break up the cores and to prepare the soil for overseeding, if necessary. Considerable overseeding was done in the spring and fall of 1976. Independence Hall gardeners broadcast the seed mechanically and also by hand, in certain areas. Both repeated aeration and overseeding are necessary in problem areas receiving heavy foot traffic, such as Independence Square, according to Jeffries.

The pest control program involves putting down a broad spectrum fungicide in mid-March. This is done in those areas that have been susceptible to fungus problems in the past. In mid-April a preemergence crabgrass control is put down. A broadleaf killer is applied in mid-May with a follow-up application in mid-July. The fungicide also is applied again in mid-November.

In terms of performance, Jeffries commented, "Our maintenance program contributes greatly to the lawn's germination process, overall adaptability and in helping us to improve the appearance of the park grounds."

Germination in 4-5 days and developing deep roots quickly are both important considerations when a quick lawn cover is needed, and to help eliminate the problem of weed competition.

George Lucko, left, park chief of area services, and Joe Duich, professor of turfgrass science at Pennsylvania State University, examine the lawn behind Carpenter's Hall.

Jeffries emphasized the need for a strong turf in anticipation of the Fourth of July crowds. "As it turned out, over 2,000,000 people visited historic Philadelphia over the Bicentennial weekend," he said. "The bulk of them visited Independence National Historical Park, and there were no restrictions on the use of the lawn. Picnickers, tour groups and many active children were among those using the park heavily and consistently. The lawn held up well in terms of density during the heavy traffic. The few areas that did show signs of wear were quickly restored."

There are over 1,900 trees in the park, resulting in some dead shade areas throughout the day, and a lawn was needed that would also establish well in the heavily shaded areas, Jeffries said.

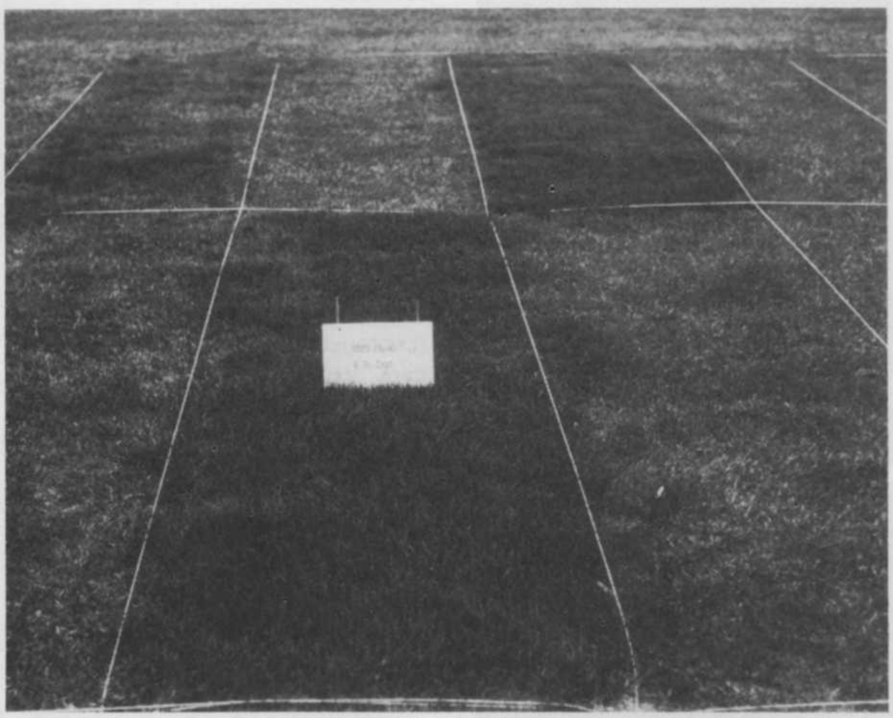
"Our overseeding has solved some other problems," he observed. "In the past, we had problems with diseases such as Fusarium and brown patch. We now have good resistance to these diseases and the park grounds have a pleasing overall appearance."

