Turfgrass Soil Management
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P.E. Rieke, M.T. McElroy and J.A. Murphy
Crop and Soil Sciences, M.S.U.

SULFUR STUDIES

Three studies were initiated in 1986 to study the response of turfgrasses to sulfur applications. These studies were initiated in July. The first was applied on a Kentucky bluegrass turf which had been seeded in 1980. The soil was compacted clay loam subsoil. Plot size was 6 feet by 10 feet with 3 replications for each treatment. Treatments applied are given in Table 1. Data for this study are given, in Tables 1 and 2. Rates of sulfur application were 10 and 20 pounds of sulfur carrier depending on treatment.

The most striking responses were to treatments with Cleary's flowable sulfur. There was a significant response in turf density and clipping weights (Table 1) as well as in color and turf quality ratings (Table 2). Note the dramatic increase in weight of clippings as an indicator growth response. In one month after application the 10 and 20 pound rates of applications gave comparable growth responses, while after two months the 20 pound rate resulted in significantly more growth than the 10 pound rate.

There were few responses to other sulfur carrier applications except for Thiolux which showed some tendency to result in a darker green color. Although there was a significant response to the flowable sulfur in particular, the rates applied were quite high and injury could easily result from such application rates. In this regard, there was reduction in color ratings taken in October on both and 20 pound treated plots.

Soil pH tests taken in October indicated there was no change in pH when sampled to the 1.0 inch depth. pH values ranged from 7.2 to 7.5. Injury from sulfur applications will occur because of rapid pH change in the very soil surface. This pH change can be very dramatic and can cause injury to plant tissue (roots and crowns). Gradually the acid released will leach downward to change the pH a little deeper in the soil. In this study the reduction in turf color is not understood. It could result from too much acidity in the surface 1/4 inch or so (although there was no indication of this in the pH test) or from some other nutritional response.

Responses to the sulfur applications on annual bluegrass fairway height turf at the Hancock Turfgrass Research Center were quicker than on the Kentucky bluegrass. There was very clear growth and density response to both the 5 and 10 pound rates used in this study (see Table 3), within a week or so although no clipping weights were taken because of smaller plot size. Turf color response was different than with Kentucky bluegrass. There was a short term response in turf color causing a darker green on the flowable sulfur plots but after one month the turf was lighter green than on the untreated plots. This was very noticeable two months after

treatment in September when all other plots had a darker green color. In September the turf density on the flowable treated plots was more open especially at the 10 pound rate (compared to the 5 pound rates). Clearly there was weakening of the turf during the fall due to treatment. Again soil test did not reflect a meaningful change in pH at least in the 1.0 inch depth.

It should be noted that there was some response of annual bluegrass to the Thiolux treatments. There was darker green color, an improvement in quality ratings and relative growth compared to the untreated control for about a month (Table 3). There was also some indication of injury which occurred on small spots at the edges of plots where a little extra product fell during application of Thiolux. To a lesser degree this occurred with the flowable product. No indication of this occurred with other products.

A second study on annual bluegrass was initiated in August as outlined in Table 4. There was no indication of any response to any of these treatments with Thiolux or Cleary's flowable sulfur. Apparently there are other factors involved in the nature of this response. It is not known if these are related to physiological, environmental, or soil conditions.

On July 19 a small study on sulfur response of Penncross creeping bentgrass under greens conditions was begun. After about a month there was significant turf color response to the flowable sulfur that persisted through the end of the growing season. There was no apparent response in turf density or growth rate although no clipping weights were taken because of small plots size.

Table 1. Effect of sulfur applications on turf density and clipping weights of Kentucky bluegrass growing on clay loam subsoil. Treatments applied July 12, 1986 at rates shown pounds product per 1000 square feet. Averages for 3 replications. Hancock Turfgrass Research Center. A density rating of 9 = highest density.

Treatment		Turf density		Clipping weight gm	
Carrier	Rate	8/14	9/8	8/14	9/10
Thiolux	10	8.0 a	7.5 bc	21	40 c
	20	6.3 b	7.2 cd	6 b	39 c
LESCO Microprill	10	6.3 b	6.0 d	7 b	25 de
	20	6.7 b	6.5 cd	10 b	21 e
LESCO Water degradable	10	6.5 b	6.3 cd	9 b	23 e
	20	6.5 b	6.7 cd	11 b	38 cd
Frit-Sul-Ate	10	6.7 b	6.7 cd	11 b	29 cde
	20	6.3 b	6.8 cd	5 b	31 cde
Cleary Flowable	10	8.5 a	8.5 ab	47 a	75 b
	20	8.7 a	9.0 a	49 a	143 a
Check		6.7 b	6.0 d	5 b	20 e

Table 2. Effect of sulfur applications on color and turf quality ratings of Kentucky bluegrass growing on clay loam subsoil. Treatments applied July 12, 1986. Application rate in pounds product per 1000 square feet. Hancock Turfgrass Research Center. Averages for 3 replications. A rating of 9 = dark green color or high turf quality.

