Turfgrass Nitrogen Sources

By Donald V. Waddington
Department of Agronomy
The Pennsylvania State University

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Nitrogen (N) sources used for turfgrass fertilization encompass a wide variety of properties and release characteristics. Physical forms range from granules for dry applications to powders, suspensions, and true solutions for liquid application. Release of N is rapid with some sources and slow with others, and there are different release mechanisms among the slow-release N sources. Slow-release N sources have lower salt indexes and thus less potential for fertilizer burn than quick-release, or soluble, N sources; and salt indexes differ among the quick-release sources. Nitrogen sources can be used alone or in mixed fertilizers with phosphorus and/or potassium sources, and various combinations of slow- and quick-release N sources may be used. Knowledge of the properties and characteristics of N sources is of great importance when one is making decisions of N fertilization programs. Examples of N sources are listed in Table 1.

Quick-Release N Sources

Quick-release sources are also called quickly-available, fast-acting, soluble, readily-available, and other terms that indicate rapid availability of N after application. This group includes urea (a synthetic organic), inorganic salts containing ammonium (NH4+) or nitrate (NO3–), and a group of urea-formaldehyde reaction products. Some Urea-formaldehyde reaction products contain enough water-soluble nitrogen so that they give a response closer to that obtained with urea and other solubles than with the slow-release sources such as activated sewage sludge, IBDU and ureaform. The quick-release sources are divided into two groups for discussion.

Inorganic salts and urea: These materials are soluble, have N contents ranging from 15 to 46%, and are less expensive than slow-release sources. Being water soluble, they may be applied in solution as well as in dry form. These sources have high salt indexes and thus have high potentials for fertilizer burn. They give a rapid response and frequent applications at low rates are recommended to minimize over-stimulation of growth and fertilizer burn.

These salts readily dissolve in water and dissociate into their cation and anion components: e.g., ammonium nitrate (NH4NO3) dissociates into ammonium ions (NH4+) to NO3– in an oxidation process called nitrification. Plants may utilize nitrogren in either the NH4+ or NO3– form, but most is taken up as NO3–. Nirtrates are readily leached, but ammonium is less susceptible to leaching because it can be adsorbed by soil colloids (clay and humus).

Urea is water soluble, and is quickly hydrolyzed (reacts with water) in the presence of adequate moisture and the enzyme ureas to form ammonium–N. More than 60% of the applied urea can be expected to hydrolyze in one day, and hydrolysis should be complete in about 7 to 10 days. Under alkaline conditions gaseous loss of N as ammonia may occur from urea and ammonium compounds. This process, called volatilization, is also favored by low soil cation exchange capacity, drying of moist soil and high temperature. Losses are usually greatest with urea, and on grass areas, losses as high as 30% of the applied N have been reported. Watering-in fertilizer will minimize such losses.

Urea-formaldehyde Reactions Products: A well-known urea-formaldehyde fertilizer is ureaform, which is a slow-release source of N with about 70% of the total N being water insoluble. By altering the ratio of urea to formaldehyde, reaction products with considerably less water-insoluble N (WIN) can be produced. The water soluble nitrogren of these products contains compounds such as unreacted urea, methylol urea and methylene ureas. The amount of each is largely dependent on the urea/formaldehyde ratio and the conditions under which the reaction takes place. these N sources are more expensive than the conventional solubles, but they are safer from the standpoint of fertilizer burn.

Methylol urea is the first compound formed when urea and formaledehyde are chemically combined. As the reaction continues, short-chain and, later, long-chain methylene urea polymers are formed.

The short-chain molecules are water soluble and the longer chain molecules are water insoluble. RESI-GROW 4340 and 4341 are clear aqueous solutions containing methylol urea and unreacted, or free, urea, which supplies abou t 50% of the N. Other water-soluble urea-formaldehyde reaction products are Formolene Plus, CORON, and Nitro-26 CRN. They are solutions that contain water soluble methylene ureas and some unreacted urea. About 25 to 30% of the N is from unreacted urea. N-SURE is a solution that differs from the previously mentioned solu-

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tions in that it contains N primarily in the forms of triazones and urea. Triazones are cyclic N compounds that form when the fertilizer is manufactured by reacting urea, formaldehyde and ammonia. Each of these solutions has a lower burn potential than urea, and can be used more safely at higher rates or on heat or water stressed turf. However, turfgrass response to these N sources has been very similar to that obtained with urea.

