly available sources, which are also called slow-release, controlled-release, slow-acting and insoluble, can be further classified according to the method by which the rate of release is controlled: (1) microbial decomposition releases nitrogen from natural organics and ureaform; (2) low solubility limits dissolution and hydrolysis, which are necessary for nitrogen release from IBDU; and (3) coatings act as physical barriers, which delay dissolution of soluble nitrogen sources used in sulfur-coated area urea and plastic-coated fertilizers.

**Quickly available sources.** Waddington said quickly available sources have relatively high nitrogen contents and are the least expensive forms of fertilizer nitrogen. Being water-soluble, they may be applied in solution as well as in dry form. The soluble sources have high salt indexes, thus a high potential for fertilizer burn.

"The general rule of applying no more than one pound of soluble nitrogen per 1,000 square feet in one application should be followed," he said. "On dense, close-cut turf, such as that on putting greens, one-half pound is a more reasonable limit. Because solubles are subject to leaching and because turf takes up more nitrogen than needed if given the chance, frequent applications also contribute to more efficient utilization of nitrogen. The soluble sources are hygroscopic, attracting moisture from the air, and may cake up in storage, particularly in damp areas and in unsealed bags or containers."

**Inorganic salts.** Examples of inorganic salts include ammonium phosphates, ammonium nitrate, ammonium sulfate, calcium nitrate, sodium nitrate and potassium nitrate. These salts readily dissolve in water and dissociate into their cation and anion components: e.g., ammonium nitrate ($NH_2NO_3$) dissociates into ammonium ions ($NH_4$+) and nitrate ions ($NO_3$—). In a process called nitrification, $NH_4$+ is oxidized by bacterial activity to form $NO_3$—. Plants may utilize nitrogen in either the nitrate or ammonium form, but most is taken up as nitrate. Nitrates are readily leached, but ammonium is less susceptible to leaching because it can be adsorbed by soil colloids (clay and humus).

**Urea.** Urea is manufactured by reacting ammonia and carbon dioxide at greatly elevated pressure and temperature, according to Waddington. Urea is water-soluble, and is quickly hydrolyzed in the presence of the enzyme ureas to form ammonium nitrogen. More than 60 percent of the urea can be expected to be hydrolyzed in one day, and hydrolysis should be complete in seven to 10 days. Under alkaline conditions nitrogen may be lost as ammonia from urea or ammonium compounds. This process, called volatilization, is also favored by low soil cation exchange capacity, dry soils and high temperatures.

**Slowly available sources.** Slowly available sources provide a longer duration of nitrogen release than the quickly available sources, he said. They are safe from the standpoint of burn, and may be applied at higher rates and with less frequency than the solubles. The efficiency of slow-release materials is often low in the first year or two of use. They are more expensive than the solubles.

"We have evaluated many slow-release sources at Penn State and

**Nitrogen** *(continued)*

none have produced high quality turf throughout the growing season with only one application," he said. "Some treatments have come close and perhaps would be acceptable to some of the less-demanding users. However, it seems that at least two applications, some times more, should be used to give more efficient utilization of applied nitrogen as well as good season-long color without periods of excessive growth."

**Natural organics.** For the most part, these materials are by-products from the plant and animal processing industries or waste products, he said. Considerable variation exists in the properties of different materials, and even within a given material. The natural organics can be characterized by relatively low nitrogen content, the presence of water-insoluble nitrogen and nitrogen release intermediate between that of soluble nitrogen sources and ureaform. Examples include hoof and horn meal, fish scrap and meal, seed meals, dried manures, and the two types most commonly associated with turf fertilization — activated sewage sludge and process tankage.

According to Waddington, release of nitrogen is dependent on microbial activity. Factors influencing release are the chemical composition of the material and environmental conditions that influence microbial activity. Protein sources of nitrogen are relatively easily decomposed. Leather, feathers, hair, hoof and horn contain resistant compounds and are usually treated with steam, and some times acid, to hydrolyze the resistant forms of nitrogen. Environmental conditions influencing breakdown of natural organics include temperature, moisture and oxygen, soil pH, and available minerals.

