Are you getting the most from your granular nitrogen fertilizers?

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NITROGEN (N) is the essential mineral nutrient required in greatest amounts by turfgrasses. Although more than 78% of the air we breathe is N2, turfgrasses are unable to capture it from the atmosphere so many researchers, chemists and fertilizer manufacturers spend considerable time and effort every year developing granular N-containing fertilizers for turf.

Some of these are homogenous, with granules having an equal amount of nutrition. Others are blends of several nutrient sources or carriers. Depending on how it is formulated, a fertilizer may release N very quickly or for an extended period of time. Since energy is required to convert atmospheric N to ammonium and nitrate, the forms that turfgrasses use, the cost of fertilizers increases as energy and fuel costs rise.

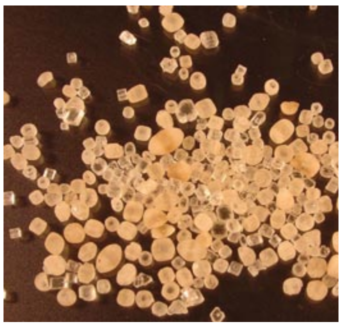
Knowing how much N a turfgrass requires, how long N is available after a fertilizer is applied, the factors that affect how N is released and the physical properties of a fertilizer helps sports turf managers make informed decisions when purchasing and applying granular fertilizers.

The N requirement of cool- and warm-season turfgrasses varies among species. Bermudagrass and Kentucky bluegrass usually need more N per growing month than tall fescue and perennial ryegrass. For example, bermudagrass and Kentucky bluegrass usually require from 0.5 to 1.5 lb. of N per 1,000 sq. ft. per growing month, and tall fescue and perennial ryegrass, from 0.4 to 1 lb. of N per 1,000 sq. ft. per growing month. This information is helpful when developing a fertilization program and budget.

The chemical properties of the N carrier(s) in a fertilizer influence how, and the rate at which, N is released. Physical properties such as the size and uniformity of granules influence the ballistic properties, and may also affect N release. If the granules contain an herbicide, their size and uniformity may directly influence herbicide coverage and performance.

CHEMICAL PROPERTIES

Highly Water-soluble N Carriers. There are two groups of highly water-soluble N carriers. Inorganic (containing no carbon) salts are synthetic, dry and solid materials formed as N from the air reacts with other materials. Urea, unlike the inorganic salts, is a quickly available, synthetic-organic (containing carbon) N carrier. It is made by reacting carbon dioxide with anhydrous ammonia under high pressure (e.g., 3000 psi) and temperature (~350 degrees F). Water is removed during this process and a molten N-containing substance is converted into small, hollow prills (Figure 2) or solid granules.

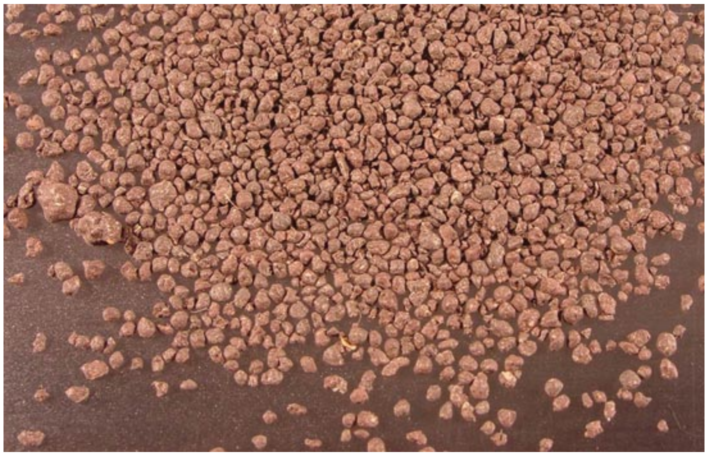


>> **Figure 2.** UREA Prills. **Figure 3.** Granular Ammonium Sulfate. **Figure 4.** Monoammonium Phosphate.

Inorganic salts like ammonium sulfate (Figure 3), calcium nitrate, diammonium phosphate (DAP), monoammonium phosphate (MAP, Figure 4) and potassium nitrate have several characteristics in common. In addition to being very soluble in water, N carriers in this group produce an initial rapid-growth response, even at low temperatures; have the potential to burn turf; have a growth response limited to about 4-6 weeks; are prone to leaching in the nitrate form; and are usually less expensive than more highly processed, extended-release N carriers. To avoid fertilizer burn, these N carriers should be applied to dry turf when the air temperature is less than 80 degrees Fahrenheit and at a relatively low rate (for example, no more than 1 lb. of N per 1,000 sq. ft.).

