

Fertilization of Established Roadside Turf With Various Rates and Sources of Nitrogen Fertilizers

H. D. PALMERTREE, C. Y. WARD, and E. L. KIMBROUGH

Respectively, Assistant Agronomist, Agronomist, and Former Graduate Assistant, Mississippi Agricultural Experiment Station, State College, Mississippi

A field evaluation of ammonium nitrate, urea, coated urea, ureaform and a natural organic at 25, 50, 100 and 150 lb of nitrogen per acre for fertilization of bermudagrass (*Cynodon dactylon*) sod on highway roadsides showed that the first two sources produced the most desirable sod density during the first growing season after application. During the second season, sod fertilized with ureaform was equal in density to that produced by ammonium nitrate, urea, and coated urea.

In the spring and early summer months after application, mixtures containing proportionally more ammonium nitrate than ureaform produced a denser sod than the reciprocal mixtures. However, by the end of the growing season, mixtures containing equal and greater amounts of ureaform to ammonium nitrate were producing sod of density equal to mixtures containing higher amounts of ammonium nitrate. All studies indicated that at least 100 lb of nitrogen are needed during the first season to develop a dense erosion-resistant turf, and that slow-release sources in combination with readily soluble sources can reduce fertilizer application frequencies and mowing costs.

•**MAINTAINING** established sods with sufficient density to resist erosion on roadside backslopes is a critical problem. Thousands of acres of roadside backslopes in Mississippi have been established to excellent stands of bermudagrass and other grasses only to be lost to the ravages of erosion during the early years of maintenance. Inadequate soil nitrogen is believed to be the most limiting factor in maintaining grass sods in Mississippi. Most soils in Mississippi and throughout the Southeastern United States developed under an ecology of high mean temperatures and excessive rainfall, which produced very thin, sandy surface soils and very dense, highly erosive clay subsoils—both low in nitrogen. Fertilizer nutrients, particularly soluble nitrogen, applied to these soils are often leached away because of the high annual rainfall and erosive nature of the soils.

Experiments show that fertilizing with nitrogen has been very effective in maintaining established grasses on roadsides, and in providing adequate growth to resist erosion. However, several problems exist in the use of nitrogen fertilizer. Where the water-soluble sources of nitrogen are used, it is difficult to obtain grass growth adequate to provide erosion resistance without excessive overgrowth. Commonly used nitrogen sources such as ammonium nitrate or urea are readily available and cause a rapid, lush growth which usually results in at least one extra mowing. These mowings are costly and often remove excessive amounts of vegetative top growth, leaving the sod vulnerable to erosion, especially if mowing occurs in late summer and no significant growth occurs before dormancy of the bermudagrass.

Another problem is that the period of stimulated growth obtained from an application of water-soluble nitrogen sources is only about 60 to 90 days, which means that where

only water-soluble sources are used, annual applications of nitrogen fertilizer are needed. This frequency of application is expensive since labor costs are a large portion of the cost of fertilizing roadsides.

The use of a fertilizer which slowly releases nitrogen over a long period of time would seem ideal for use on roadsides. A slow release of nitrogen would prevent excessive growth yet give sustained growth longer than one season. The ureaformaldehydes and resin-coated soluble nitrogens release nitrogen more slowly than the currently available water-soluble sources.

The objectives of these experiments were: (a) to determine the optimum source and rate of nitrogen to apply to maintain a desirable turf, (b) to measure the rate of release and the percent recovery of nitrogen from these sources, and (c) to measure the suitability of mixtures of slow- and fast-release nitrogen sources for producing sustained growth of bermudagrass for periods greater than one season.

The studies were conducted on roadside slopes along Interstate and primary highways in central Mississippi during the growing seasons, and in greenhouses at Mississippi State University during winter seasons.

RESULTS

Comparison of Nitrogen Rates and Sources

This study consisted of four rates, 25, 50, 100 and 150 lb of actual nitrogen per acre arranged in a split-plot design with rates of nitrogen as the whole plots and sources as the subplots. Sources tested were ammonium nitrate, urea, coated urea, ureaformaldehyde and a natural organic. Some physical and chemical characteristics of these materials are given in Table 1. The study consisted of three replications and was established at two locations. Plot size was 10 ft by 50 ft, the latter running vertically up the backslope.

Data taken 6 months after nitrogen application are given in Table 2. According to the visual rating system employed at the time of these measurements, it was thought that a sod which received a density rating of 5 would provide a ground cover sufficient for erosion protection. All density ratings reported were average ratings for three independent visual estimates, rated on the basis of 1 to 10, with 10 being the densest sod. The density rating takes into consideration the ground cover, thickness of sod, ratio of leaves to stems and height of grass.

