phosphate, potassium nitrate and calcium nitrate fertilizers do not need to undergo conversion by nitrobacteria, since their nitrogen is already in nitrate forms.

**Slow-Release Nitrogen Sources**

In an attempt to overcome some of the disadvantages of soluble nitrogen sources, fertilizer manufacturers have developed an array of slow- or controlled-release nitrogen sources. These sources generally produce a more uniform growth response and a longer residual plant response. They also have less potential for nitrogen loss and allow a higher application rate than readily soluble sources. In addition, their burn potentials are lower due to their low salt index values. The application rate at which these sources release nitrogen may vary with the timing of fertilizer applications, source, temperature, moisture, pH, and particle size.

Drawbacks of slow-release nitrogen sources include high per unit cost and slow initial plant response. Some sources also are not adaptable to liquid application systems. Turf managers should understand the various nitrogen sources and conditions favoring nitrogen release before formulating their annual fertilizer programs.

**Coated, Slow-Release Nitrogen Sources.** Coated nitrogen fertilizers consist of urea or other soluble sources coated with a semipermeable barrier. The nitrogen-release rate is slow because the coating prevents wetting of the soluble nitrogen source. Release rates depend on coating degradation or on the physical integrity of the coating.

**Sulfur-Coated Urea (SCU).** Sulfur-coated urea is formulated by moving granulated or prilled preheated urea pellets through a stream of molten sulfur by means of a rotating drum. The urea is then coated (sealed) with a microcrystalline wax, which strengthens the sulfur shell and decreases the initial rate of urea release, thereby protecting the surface from microbial degradation. After it is coated, the product is cooled and a diatomaceous earth or vermiculite clay conditioner is applied to further reduce cracking and to promote sealant stickiness. Urea release consists of a gradual diffusion through this coating via cracks, pinholes, and imperfections naturally occurring in the surface as the particles cool.

Because of the lack of uniformity and integrity in the coating process, the urea granules crack at different times; therefore, they exhibit variable nitrogen release rates. These granules also are vulnerable to damage during transportation, blending, and application, and to injury due to pressure from mower reels, rollers, or wheels. Therefore, handling should be kept to a minimum and drop spreaders avoided when applying urea granules.

The rate of urea diffusion from SCU depends on microorganism activity, particle size, and, as previously discussed, coating thickness and integrity. Nitrogen release from SCU increases with warm temperatures, moist soils, and neutral soil pH. These conditions favor soil microorganism activity, as does a thinner wax coating. Heavy sulfur coatings result in larger fertilizer granules, which release the nitrogen more slowly. Mower crushing or pickup problems may occur with these larger granules. To minimize these problems, a finely prilled product with a very uniform nitrogen release rate is produced for greens application.

SCU applied during the winter may produce turfgrass with a mottled appearance. The intensity of this mottled appearance is correlated with coating thickness and granule size. Normally it dissipates within 2 to 4 weeks, depending on the rate of nitrogen application and weather conditions.