Treatment		Color rating			Turf quality		
Carrier	Rate, lbs	7/31	8/14	10/23	8/14	9/8	10/23
Thiolux	10	7.8 ab	7.8 ab	7.0 b	7.7 ab	7.7 bc	6.5 ab
	20	7.0 bc	7.0 ab	8.0 a	6.8 bc	7.0 c	6.2 b
LESCO Microprill	10	6.5 cd	6.7 ab	6.8 b	6.2 c	6.7 c	6.3 ab
	20	6.8 bd	6.8 ab	6.8 b	6.5 c	6.8 c	6.3 b
LESCO Water Degradable	10	6.7 cd	6.7 ab	6.8 b	6.3 c	7.0 c	7.2 ab
	20	6.5 cd	6.5 b	7.2 b	6.3 c	7.3 c	6.8 ab
Frit-Sul-Ate	10	5.8 d	7.0 ab	7.3 b	6.5 c	7.2 c	7.3 a
	20	6.8 bd	6.5 b	7.0 b	6.0 c	7.0 c	7.2 ab
Cleary Flowable	10	8.5 a	8.0 a	6.0 c	8.3 a	9.0 a	6.7 ab
	20	8.3 a	8.0 a	6.0 c	7.8 a	8.5 ab	6.2 b
Check	-	6.3 cd	6.5 b	6.7 b	6.2 a	6.8 c	6.7 ab

Table 3 . Effect of sulfur applications on annual bluegrass turf growing on loam soil. Treatments applied July 12, 1986 at rates shown in pounds per 1000 square feet. Averages of 3 replications. Hancock Turfgrass Research Center. A rating 9 is best.

Treatment		Color rating			Quality rating		Relative shoot growth	Relative density
Carrier	Rate	7/21	8/14	9/19	8/14	9/18	7/21	9/8
Thiolux	5	7.2 ac	7.5 ab	6.0 a	7.8 a	6.8 ab	7.3 b	7.2 a
	10	8.0 a	8.2 a	6.2 a	7.3 ab	7.0 a	6.8 bc	6.8 ab
LESCO	5	6.5 cd	7.2 ac	6.3 a	7.0 ab	6.7 ab	6.0 d	6.8 ab
Microprill	10	6.3 cd	7.0 bc	6.2 a	7.7 a	6.5 ab	6.0 d	6.7 ac
LESCO Water	5	6.0 d	6.5 bc	6.3 a	6.3 bd	6.7 ab	6.0 d	6.7 ac
degradable	10	6.3 cd	7.0 bc	6.5 a	6.5 ad	7.0 a	6.5 cd	7.2 a
Frit-Sul-Ate	5	6.7 bd	6.7 bc	6.2 a	6.3 bd	6.5 ab	6.3 cd	6.3 bc
	10	6.3 cd	7.0 bc	6.2 a	6.7 ac	6.5 ab	6.0 d	6.5 ac
Cleary	5	7.7 ab	6.2 cd	5.2 b	5.5 cd	5.8 b	8.5 a	6.0 c
Flowable	10	7.7 ab	5.5 d	5.0 b	5.2 d	4.8 c	8.5 a	5.2 d
Check		6.0 d	7.0 bc	6.3 a	6.3 bd	6.5 ab	6.0 d	6.7 ac

Table 4. Effect of sulfur applications on annual bluegrass turf growing on loam soil -- Study II. Treatments applied August 22, 1986 at rates shown in pounds per 1000 square feet. Averages of 3 replications. Hancock Turfgrass Research Center. A rating of 9 is best.

Treatment		Color rating	
Carrier	Rate	9/8	9/19
Thiolux	1	6.7 ns	6.0 ns
	2	6.7	5.8
	5	6.8	5.8
Cleary	1	7.3	5.0
	2	7.0	5.8
	5	6.8	5.3
Check	-	6.8	5.3

Table 5. Effects of sulfur applications on Penncross creeping bentgrass turf growing on loamy sand soil. Treatments applied July 19, 1986 at rates shown in pounds product per 1000 square feet. Averages for 3 replications. Hancock Trufgrass Research Center. A rating of 9 is best.

Treatment		Color rating (9=dark green)				
Carrier	Rate	8/8	8/14	9/8	9/19	10/16
Cleary	5	6.7 ab	7.5 a	7.0 b	7.3 a	7.5 a
Flowable	5 + 5	7.2 a	6.8 a	7.5 a	7.5 a	7.5a
LESCO	5	5.7 b	5.7 b	5.5 c	5.5 b	6.3 b
Microprill	5 + 5	6.2 ab	5.7 b	5.5 c	5.5 b	6.3 b
Check	-	6.5 ab	5.7 b	5.5 c	5.7 b	6.3 b

EFFECTS OF PHOSPHORUS AND POTASSIUM APPLICATIONS ON SOIL TEST AND TURF RESPONSE

In an ongoing study at the Hancock Turfgrass Research Center application rates of P_2O_5 and K_2O are made as shown in Tables 6 and 7, respectively to Penncross creeping bentgrass growing on three different soils. These soils are a dune sand (built to PurrWick specification), a 2NS sand with 25% peat mixed into the surface 4 inches; and a native sandy loam soil. The ability to hold applied phosphorus (Table 6) is evident in the sandy loam and sand/peat soils. There is already a high phosphorus level in the untreated sandy loam soil while the phosporus test in the sand/peat untreated soil is only 10 pounds per acre. This should be low enough to result in a lack of growth although this is not evident on the plots. The sand does not hold the phosphorus as well and some leaching has obviously occurred. It has become evident that more frequent applications of phosphorus at lighter rates are necessary on sands.