Similar to the overall traffic problems experienced during the Bicentennial weekend are the problem areas caused by compaction from people taking short cuts through the park. According to Jeffries, "The National Park Service doesn't want to destroy the natural beauty and historic significance of the park by adding a lot of walkways, so trampled areas develop quite easily. If a special event is held in a certain area of the park, the traffic to and from that area alone can cause compaction that did not exist previously. Our lawn is wearing well and has done a good job of reviving these problem areas in a minimum amount of time."

"In addition to a strong, permanent lawn that would come up quickly, be attractive, and withstand heavy use, the Park Service wanted a lawn that would allow a minimum amount of maintenance because of the size of the area, the way it is spread out and the large visitation that certain areas receive. These are the criteria we developed for the lawns at Independence National Historical Park," Jeffries said. □

Understanding Slow-Release Nitrogen

by Dr. James Wilkinson



Response of Kentucky bluegrass on April 1st to 3 kg N/are (6 lb. N/100 square feet) from IBDU applied the previous September. Plots to the right and left received similar rates of UF.

TABLE I. Comparison of WSN and WIN fertilizers.

WSN	Characteristic	WIN
quick	response time	slow
short	residual	long
frequent	application frequency	infrequent
high	burn potential	low
high	water solubility	low
low	cost	high
high	surface run-off and leaching potential	low

The use of slow-release nitrogen (or water-insoluble nitrogen [WIN] fertilizers on turf has grown steadily over the last few years. Despite the high cost of WIN compared to water-soluble nitrogen (WSN), WIN fertilizers continue to grow in popularity.

The characteristics of WIN and WSN fertilizers are summarized in Table 1. WSN fertilizers do offer some advantages over WIN, including rapid initial response, low cost, and high water solubility for liquid application. The use of such rapid release materials does have drawbacks, however: high potential for burn; production of a flush of growth after application at anything greater than moderate rates; relatively short residual, resulting in the need for frequent application; and the potential for significant N lost due to surface run-off and leaching.

Most of these problems associated with WSN can be minimized using any one of several commercially available WIN sources. WIN offers the primary advantage of a longer residual (longer response time) compared to WSN, allowing for higher application rates, together with reduced frequency of application and reduced labor costs. Other advantages of WIN include low burn hazard, and reduced potential for loss due to surface run-off and leaching. Disadvantages of WIN include the high cost per unit of N, and slow initial response.

There are five categories of WIN fertilizer available today:

1) ureaformaldehyde (UF)
2) isobutylidene diurea (IBDU)
3) sulfur coated urea (SCU)
4) plastic coated fertilizers
5) natural organics: activated sewage sludge, process tankage, seed meals, fish scrap, etc.

Many turf fertilization programs utilize a combination of WSN and WIN, taking advantage of the desirable characteristics of both. In order for the turf manager to effec-