The said guidelines for use are as follows: on lawns, athletic fields, fairways and similar areas, use three applications per season — summer, winter, fall — one to two pounds of nitrogen per thousand square feet per application depending on species and use of area. Cut back on the summer application to cool-season grasses in warmer climates and omit summer application on non-irrigated, dormant turf. On putting greens use monthly applications of one to 1 ½ pounds per thousand square feet or apply ½ pound per thousand square feet every two to three weeks. "The latter timing doesn't offer a labor savings over the use of solubles. When turfgrass response to a normal application has been delayed due to cool or dry conditions, do not apply more natural organics," Waddington said, "because when the limiting condition ends, both applications may release excessive amounts of nitrogen. Use a light application of a soluble fertilizer to get response during the limiting period, rather than loading up the area with more slow-release. This advice applies to the use of other slow-release fertilizers."

**Ureaform.** Ureaform is made by reacting urea with formaldehyde. Ureaform is not a single compound, but is composed primarily of a mixture of straight chain polymers. Ureaform contains 38 percent nitrogen and about 70 percent of this nitrogen is water-insoluble. Ureaform can be divided into three, almost equal fractions based on solubility.

He said fraction I is soluble in cold water and contains unreacted urea and the short-chain methylene ureas — methylene diurea and dimethylene triurea. Availability of nitrogen in this fraction is similar to that of soluble sources, but it is not as quickly available. Fraction II is made up slow-release, intermediate-length polymers — trimethylene tetraurea and tetramethylene pentaurea. It is insoluble in cold water, but soluble in hot water. Fraction III is insoluble in both hot and cold water and is made up of pentamethylene hexaurea and longer-chain polymers. It is the most resistant fraction. In a 1967 study by G. C. Kaempffe and O. R. Lunt, the breakdown of these fractions was studied over a period of 26 weeks. After this time period, four percent of fraction I, 25 percent of fraction II and 84 percent of fraction III remained in the soil. The slow decomposition of fractions II and III accounts for the low efficiency of ureaform in the initial years of use. With continued use and build-up of ureaform, recovery of applied nitrogen improves.

"Release of nitrogen from ureaform is dependent on microbial activity and the same environmental factors that affect release from natural organics also affect release from ureaform," Waddington said.

He said ureaform is sold as "Uramite" by DuPont and a "Nitroform" by Hercules. It is available in granular form and in a powdered form suitable for spraying. "At Penn State we have not measured significant differences in response to the two particle sizes," he said. "Two applications a year in spring and fall give good results. It is usually necessary to supplement with solubles or use higher than normal rates in first years of use. If necessary, supplement with ¼ to ½ pound nitrogen per thousand square feet from solubles during periods of low release."

**IBDU.** Isobutylidene diurea is made by reacting isobutyraldehyde and urea. It is produced by Mitsubishi Chemical Industries in Japan, and is distributed in the United States by Swift Agricultural Chemicals. It contains 31 percent nitrogen, of which 90 percent is water-insoluble. Release is slow due to low solubility; but once in solution, IBDU is hydrolyzed and releases available nitrogen. Particle size has a large effect on release of nitrogen, with smaller particles releasing more quickly. Release also increases with increased soil water content. Release is also affected to some degree by temperature and pH. Hydrolysis is faster under acidic conditions. The rate of release also increases with temperature, but low temperature does not affect IBDU as much as it does those sources dependent on microbial activity for release.

"Our work with IBDU was started in 1966," Waddington said. "We have observed a three- to four-week delay before obtaining response from IBDU applications on Kentucky bluegrass, but not after applications to an aerified and topdressed green. Probably the close contact with wet soil and more liberal irrigation practices enhanced release on the putting green." If the delay in response is considered objectionable, he said, a soluble nitrogen source can be used to supplement the IBDU.

"We have observed early spring

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**SOD** *(from page 26)*

dry soil was watered to wet the soil under the sod immediately after installation (1). Obviously, waiting 11 days for sod to root in the middle of summer may be the difference between success and failure.