FLUF, homogesol-27 and RESI-GROW 4318 are flowable urea-formaldehyde reaction products that contain water-insoluble as well as water-soluble methylene ureas. Quick response is obtained with these materials, but the intensity of response is not as great as with urea and the previously discussed solution fertilizers.

Methylene ureas can be made with varying amounts of WIN. We have used a granular material supplied by O. M. Scott & Sons that had 36% of the total N as WIN, and a sprayable material having 30% of the N as WIN. Such materials can be expected to give a good initial response, but also have a greater residual effect than the soluble materials. The granular product gave turfgrass response similar to that obtained with fertilizers containing 50 and 60% ureaform-N, with the remainder from soluble N sources. Such response more closely followed that from soluble N sources than that from ureaform. Other methylene ureas used by Scotts contain considerably less WIN, but safety is preserved by the presence of soluble, short-chain methylene ureas. Homestead's Homogenite 40 is a granular methylene urea product containing 41% N, with about 27% of the N as WIN. Nutralene is NOR-AM's product in this category. It contains 40% N and 14.5% WIN.

Slow-Release Nitrogen Sources

Slow-release nitrogen sources, which are also called controlled-release, slowly-available, slow-acting, and insoluble, can be classified according to the method by which the nitrogen is released:

(1) microbial activity is required for decomposition and release of N from natural organics and urea-formaldehyde reaction products (ureaform, methylene ureas), (2) low water solubility and a very slow rate of dissolution gives the slow-release characteristic of IBDU, and (3) coatings on soluble N sources act as physical barriers that delay the dissolution of N from sources such as sulfur-coated urea and plastic-coated fertilizers.

Slow-release sources provide a longer duration of N release than the soluble, quick-release sources. They are safe from the standpoint of fertilizer burn (lower salt index), and may be applied at higher rates and with less frequency than soluble sources. The efficiency of some slow-release sources is often low in the first year or two of use. The low efficiency (often expressed as the percentage of the applied N utilized by the plant) and higher cost for N associated with the slow-release sources are reasons that combination of slow and fast-release N sources are used in many turf fertilizers. A discussion of individual slow-release sources follows:

Natural ogranics: For the most part, these materials are by-products from the plant and animal processing industries or waste products. Considerable variation exists in the properties of different materials, and even within a given material. The natural organics can be characterized by relatively low N content, the presence of WIN, and N release intermediate between that of soluble N sources and ureaform. Examples include hoof and horn meal, fish scrap and meal, seed meals (cottonseed, linseed, castor pomace), dried manures, activated sewage sludge and process tankage. Release of N is dependent on microbial activity. Environmental conditions affecting breakdown of natural organics include temperature, soil moisture and oxygen, soil pH and available minerals. Milorganite is an activated sewage sludge and is the most popular natural organic N source used on turf. Milorganite has been more efficient than several other natural organics in our tests. Terrene is a relatively new product with characteristics similar to Milorganite. A number of other natural organics, such as poultry manure and seed meal, are used in products sold under the names of Harmony, Plant Right, Ringer and Sustane as well as others.

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% N and about 70% of this N is water insoluble. Ureaform can be divided into three, almost equal fractions based on solubility. Fraction I is soluble in cold water, and contains unreacted urea and the short-chain methylene ureas: methylene diurea and dimethylene triurea. Availability of N in this fraction is similar to that of soluble sources, but is not as quickly available. Fraction II is made up of slow-release, intermediate length polymers (trimethylene tetraurea and tetramethylene pentaurea). It 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 study by Kaempffe and Lunt (from California) the breakdown of these fractions was studied over a period of 26 weeks. After this time period, 4% of fraction I, 25% of fraction II and 84% 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 or ureaform, recovery of applied N improves.

According to the Association of American Plant Food Control Officials, ureaform should contain at least 35% N, with at least 60% of the total N being water insoluble N (WIN), and the WIN should have an activity index (AI) of at least 40%. The AI represents the amount of cold water insoluble N that is soluble in hot water (commercially avail-

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able material has an AI of about 55%). Nitroform Blue Chip and Powder Blue meet these criteria. Urea-formaldehyde reaction products not falling within these guidelines are referred to by other terms such as methylene urea, methylol urea and flowable ureaform. By using urea-formaldehyde solutions, ureaform (or methylene ureas) can be made during the manufacture of mixed fertilizers.