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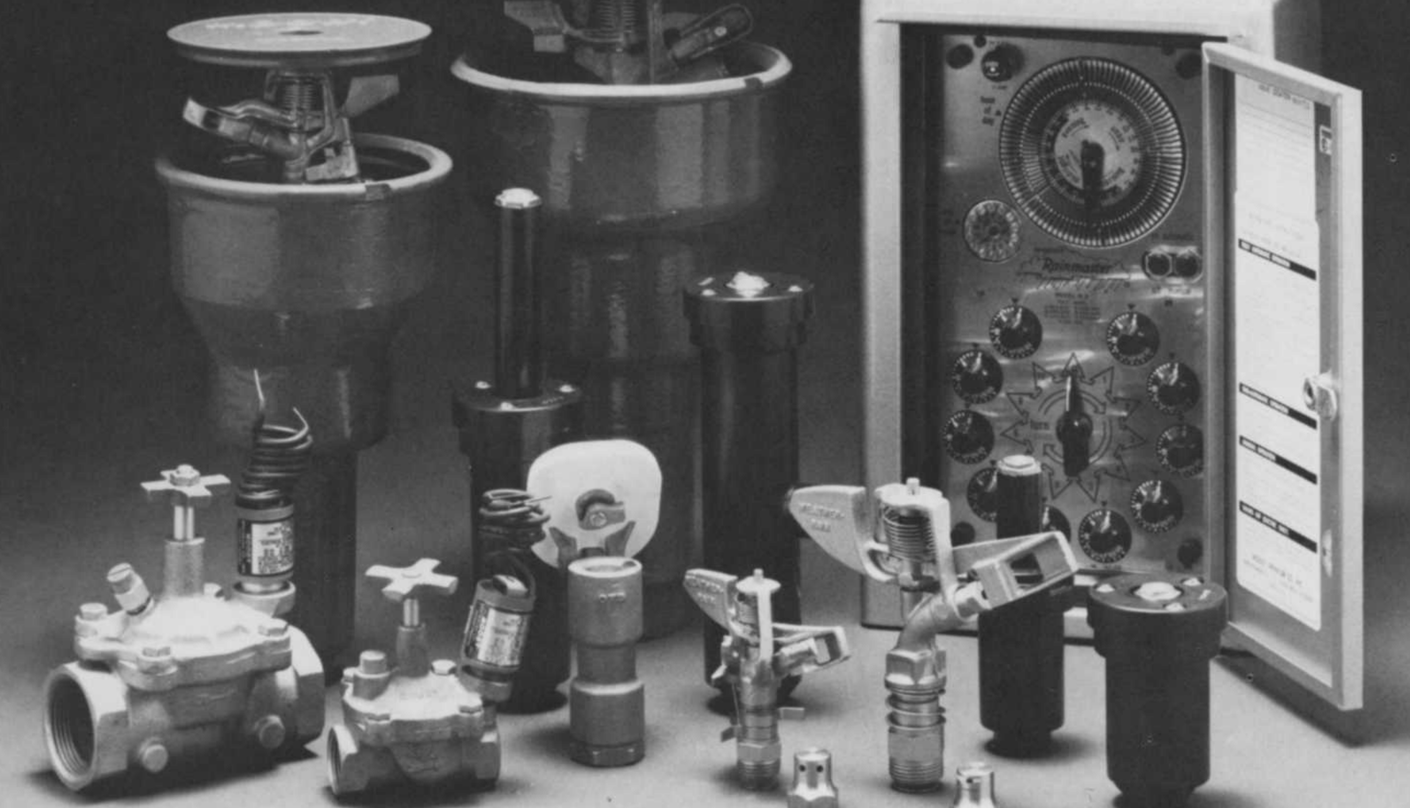


Slow-release

Continued

tively utilize slow-release N sources as part of a complete turf care program, he must be fully aware of the factors influencing N release from these materials. Factors such as soil moisture and temperature play a large role in the N release characteristics of the WIN fertilizers. If the influence of these factors is not understood, many people will be disappointed or misled as far as what type of turf response to expect.

A detailed description of each WIN source is summarized in Table 2. The following is an explanation of the N release mechanism involved for each WIN source to help the turf manager better understand the type of turf responses to expect from each material.

UF

Nitrogen is released from the insoluble fraction of UF as the result of microbial degradation. Therefore, any factor which increases or decreases microbial activity will have a similar effect on UF-nitrogen release.

UF-N release will reach a maximum when:

a. soils are warm (generally above 55° F.),

b. soil moisture is adequate, but not excessive,

c. soil oxygen is plentiful, and,

d. soil pH is near neutral.

These same factors have a similar effect on the growth rate of turf. As a result, N release from UF is maximized under conditions which are ideal for turfgrass growth. This could be important, for example, during a summer drought stress period. Cool-season turfgrasses will go dormant under these conditions, while N release from UF will be minimal because dry conditions minimize microbial activity. Excessive N release during such a period may be detrimental and hinder turf recovery when moisture becomes available.

Most UF materials contain a WSN fraction. Turf response to this fraction is not dependent on microbial activity. As a result, a rapid turf response can be expected, especially at higher rates. Most UF's contain at least 30 percent of their total N as water soluble.

It should be emphasized that all UF materials are not identical in terms of water solubility and N release characteristics. Some contain considerably more WSN than others. The solubility characteristics of UF materials are expressed in either of two ways: a). activity index, the traditional manner used to express UF solubility characteristics, and, b). ureaformaldehyde ratio, a more recently used expression of UF solubility characteristics.

Activity index: UF materials traditionally used for turf fertilization can be broken down into three fractions based upon solubility. Solubility is governed mainly by the length of the UF "chains", shorter chains being more soluble.