Due to its strong acidifying properties, ammonium sulfate is commonly applied to turfgrasses growing in soils with an excessively high pH (for example, >7.2). The burn potential of ammonium sulfate is greater than that of the other synthetic-inorganic N carriers. Monoammonium phosphate supplies plants with both N and phosphorus (P). Granular MAP contains about 11% N and 52% phosphate. Like MAP, DAP contains both N (about 18%) and phosphate (about 46%). An application of MAP creates an acidic zone around each granule, while the zone around granules of DAP is basic. Potassium nitrate contains about 13% N and about 36% K. The entire amount of N in potassium nitrate is in NO3- form.

Urea was discovered by a French scientist in 1773 and was first



>> **Figure 5.** Activated Sewage Sludge / Milorganite.™

>> **Figure 6.** Urea Formaldehyde.

produced from two inorganic materials, silver cyanate and ammonium chloride, by a German chemist in 1828. Today, urea is used worldwide to fertilize agronomic and horticultural crops, ornamental plants and turf. The N in urea must be converted to NH4+ before being absorbed from the soil by turfgrasses. When broadcast over turf, molecules of urea are converted to ammonium carbonate by hydrolysis (reaction with water). The enzyme urease, which is found in turfs, speeds this conversion and leads to the formation of NH4+and the release of CO2. More than 60% of the total amount of applied urea may be hydrolyzed in 24 hours. Urea is usually completely hydrolyzed within 7 days after a turf is fertilized.

When the soil is warm, moist and slightly acidic (for example, pH between 6.0 and 6.9), soil microorganisms convert NH4+ to NO3- within a few days. Conversely, once inside a turfgrass plant, NO3- is converted back to NH4+, a process requiring energy.

Extended-release N Carriers. Several carriers release N slowly compared to highly water-soluble carriers. These include natural organics with N bound in organic compounds; synthetic organics with urea in short-, medium- or long-chain compounds; sulfur-coated urea (SCU); polymer-coated urea (PCU); polymer-coated, sulfur-coated urea (PCSCU); and carriers with a reactive layer coating (RLC).

Natural organics are categorized as water-insoluble N, or WIN carriers. A natural organic fertilizer may originate from plants or animals. Nutrient concentrations are often low (for example, Milorganite with a grade of 6-2-0 + 4% Iron). About 70 to 85% of the N in natural organics, such as activated sewage sludge (Figure 5), bone meal, composted turkey litter, feather meal, leather meal, soybean protein and spent mushroom compost are in WIN form. The rate of N release from natural organics is influenced by soil moisture, temperature and the activity of soil microorganisms. The rate of release of N from natural organics becomes very slow at soil temperatures below 55 degrees Fahrenheit. Natural organics have a very low burn potential and may release N for 12 months or longer.

Isobutylidene diurea (IBDU) and urea formaldehyde (UF, Figure 6) are examples of synthetically produced, extended-release organic N carriers. Presently, synthetic-organic N carriers receive greater use in sports turf management than natural organics. Because IBDU and UF are produced by reacting urea with other compounds, they are sometimes referred to as reacted products.

Isobutylidene diurea contains 31% N with more than 80% N in slow-release, water-insoluble form. There are no coatings for water or nutrients to pass through. The rate of release of N from IBDU is influenced by soil moisture and particle size, and does not depend on the activity of soil microorganisms. Since the release of N is minimally dependent on soil temperature, sports turf managers may apply IBDU in late summer or early autumn to provide cool-season turfgrasses with N during September, October and November. The release of N from IBDU may last for 12 or more months.

Urea formaldehydes, or ureaforms, are produced by reacting urea with formaldehyde under controlled conditions. The longer these two chemicals are allowed to react, the longer the urea-containing molecule. The longer the molecule, the more C and N it contains, the longer it takes for N to release and the lower the possibility of fertilizer burn.

Theoretically, all of the granular fertilizers formed by reacting urea with formaldehyde are methylene ureas (MUs). However, the fertilizer industry recognizes three distinct groups or classes in a UF fertilizer. The classes MUs, MDU/DMTUs and ureaforms are based on the length of urea chains. Ureaforms have the longest urea chains, MUs are intermediate in length (primarily four- and five-urea chains), and MDU/DMTUs are shorter, having two- and three-urea chains. The release of N from these carriers is affected by moisture, which releases N from non-reacted urea and some of the shorter-chain compounds, and microbial activity, which influences the release of N from longer urea chains.

The ratio of urea to formaldehyde and the activity index are helpful when predicting how N will release from one of these carriers. For example, a fertilizer with a 1.3:1 U:F ratio has about 67% slowly soluble N and 33% cold-water-soluble (77 degrees F) N (CWSN). The CWSN fraction contains non-reacted urea and low-molecular-weight, short-urea-chain compounds. The cold-water insoluble (CWIN) portion of UF is not soluble in cold water.

