



SULFUR-COATED UREA: COVER CONTROLS NITROGEN RELEASE

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Potential benefits from controlled-release nitrogen (N) fertilizers include: 1. More efficient crop use of N (control of luxury uptake) 2. Decreased leaching of nitrate 3. Lower toxicity (reduced ammonia or salt injury or both) 4. Longer lasting, more uniform nutrient supply (fewer applications needed) 5. Reduced volatilization losses to the atmosphere (ammonia or gaseous products of denitrification).

Most controlled-release fertilizers, both synthetic and natural, fall into one of three classes: 1. Biodegradable organic compounds yielding ammonia or nitrate or both through the action of soil microorganisms (ureaform and natural fertilizers) 2. Organic compounds of low water solubility that slowly hydrolyze to form urea, which is then converted to ammonia and nitrate (IBDU) 3. Coated soluble sources that release the nutrient through membrane rupture or diffusion of solutes through pores or imperfections in the coating (SCU).

This paper is primarily concerned with the mode of action of SCU and its relationship to crop response.

Sulfur-coated urea is now available from three suppliers in North America. All use the process developed by TVA at Muscle Shoals, Alabama. In its simplest form, the process involves heating urea (granules or prills) to approximately 140°F., followed by spray application of molten sulfur (S) at 300°F. in a rotating drum apparatus. A sealant coat of polyethylene oil or microcrystalline wax is applied, and the final product is conditioned with diatomaceous earth or some other suitable conditioner. Typical products contain about 36 percent N, 16 percent S, and 5 percent sealant plus conditioner. Since an S coating of finite thickness is required, large and small granules of SCU often contain less or more S, respectively, than the average value reported. By varying coating weight or sealant or both, products differing in initial solubility may be prepared. For quality control purposes, products are often characterized by determining the amount of N released in 7 days in water at 100°F. Thus, SCU-30 refers to a product in which 30 percent of the N is released under the prescribed conditions. The 7-day dissolution value is primarily a measure of the relative number of imperfectly coated granules. Release of N from the insoluble fraction involves other variables to be discussed later.

The dissolution pattern may be estimated by extending the 7-day test over a longer period with analysis of N released at appropriate intervals. The results obtained, however, may be difficult to in-

terpret in terms of expected field performance. More useful data have been obtained from experiments involving placement of SCU in soil under varying conditions followed by recovery and analysis of undissolved granules at appropriate intervals. Many trials have been conducted, all of which support the premise that individual granules release N rapidly once all the coating fails and water gains access to the substrate. Thus, controlled release of N results from many granules that supply N at different times rather than from gradual release of N from all granules at the same time. Once this fact was established, it was possible to characterize the dissolution pattern by recovery and analysis of undissolved granules. That portion of applied N not recovered is assumed released to the soil as water-soluble urea.

It has been shown by this procedure that many factors regulate release of N from SCU; a brief summary of the more important variables follows: 1. Release of N from SCU is accelerated in warm soil, which suggests that soil microorganisms are at least partially involved in coating failure. It has not been determined whether biodegradation of sealant or S is the dominant process. However, soil microorganisms do oxidize the S coating, yielding crop-available sulfate. Following coating failure, the flow of urea solution into the soil is primarily an osmotic process, which is much less sensitive to changes in soil temperature. 2. Experiments conducted in controlled environment regimes show that soil moisture stress increases the rate of dissolution of SCU. Thus, the rate of release in a silt loam soil at 75°F. was in the order: dry (10 percent H₂O) > alternating moist/dry > continuously moist (20 percent H₂O). Lowering the temperature to 55°F. slowed dissolution but did not change the ranking of soil moisture regimes. 3. Experiments conducted in both field and laboratory suggest faster dissolution with surface placement than with mixed placement. This effect is believed to be related to much wider ranges in soil temperature and moisture stress at the soil surface. 4. Root action apparently accelerates dissolution of SCU. This conclusion is based on recovery of undissolved SCU from fallow soil, as compared with cultures cropped with bermudagrass. 5. Dissolution was not affected by soil pH in the range 5 to 8. 6. That portion of SCU not dissolved is protected from loss during leaching incidents.

Results from many experiments conducted under widely varying conditions suggest that 5 to 30 percent of applied SCU may not dissolve during the season of application. There is evidence that

most of the carryover becomes available to crops in later years.

Crop Response to N in SCU

The chief objective of SCU research has been to improve crop yields by more efficient utilization of applied N. A wide variety of field and greenhouse experiments has been conducted with many crops throughout the world. This discussion is limited to results from forage and turfgrasses. The following brief summary is concerned with principles, rather than data from individual experiments: 1. More uniform seasonal growth usually results from SCU than from a single annual application of soluble N sources. In numerous experiments, the growth pattern has been similar to that obtained from multiple applications of soluble N. 2. In some greenhouse experiments, total yield from SCU has exceeded that from soluble N sources. Calculation of N uptake suggests that control of luxury uptake in early clippings is the dominant factor. 3. In other experiments, total yield from SCU has been less than that from soluble N. Recovery of undissolved SCU shows that the difference may be explained by rate effects produced by incomplete dissolution of SCU in the season of application. 4. Since dissolution of SCU is temperature sensitive, products with higher initial dissolution have given better results in northern areas; less soluble formulations may be preferred in the South, where soil temperature is higher and the growing season is longer. 5. Less than one-third of the total N applied from SCU is readily soluble. Thus, turf damage from SCU has been less than that from comparable rates of soluble N sources. 6. Losses of ammonia from surface application of N fertilizers are difficult to measure under field conditions. However, N recovery studies suggest that such losses may be reduced by use of SCU.

Crop Response to S in SCU

The coating in SCU is elemental S, a form not available for crop use until it is oxidized to sulfate by soil microorganisms. Sulfur oxidation studies invariably show that finely divided S mixed with the soil is oxidized in a few weeks, while prills or granules oxidize very slowly. The difference in oxidation rate is related to the surface area of S particles in contact with soil. On this basis, one would predict delayed availability of S in SCU. The N:S ratio in SCU is about 2:1; thus, normal N rates supply two to five times the S requirement for most crops. Greenhouse studies with low-S soils where crops respond to both N and S permit the following conclusions: 1. Oxidation of S in SCU commences rapidly in warm soil, and crop response to S in SCU has been measured in 2 months. Since the rate of S is higher than necessary, oxidation of a small portion of total S apparently supplies crop needs. 2. Yield response and uptake of N and S clearly show that SCU is an excellent controlled-release source of both nutrients. 3. On a long-term basis (6 months of cropping), yield of bermudagrass not limited by N supply was greater from SCU than from Na_2SO_4 . The difference was attributed to control of luxury uptake of sulfate in early clippings. 4. Increase in soil acidity by the H_2SO_4 formed through oxidation of S in SCU should not be a problem in most soils.

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55