Fraction:

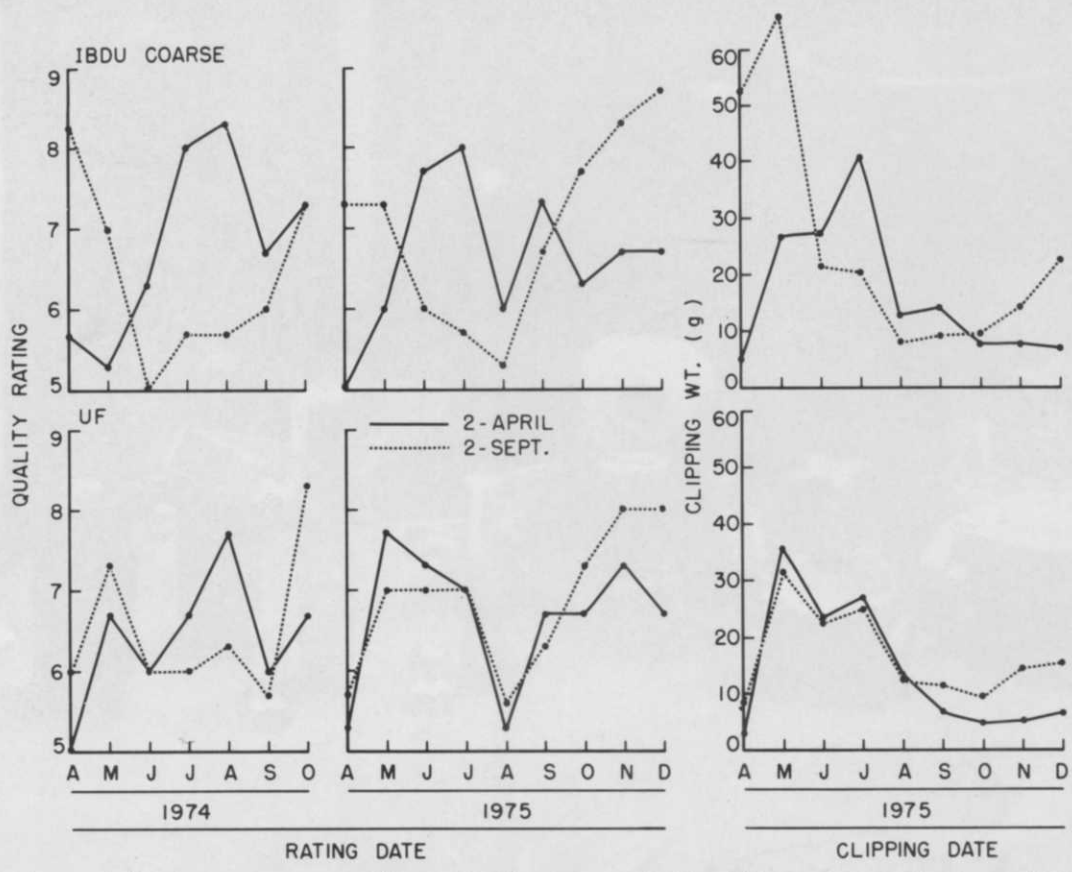
I. cold water soluble nitrogen (CWSN).

II. cold water insoluble nitrogen (CWINN).

III. hot water soluble nitrogen (HWIN).

N release from Fraction I is rapid and similar to soluble N sources. Fraction II is insoluble in cold water but soluble in hot water. N from

Continued on page 16



Turf quality and clipping wt. response of Kentucky bluegrass to April and September applications of IBDU and UF, each at 2 kg/are (4 lb./1000 square feet.)

Slow-release

Continued

Fraction II is slowly available over a number of weeks. Fraction III is insoluble in hot water and becomes available to turf over a number of years.

The rate of N release from different UF materials can be expressed as an activity index:

$$A.I. = \frac{\%CWIN - \%HWIN}{\%CWIN}$$

The higher the AI, the more rapid the N release rate. A satisfactory UF should have a minimum AI of 40. A UF material with an AI below 40 would have very slow release properties. Many UF products such as Nitroform and Ureaform traditionally have been characterized using AI.