Properly harvested sod should contain approximately ¾ inch of soil. Standard size sections of sod should be strong enough to support their own weight if picked up by any end. Quality sod should not be harvested during periods when moisture content (excessively dry or wet) may adversely affect its survival. Sod should be harvested, delivered and installed within a period of 36 hours.

As noted earlier, during periods of high temperature, it is beneficial to lightly irrigate the soil immediately prior to laying the sod to cool and moisten the soil. The sod should not be stretched or overlapped and joints should be closely butted together. On sloping areas where erosion may be a problem sod should be laid with staggered joints, rolled and secured by pegging. All sod should be rolled and watered immediately after installation to prevent drying and remove air pockets. This irrigation should thoroughly wet the sod and the soil under the sod.

The sod should receive water daily until adequate root systems are developed to support the grass plants. The first mowing should not occur until the sod is firmly rooted and secure in place. Not more than 1/3 of the grass blade should be removed by the initial or subsequent cuttings.

After the sod has successfully rooted and established itself, it should be placed on a rational fertilization program corresponding to most university and industry recommendations.

Following these simple but essential steps for proper sod installation will considerably decrease sodding failures. □

*Reference 1) King, J. W. and J. B. Beard. 1972. Agronomy Journal 64 (3):259-262*



**NITROGEN** *(from page 24)*

greening with IBDU and nitrogen recovery from IBDU exceeded that from ureaform during the initial years of use," he said. "Two applications in spring and fall have given good results on both bentgrass and bluegrass. On bluegrass we found no advantage to three applications. A single spring application had a longer residual effect than a single fall application."

**Plastic-coated fertilizer.** Sierra Chemical Co. uses the "Osmocote" process to produce plastic-coated fertilizers, he said. In this process, plastic coatings, also called resin or polymeric coatings, are applied to soluble sources of nitrogen, phosphorus and potassium. For release to occur, water passes through the coating and dissolves the fertilizer salt. This causes pressure which swells the capsule, and the dissolved salts diffuse out through enlarged pores in the coating.

Different coating thicknesses are used to obtain different release patterns, he said. The thicker the coating, the slower the release. Release increases with increased temperature. If coatings are ruptured or cracked by mechanical damage or due to prolonged, excessive drying, release rate increases. The release rate is not significantly influenced by soil moisture levels, volume of water applied, soil pH, or microbial activity.

"The number of applications required is dependent on the formulation," Waddington said. "We used a six-month formulation on a putting green and performance fell short of six months. At lower temperatures the same formulation would be expected to last longer. We applied the fertilizer after aerification on the green to minimize mower damage to particles. After a single application of six pounds nitrogen per thousand square feet on fairway bentgrass, we observed turf damage when coated sources were damaged by tractor and mower traffic."

**Sulfur-coated urea.** Sulfur-coated urea is made by spraying preheated urea granules with molten sulfur. Sometimes a wax coating is then applied to seal pores in the sulfur coating. In some experimental formulations using wax, a microbicide was used to slow microbial decomposition of the wax. Nitrogen is released from sulfur coated urea by degradation of the coating and/or diffusion of soluble nitrogen through pores in the coating.

"Release rate is affected by coating thickness and temperature," he said. "The formation of ferrous sulfide on sulfur-coated urea under water-logged conditions also slows release of nitrogen. As with plastic-coated materials, breakage of the coating increases release."

He said the seven-day dissolution rate in water is commonly used to characterize different formulations of sulfur-coated urea. The Tennessee Valley Authority has done considerable development and agronomic work with sulfur-coated urea. Imperial Chemical Industries, Ltd., of England is commercially producing sulfur-coated urea under the trade name of "Gold-N". It contains 32 percent nitrogen, and was available in the United States during 1974. "We have had very good results with this and some TVA experimental formulations in our research," he said. "Some of the heavily coated materials did not give very good performance in the first year of use. However, other researchers have shown that these types release in later seasons." □