Hot-water-soluble N (HWSN) is released slowly for a period of weeks. Hot-water-insoluble N (HWIN) is very slowly soluble, so slowly soluble that it may not be available to turfgrasses. The Activity Index, or A.I., is the fraction of CWIN that goes into solution in hot (212 degrees F) water. The higher the A.I. value, the more rapidly N becomes available.

Urea formaldehyde should have an A.I. of at least 40%. Granular UF fertilizers contain at least 35% N with 60% or more N in cold-water-insoluble (CWIN) form. Granular MU fertilizers contain 39 to 40% N with 25 to 60% in CWIN form. Granular MDU/DMTU fertilizers are at least 40% N with less than 25% in CWIN form. Two or more fertilizers containing ureaform, MU and DMU/TMDU can be compared based on their CWSN, HWSN and HWIN contents.

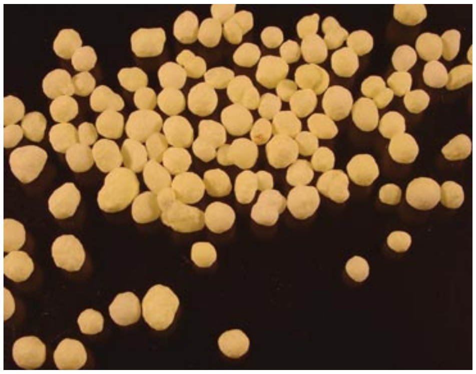
Urea can be coated to reduce its burn potential, and delay N release. Sulfur-coated urea is formed when granular urea is coated with molten sulfur. The Tennessee Valley Authority (TVA) began developing sulfur-coating technology in the 1960s. Pilot SCU manufacturing plants were constructed by TVA in the 1960s and 70s. Several plants were then built in the United States and Canada from 1975 to 1985. Sulfur-coated urea contains from 30-40% N and 10-30% sulfur.

The rate of release of N from SCU is influenced by temperature, soil moisture, coating thickness and the number of granules with broken coatings. If wax has been used to seal the sulfur coating, soil microorganisms also influence N release. The wax coating is degraded by soil microorganisms before N is released. The release of N among fertilizers containing SCU is often highly variable and may last from several days to months. Sulfur-coated urea may cause mottling if the coating is cracked during transport, handling or as the fertilizer is applied. If the sulfur coating is cracked, N releases too rapidly, a condition known as "burst."

>> **Figure 8.** Polymer-coated Urea.

A soil pH range of 6.0 to 7.0 usually favors microbial activity and N release from natural organics, UF and SCU with a wax coating. Since populations of many species of beneficial microorganisms are reduced at low pH, the release of N from these carriers may be delayed in strongly acid soils.

Polymer-coated fertilizer technologies vary among manufacturers. Several materials are used as polymer coatings including polyurethane, polyethylene and alkyd-resin. Depending on polymer chemistry and coating width, temperature and soil moisture level, the release of N from PCU (Figure 8) often lasts from one to two or more months. Unlike SCU which releases N through small, pin-hole-like micropores in the sulfur coating, the N in PCU releases by diffusion through the polymer coating as it swells. Nitrogen release is delayed until water penetrates the polymer coating and begins dissolving the N-rich granule inside. Nitrogen then diffuses out through the expanded polymer coating and is available for uptake by turfgrasses.



>> **Figure 9.** Polymer-coated, Sulfur-coated Urea.

Polymer-coated, sulfur-coated urea (Figure 9) combines both polymer- and sulfur-coating technologies. Sulfur is usually applied to urea before the polymer. The sulfur coating of PCSCU is most often thinner than that of SCU. Similarly, the polymer coating of PCSCU is usually thinner than that of PCU. As a result, PCSCU is often less expensive than PCU and the coating weighs less than that of SCU. The release of N from PCSCU depends on both diffusion and capillary action. For example, Water first diffuses through the polymer layer. Then, as it encounters the polymer-sulfur interface, water penetrates the micropores in the sulfur coating by way of capillary action. Once inside, the urea granule begins dissolving and N makes its way through both coatings.

Reactive Layer Coating, or RLC, is a fairly new technology that creates a very, very thin polymer coating as two reactive compounds are applied simultaneously to fertilizer granules in a "continuous coating" drum. Several N carriers including ammonium sulfate, MAP, potassium nitrate and urea are available with RLCs. The RLC encapsulating a urea granule may weigh as little as 1% of the total weight of the coated urea granule. This process often costs less than several other coating processes and, like PCUs, and PCSCUs, the release of N from RLCs is influenced by temperature and soil moisture.