Ureaformaldehyde ratio: A more recently used expression of UF-N release characteristics is the urea:formaldehyde ratio. This ratio can be varied significantly during manufacturing and can result in large changes in the characteristics of the resulting UF material. A 1.3:1 ratio, typically found in materials such as Nitroform, yields a material with approximately 1/3 WSN and 2/3 WIN. A 1.9:1 ratio, as used today in materials such as Scott's Proturf line, has approximately 2/3 WSN and 1/3 WIN.

Numerous manufacturers are now beginning to produce UF materials with widely varying release properties. Nearly any combination of WSN and WIN can be achieved if careful controls are placed on the manufacturing process. One should always take care to be cognizant of the properties of the UF material he is considering for use. No one urea-formaldehyde ratio or activity index is optimum for use all the time. The ideal ratio will vary with season, turf species, location, and results desired.

IBDU

IBDU is a compound which goes into solution very slowly. The two factors primarily controlling the

Continued on page 18

TABLE 2. Comparison of several WIN fertilizers

	UF	IBDU	SCU	Plastic Coated Fertilizer	Natural Organics
% N	38 (% may vary in newer products)	31	32	Varies (10-20)	Varies (2-6)
Basis for Insolubility	Urea reacted with formaldehyde forming insoluble compound	Very low solubility in water	Urea encapsulated in sulfur (and sometimes wax)	Soluble fertilizer encapsulated in plastic	Nitrogen part of organic complex
Expression of Insolubility	Activity index or urea-formaldehyde ratio		Seven day dissolution rate		
Basis for Nitrogen Release	Microbial degradation	Slow dissolution	Microbial degradation of coating, and diffusion of urea out of granule	Diffusion of soluble fertilizer out of plastic coating	Microbial degradation
Primary Factors Influencing Rate of Nitrogen Release	Any factor influencing microbial activity; soil moisture, temperature, pH, nutrient content, oxygen.	Particle size, moisture availability	Coating thickness, moisture and temperature	Coating thickness, temperature, (moisture to a lesser degree)	Any factor influencing microbial activity; soil moisture, temperature, pH, nutrient content, oxygen
Primary Drawbacks	Low nitrogen recovery first 2-3 years of use	Poor initial response	Rapid release at high temperatures	Handling and application may destroy coating	Low analysis, high cost
Advantages	Some soluble nitrogen	Excellent low temperature response	More rapid initial release than most other WIN sources, some S provided	Complete fertilizers available	P and K often provided, may supply some micronutrients
Manufacturer/ Distributor	Hercules, O. M. Scott, plus numerous others	Swift Chemical Co.	Canadian Industries Limited	Sierra Chemical Co.	Numerous
Trade Name(s)	Nitroform, Powder blue, various ProTurf products, plus numerous others	Par Ex	Gold-N	Agriform (Osmocote)	Milorganite and many others

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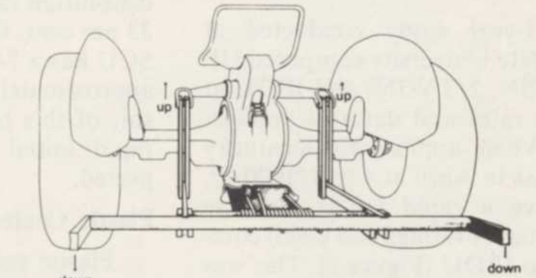

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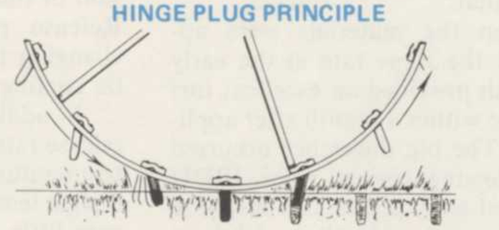

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Slow-release

Continued

rate of N release are: a) soil moisture — the more moisture available, the more rapid N release; and b) particle size — IBDU is available in both coarse and fine particle size, with the finer material having a more rapid N release rate. Also, release rate may be slightly faster under acid conditions. Temperature does have a limited effect on N release, but low temperatures do not substantially limit IBDU-N release as they would with UF.