Release of N from ureaform is dependent on microbial activity and the same environemtnal factors that affect release from natural organics also affect release from ureaform (or methylene urease) can be made during the manufacture of mixed fertilizers.

Release of N from ureaform is dependent on microbial activity and the same environmental factors that affect release from natural organics also affect release from ureaform. Because of low N recovery (efficiency) in the first years of use, it is usually necessary to use higher rates or supplement ureaform with soluble sources in these years. This low recovery and slow response during cool periods support the concept of fertilization with combinations of ureaform and solubles.

Organiform: Organiform is a N source made by reacting urea and formaldehyde in the presence of a natural organic N source. Organiform contains about 24 to 25% N, of which about 70% is WIN. Organiform LT is a copolymer of leather tankage and methylene ureas, and Organiform SS is a copolymer of sewage sludge and methylene ureas. Release of N is dependent on microbial activity. We have found these materials to be slower in release and less efficient than Milorganite and Nitroform. Response has improved with continued use. A combination of 50% Organiform N and 50% soluble N greatly exceeded the performance obtained with straight Organiform.

Other urea-formaldehyde reaction products: Although we often think of slow-release N when we hear the term urea-formaldehyde, there are some urea-formaldehyde reaction products that tend to be more quick-release than slow-release. The ratio of urea to formaldehyde used during manufacture affects the amount of WIN in the fertilizer. Ureaform is made using a ratio of about 1:3:1. Other N sources are made using wider ratios (more urea), and the result is lower amounts of WIN. I am not aware of any formal or informal rules that dictate when the term 'slow-release' is justified for a N source with a given amount of WIN. Certainly, confusion can arise when 'slow-release' is used with a material that has less of the total N as WIN than mixed fertilizers containing combinations of slow-release and soluble N such as 50% IBDU or Ureaform N and 50% soluble source N. Even more confusion occurs when water soluble methylene ureas are described as being sources of slowly available N. The characteristics of three urea-formaldehyde reaction products (methylene ureas, methylol urea and flowable ureaform) were given under the 'Quick-Release N Sources' heading. Of these three, the slowest-release of N would occur with methylene ureas having the higher amounts of WIN.

Table 1. Typical properties of nitrogen sources used for turfgrass fertilization.

Physical Form	Common or Trade Name	Manufacturer	Fertilizer Grade	Total N	Water-Insoluble
				%	%
SOLUBLE SOLIDS					
	Monoammonium phosphate	-	10-50-0	10	0
	Diammonium phosphate	-	18-46-0	18	0
	Ammonium nitrate	-	33.5-0-0	33.5	0
	Ammonium sulfate	-	20-0-0	20	0
	Calcium nitrate	-	15-0-0	15	0
	Sodium nitrate	-	16-0-0	16	0
	Potassium nitrate	-	13-0-44	13	0
	Urea	-	46-0-0	46	0
SLOW-RELEASE SOLIDS	Milorganite	1	6-2-0	6	5.5
	Terrene	15	6-2-0	6	5.5
	Nitroform Blue Chip	2	38-0-0	38	27.0
	IBDU (coarse)	3	31-0-0	31	27.9
	IBDU (fine)	3	31-0-0	31	26.3
	Nutralene (Methylene ureas)	2	40-0-0	40	14.5
	Other Methylene ureas	4,13	--	38-41	10-14
	Sulfur-coated urea	4,5,6,8	--	32-38	--
	Plastic-coated fertilizer	3,7,8	Variable (see text)		
	Melamine, "Super 60"	8	Variable (see text)		
SOLUTIONS	RESI-GROW 4340	9	30-0-0	30	0
	RESI-GROW 4341	9	30-0-2	30	0
	CORON	10	28-0-0	28	0
	N-SURE	11	28-0-0	28	0
	Nitro-26 CRN	12	26-0-0	26	0
	Formolene Plus	11	30-0-0	30	0
SUSPENSIONS	Homogesol-27	13	27-0-0	27	2.7
	FLUF	14	18-0-0	18	4.5
	RESI-GROW 4318	9	18-0-0	18	4.5
SPRAYABLE POWDERS	Methylene Urea	4	41-0-0	41	12
	Nitroform Powder Blue	2	38-0-0	38	25
	IBDU	3	31-0-0	31	23