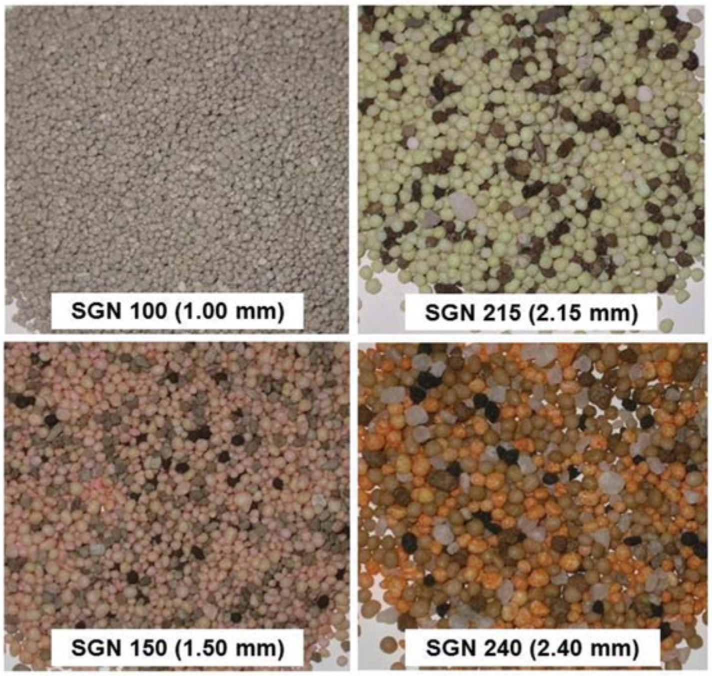
PHYSICAL PROPERTIES

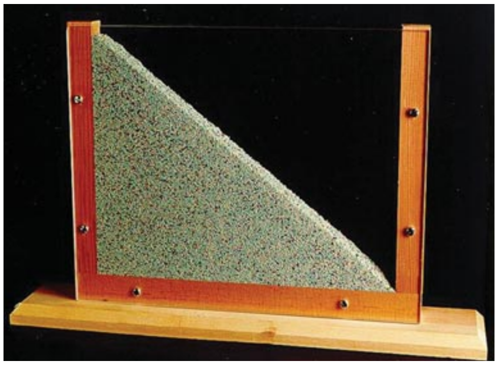
In addition to the chemical properties of N carriers, the size and uniformity of granules deserve consideration when comparing turf fertilizers.

Size Guide Number. The size guide number, or SGN, is a measure of fertilizer quality developed by the Canadian Fertilizer Institute. It represents the average or median particle size diameter in millimeters multiplied by 100. To calculate SGN, the sieve opening (in millimeters) that retains or passes 50% of the weight of a fertilizer sample is determined and is then multiplied by 100. Turf fertilizers often have SGNs ranging from 80 to 280 (Figure 10). Greens fertilizers have a low SGN (for example, 80 or 90) compared to fertilizers formulated for turfs maintained at greater cutting heights with SGNs often ranging from 145 to 230 or more.

Uniformity Index. The uniformity index (UI) is a means of de-

>> **Figure 10.** A Comparison of Fertilizers with Size Guide Numbers of 100, 150, 215 and 240. Photo Credit: Brad Jakubowski.





>> **Left: Figure 12a.** Calculating the Size Guide Number and Uniformity Index of a Fertilizer.
Right: Figure 12b. Testing for Fertilizer Granule Segregation.

termining how consistent the diameter of granules within a bag or lot of fertilizer is. To calculate the UI, the size of the sieve opening in millimeters that retains 95% (or passes 5%) of the sample is divided by the size of the sieve opening that retains 10% (or passes 90%) of the sample. This fraction is then multiplied by 100. For example, a fertilizer with a uniformity index of 50 contains a range of variable-sized particles with the average small particle being one-half the size of the average large particle. The average smallest size granule in a fertilizer with a UI of 33 is one-third the size of the largest particle. Sports turf fertilizers often have a UI of 40 or more.

Granule Segregation Test. One way to observe the variation in the relative size of granules in a fertilizer is to construct a box 24 in. long, 2 in. wide and 18 in. high from clear plastic (for example, Plexiglas) and wood, and perform a granule segregation test (Figures 12a and b). When fertilizer is poured through a funnel positioned just above the top left corner of the box, larger and heavier granules move further to the right than smaller and lighter granules. For most uniform application, granules in turf fertilizers should be nearly the same size and weight.

By evaluating each N carrier used in the fertilization program in addition to the overall turfgrass quality and field performance from one year to the next, sports turf managers can make sure that they are getting the most from their granular N fertilizers. ■

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