IBDU repeatedly has been shown to provide a poor initial turf response. Turf response is minimal for the first 2-3 weeks after application. Once this period is past, however, response to IBDU appears excellent. Because of limited dependence on temperature for N release, fall applied IBDU will provide an excellent turf during late fall and spring.

A 3-year study conducted at Ohio State University compared UF (1/3 WSN, 2/3 WIN) and IBDU at various rates and dates of application. When applied to Kentucky bluegrass in April at 4 lbN/1000 ft^2, UF gave a rapid initial response (both quality ratings and yield) compared to IBDU (Figure 1). This was due to the WSN fraction of UF. During the summer and fall, however, turf response to the single spring application of UF and IBDU was similar.

When the materials were applied at the same rate in the early fall, both provided an excellent turf response within a month after application. The big difference occurred the following spring, when IBDU produced an excellent turf response in early spring, while the turf did not respond to fall applied UF until the soil warmed up in late May. Figure 2 shows a plot photographed April 1st, fertilized in September with 6 lb N/1000 ft^2 from IBDU, showing an excellent early spring response.

SCU

Sulfur coated urea has been in the experimental stage with the Tennessee Valley Authority for a number of years and has recently become commercially available. N release rate is based upon the thickness of the sulfur coating, moisture, and temperature. N is released by degradation of the sulfur coating and/or diffusion of urea through pores in the coating.

Release rate will increase with increasing soil moisture and temperature. The response to temperature is not due to microbial activity, but accelerated degradation of the sulfur coating. As a result, one drawback to SCU may be rapid N release with high temperatures when cool-season turfgrass become dormant. Turf research at numerous universities, however, has shown SCU to be an excellent N source.

Rate of N release from SCU is expressed as a 7-day dissolution rate. The higher the dissolution rate, the more WSN available. Turf research has been conducted at numerous universities on experimental SCU materials having 7-day dissolution rates ranging from 14 to 33 per cent. Commercially available SCU has a 7-day dissolution rate of approximately 30 per cent. As a result of this high dissolution rate, a rapid initial response can be expected.

Plastic Coated Fertilizers

Plastic coatings are used to encapsulate soluble sources of N, P, and K. Release of the fertilizer nutrients occurs when water dissolves the fertilizer salts, followed by diffusion of the salts out of the granule. Release patterns are varied by changing the thickness of the plastic coating.

In addition to coating thickness, release rate is governed primarily by temperature (increased release at higher temperatures). Moisture has very little influence on release rate, unless extremely droughty conditions prevail. Under droughty conditions, N release will be halted unless damage occurs to the coating due to drying. If coating damage does occur, N release will be very rapid.

Mechanical damage to the coating, creating rapid release of the nutrients, is a problem with plastic coated materials. Damage during shipment, application (especially with drop type spreaders), or by mowing after application (both the mower wheel traffic AND damage by the reels or rotary blades) can seriously alter the slow-release properties of plastic coated materials on turf.

Natural Organics

Despite their high cost and low analysis, this group of slow-release materials continues to be used extensively as a slow-release N source on turf. The materials are by-products or waste materials. Analysis of these materials varies widely and even varies considerably for any one product. Materials used include activated sewage sludge, process tankage, fish scrap, seed meals, dried manure, etc. Milorganite, an activated sewage sludge, is perhaps the most widely used natural organic fertilizer on turf.

N release is by microbial breakdown, therefore, the same factors effecting N release from the WIN fraction of UF will influence N release from the natural organics.

One slight advantage to the natural organics is that they may supply some micronutrients, but this varies widely depending upon source. They usually contain small amounts of P and K in addition to N.

The main advantage of WIN over WSN sources is their longer residual, allowing for the use of high N rates applied at a reduced frequency. One application per year of WIN, however, generally has not proven to be satisfactory in terms of year long turf quality. Research has shown that at least two applications per year of most WIN sources is necessary to maintain an acceptable level of turf quality. There appears to be no real advantage to more frequent application. These general conclusions regarding the application frequency of WIN sources most likely would not apply to intensively managed turf (i.e. golf greens) where extremely careful control is required over N nutrition. □

Dr. James Wilkinson is currently director of research for Chem-Lawn Corp.

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