Table 2 shows that as the nitrogen rate was increased, there was an increase in sod density for each nitrogen source; i. e., as the actual nitrogen was increased from 25 to 150 lb/acre, the average density increased from 3.8 to 7.4. Six months after nitrogen application, the more soluble sources, ammonium nitrate, urea and coated urea, produced a denser sod than did the slower release sources, ureaformaldehyde and natural organic. After a period of 6 months, the only plots not producing the minimum acceptable density rating, 5, were the 25-lb rates of urea, coated urea, ureaformaldehyde and the natural organic and the 50-lb rate of ureaformaldehyde. Grass in all other plots gave acceptable erosion protection.

Table 3 gives the density ratings of the same bermudagrass 12 months after nitrogen application. Again, the more soluble forms of nitrogen were producing the densest sod.

TABLE 1
NITROGEN SOURCES

Source	Description or Formula	Percent Nitrogen	Estimated Release
Ammonium nitrate	NH ₄ NO ₃	33	Fast
Urea	CO(NH ₂) ₂	45	Fast
Ureaformaldehyde	Urea derivative	38	Slow
Coated urea ^a	Urea derivative	20	Slow-Fast
Sewerage sludge	Natural organic	6	Slow

^aThis is a combination of a fast-release and a slow-release nitrogen contained in a pharmaceutical covering.

TABLE 2
SOD DENSITY AT SIX MONTHS^a

Nitrogen Source	Pounds of N per Acre				Mean
	25	50	100	150	
Ammonium nitrate	5.0	6.3	7.2	8.5	6.8
Urea	4.2	6.2	7.0	7.8	6.3
Coated urea	4.2	5.2	7.0	8.0	6.1
Ureaformaldehyde	2.8	4.0	5.0	5.8	4.4
Natural organic	3.0	5.0	5.2	6.8	5.0
Mean	3.8	5.3	6.3	7.4	

^aIn this and all subsequent tables, a rating of 10 was the most dense sod and a rating of 5 would have been adequate for erosion protection.

TABLE 3
SOD DENSITY AT TWELVE MONTHS

Nitrogen Source	Pounds of N per Acre				Mean
	25	50	100	150	
Ammonium nitrate	6.0	5.8	8.5	9.8	7.5
Urea	5.5	6.2	7.2	8.5	6.9
Coated urea	5.0	5.0	7.5	8.2	6.4
Ureaformaldehyde	4.0	4.8	6.2	6.2	5.3
Natural organic	3.8	5.5	5.8	6.5	5.4
Mean	4.8	5.5	7.0	7.8	

TABLE 4
SOD DENSITY AT EIGHTEEN MONTHS

Nitrogen Source	Pounds of N per Acre				Mean
	25	50	100	150	
Ammonium nitrate	6.0	5.8	8.5	9.8	7.5
Urea	5.5	6.2	7.2	8.5	6.9
Coated urea	5.0	5.0	7.5	8.2	6.4
Ureaformaldehyde	4.0	4.8	6.2	6.2	5.3
Natural organic	3.8	5.5	5.8	6.5	5.4
Mean	4.8	5.5	7.0	7.8	

However, the density produced by the slow-release sources was increasing and the difference in densities produced by the slow-release and rapid-release sources of nitrogen were of a smaller magnitude. At this 12-month rating, the only plots which were producing unacceptable sod densities (less than 5) were those receiving the 25-lb rates of ureaformaldehyde and the 25-lb rate of natural organic.

A great change in trend of sod density produced by the various sources was evident 18 months after nitrogen application (Table 4). At this time, the densest sod was produced by the urea, followed by ammonium nitrate. There was no significant difference produced by the slow-release and the fast-release sources. Plots which received only 25 lb of nitrogen from slow release sources were not producing ground cover sufficient for erosion protection; the 100 and 150 lb of nitrogen from all the sources were producing adequate densities.

For comparison purposes, a summary of ammonium nitrate and the ureaformaldehyde at 6, 12 and 18 months is given in Table 5. There was a significant difference in ground cover at 6 months and 12 months; but at 18 months after nitrogen application, there was no significant difference in ground cover produced by these two sources. A dense, lush growth was obtained from the ammonium nitrate as evidenced by the mean density rating of 8.4; whereas a rating of 5 would have been sufficient for erosion protection. The growth rate produced by the ureaformaldehyde was uniform throughout the 18-month period, with a mean rating of 6.0. Therefore, the most ideal growth rate was obtained from the ureaformaldehyde. It did not produce a lush growth which would have required mowing.

Determination of Release Rate and Recovery of Nitrogen Fertilizer

This study utilized the same five sources: ammonium nitrate, urea, coated urea, ureaformaldehyde and the natural organic. Each source was applied at rates of 50, 100, 150 and 300 lb of actual nitrogen per acre to bermudagrass sod. The experiment was conducted in the greenhouse in 2-gal pots for 4 months. Dry matter yield of clippings was obtained at 3 months and at the conclusion of the study at 4 months. After each of the harvests the plant materials were analyzed for percent nitrogen. From the percent nitrogen, the percent nitrogen recovery was calculated by the following formula:

TABLE 5
SOD DENSITY AS AFFECTED BY 150 lb
NITROGEN FROM 2 SOURCES

Nitrogen Source	Months After N Application			Mean
	6	12	18	
	Ureaformaldehyde	5.8	6.2	
Ammonium nitrate	8.5	9.8	7.0	8.4

TABLE 6
PERCENT NITROGEN RECOVERY IN
CLIPPINGS AT THREE MONTHS

Nitrogen Source	Pounds of N per Acre			
	50	100	150	300
Ammonium nitrate	63	53	42	22
Urea	55	51	42	23
Coated urea	67	55	41	21
Ureaformaldehyde	24	18	21	17
Natural organic	14	14	12	9

TABLE 7
PERCENT NITROGEN RECOVERY IN
CLIPPINGS AT FOUR MONTHS

Nitrogen Source	Pounds of N per Acre			
	50	100	150	300
Ammonium nitrate	14	21	24	17
Urea	7	11	15	18
Coated urea	14	23	24	16
Ureaformaldehyde	7	5	5	4
Natural organic	7	7	6	4

TABLE 8
PERCENT NITROGEN RECOVERY IN
ROOTS AT FOUR MONTHS

Nitrogen Source	Pounds of N per Acre			
	50	100	150	300
Ammonium nitrate	3.5	3.5	4.7	2.9
Urea	3.5	3.5	3.5	3.4
Coated urea	3.5	3.5	4.7	4.1
Ureaformaldehyde	3.0	1.8	1.2	1.2
Natural organic	3.5	1.8	1.2	1.2

$$\text{Percent N Recovery} = \frac{\text{Treatment (Yield} \times \% \text{N)} - \text{Check (Yield} \times \% \text{N)}}{\text{N Applied to Treatment}} \times 100$$

Table 6 gives the percent nitrogen recovery in bermudagrass tops at 3 months. As expected, the percentage of nitrogen recovered was greatest from the more soluble sources of nitrogen. At rates within a given nitrogen source the lower the pounds of nitrogen applied, the higher the percent recovery. The soluble sources of nitrogen were the only sources in which more than half of the nitrogen applied was recovered at the first clipping.

Table 7 gives the percent nitrogen recovery in the tops at 4 months. The uptake of nitrogen was similar to that obtained at 3 months. However, the amount of nitrogen recovered from any treatment was reduced considerably from the 3-month clipping. The amount recovered from ureaformaldehyde and the natural organic was a very small portion of the total nitrogen applied.

Table 8 gives the percent nitrogen recovered in the roots of bermudagrass at the 4-month harvest. There were no significant differences in the nitrogen recovery in the roots; however, the trend was toward a smaller recovery from the slow-release sources.

Total nitrogen recovery is given in Table 9. Plants fertilized with the low rate of ureaformaldehyde recovered only 34 percent as compared to an average of 76 percent nitrogen recovery for the more soluble sources of ammonium nitrate, urea and the coated urea. As the pounds of nitrogen per acre were increased, the percent recovery decreased considerably.

Performance of Ureaformaldehyde-Ammonium Nitrate Mixtures

In another series of studies, combinations of ureaformaldehyde and ammonium nitrate applied in mixtures to established bermudagrass sod were evaluated. Sixty-six lb of actual nitrogen were used as the total nitrogen in half of the experiment and 100 lb of total nitrogen were used in the other half. This experiment was conducted in south Mississippi and was observed through 1965 and 1966. Ratings were made in May, June and November 1965, and during June 1966. The fractions of nitrogen applied at the 66-lb/acre rate from ureaformaldehyde and ammonium nitrate are given in Table 10.

Where only 66 lb of total nitrogen were applied, none of the plots were giving sufficient erosion protection (rating of 5.0) when rated 1 year and 6 months after nitrogen application. At no time during the study did the check plot give sufficient erosion protection.

Table 11 gives the fractions of nitrogen for the two sources totaling 100 lb/acre. After 1 year and 6 months the density of

TABLE 9
PERCENT NITROGEN RECOVERY IN
TOTAL PLANT MATERIALS

Nitrogen Source	Pounds of N per Acre			
	50	100	150	300
Ammonium nitrate	80	78	70	42
Urea	65	65	60	43
Coated urea	84	81	69	41
Ureaformaldehyde	34	25	27	28
Natural organic	18	23	19	14

TABLE 10
SOD DENSITY AS AFFECTED BY MIXTURES OF
NITROGEN SOURCES

Pounds N/Acre		1965			1966	Mean
Ureaform	NH ₄ NO ₃	June	Sept.	Nov.	June	
66	0	3.7	3.4	3.8	4.3	3.8
50	16	5.3	3.8	5.0	3.7	4.5
33	33	6.6	5.2	7.3	3.0	5.5
16	50	5.4	5.2	5.8	3.7	5.0
0	66	7.2	6.2	7.0	4.0	6.1
0	0	2.5	1.6	1.7	1.0	1.7

TABLE 11
SOD DENSITY AS AFFECTED BY MIXTURES OF
NITROGEN SOURCES

Pounds N/Acre		1965			1966	Mean
Ureaform	NH ₄ NO ₃	June	Sept.	Nov.	June	
100	0	3.9	4.1	4.7	3.7	4.1
75	25	6.1	5.4	6.7	5.3	5.9
50	50	7.0	6.2	6.3	5.0	6.1
25	75	7.8	6.3	7.3	5.0	6.4
0	100	7.3	6.8	6.7	4.7	6.4
0	0	2.5	1.6	1.7	1.0	1.7

the sod receiving 100 lb of nitrogen from ureaformaldehyde was 3.7 and the density rating of the sod receiving 100 lb ammonium nitrate was 4.7. These sources alone did not provide sufficient erosion protection. However, mixtures of these two sources resulted in ratings of 5.3, 5.0 and 5.0 for the 75-25, 50-50 and 25-75 mixtures respectively. These combinations were producing an ideal growth rate for all four rating dates. No lush growth was obtained from these mixtures throughout the growing period, and during the second season ratings still indicated adequate erosion protection. Ammonium nitrate alone resulted in early periods of lush overgrowth, thus causing extra mowing problems (Table 11).

From the preceding data, two management systems for refertilization of roadsides could be employed: (a) 100 lb of nitrogen applied biennially with one-half in a slow-release form and one-half in the form of a soluble source of nitrogen, or (b) at least 66 lb of nitrogen from ammonium nitrate could be applied annually. In an attempt to compare costs of these two systems, the following assumptions were made:

Ammonium nitrate cost	\$ 66.00 per ton
Ureaformaldehyde cost	250.00 per ton
Cost of fertilizer application	2.00 per 100 lb
Assume 1 (one) extra mowing per year where ammonium nitrate is used alone	5.00 per acre

From the above assumptions, the cost of the two maintenance systems for a 2-year period is as follows:

A. Combination slow release-fast release nitrogen	
50 lb N from ammonium nitrate	\$ 5.00
50 lb N from ureaformaldehyde	18.50
Cost of application	6.00
Total cost for 2 years	<u>\$29.50 per acre</u>
B. Fertilize annually with ammonium nitrate alone	
66 lb N from ammonium nitrate	6.60 × 2 years = \$13.20
Cost of application	4.00 × 2 years = 8.00
Mowing per acre (extra)	5.00 × 2 years = 10.00
Total cost for 2 years	<u>\$31.20 per acre</u>
Excess of system B over system A = \$31.20	
	29.50
	<u>\$ 1.70 per acre</u>

SUMMARY

1. At least 50 lb of nitrogen from the soluble sources and at least 100 lb of nitrogen per acre from the slow release sources were required to develop a bermudagrass turf dense enough to resist erosion on roadside backslopes.

2. Ammonium nitrate alone did not provide an ideal nitrogen release pattern for roadsides in Mississippi, because it gave periods of dense overgrowth.
3. Ureaformaldehydes alone provided neither adequate immediate nor residual release of nitrogen.
4. Combinations of ammonium nitrate and ureaformaldehyde applied in mixtures produced sods with adequate erosion protection and showed promise of providing sustained nitrogen release well into the second season after application. These combinations of nitrogen sources could reduce frequency of application and mowing costs.