A similar response has occurred with potassium (Table 7) except the sand holds essentially no potassium. There is no difference in soil potassium tests between the untreated check and the highest K_2O rate. What is applied is either being removed with the clippings or is leached due to very low cation exchange capacity. The addition of some peat to sand dramatically increase the potassium holding capacity of the soil. For those turf managers growing turf on pure sands or where sand topdressing is building a sand layer, potash should be applied several times a year, just as with nitrogen.

Phosphorus deficiency can also occur on fine textured subsoils. A study was initiated in 1984 on an apartment complex in Novi to determine the phosphorus response on a soil testing very low in phosphorus. Phosphorus was applied as 0-46-0 at rates shown in Table 8. Initially there was visual evidence of response to the phosphorus with improved density and growth but the data collected did not indicate significant differences. Extra nitrogen was applied in 1986 after which the turf quality ratings and density ratings were significantly improved (see August and September ratings). Soil tests did not reflect a significant increase in available soil phosphorus levels even at the 8 pounds per 1000 square feet application rate. The thatch was discarded before testing was done. Since the thatch is very thick on the site (over 1 inch) the phosphorus is likely still in the thatch layer. Obviously, further study is necessary. The bottom line is that lawn care companies and others who are treating sodded turfs on compacted subsoils should be sure to include some phosphorus in their fertility programs. We cannot afford to have poor turf response to nitrogen because phosphorus or some other element is deficient.

Table 6. Effect of phosphorus applications on phosphorus soil tests of three soils maintained under greens conditions. Treatments initiated in 1983. Hancock Turfgrass Research Center. Averages of 3 replications.

P_2O_5 annually	Phosphorus soil tests, lbs/acre		
lbs/1000	sand	sand/peat	sandy loam
0	12	10	116
0.5	18	45	136
1.0	47	94	173
2.0	89	166	290

Table 7. Effect of potash applications on potassium soil tests of three soils maintained under greens conditions. Treatments initiated in 1983. Hancock Turfgrass Research Center. Averages of 3 replications.

K_2O annually	Potassium soil tests, lbs/acre		
lbs/1000	sand	sand/peat	sandy loam
0	32	91	83
0.5	35	123	112
1.0	40	144	141
2.0	35	236	221

Table 8. Effect of phosphorus applications on Kentucky bluegrass sod growing on a compacted clay loam subsoil testing very low in phosphorus.

Treatment P rate lbs/1000	Turf quality rating (9=best) 7/3	8/19	9/26	Turf density (9=best) 7/3	8/19
0	4.8 a	5.2 b	5.5 b	6.5 a	5.3 b
1	5.7 a	8.8 a	8.2 a	6.8 a	8.8 a
2	6.7 a	8.8 a	8.7 a	7.7 a	9.0 a
4	6.5 a	8.5 a	8.2 a	7.3 a	8.7 a
8	6.3 a	8.5 a	8.7 a	7.7 a	9.0 a

TOPDRESSING STUDIES ON GREENS

A new study on topdressing of a Penncross creeping bentgrass green was initiated in 1986 utilizing sand and sand/peat mixes prepared by the Great Lakes Minerals Co. The objective is to determine if the addition of peat or peat and soil into the mix will result in an improved soil medium for greens. The treatments applied are given in Table 9. The TDS-50 is the sand used in the study. The 80:20 mix is 80% TDS-50 sand and 20% peat on a volume basis while the 60:20:20 mix is 60% sand, 20% peat and 20% soil. The hypothesis is that the 80:20 or the 60:20:20 mixes will result in equal quality turf (or improved) with a soil medium that will be easier to manage than sand alone because of increased water and nutrient holding capacities. Of necessity this is a long term study to allow a buildup of the topdressing material. Data taken this first year indicate there were few consistent, major differences, although there seems to be an improved turf quality following topdressing applications. Note particularly the improved turf ratings after the heavier topdressings applied in the fall compared to the ratings on the light and frequent (every 3 weeks) topdressing treatments. Since this study has just begun, we cannot yet make a recommendation based on results.

The long-term sand topdressing study which has several frequencies and rates of sand topdressing and two nitrogen rates was continued. This has been reported on in past years so no new data will be presented here. Golf course superintendents are strongly encouraged to follow their sand topdressing program faithfully to prevent any development of layers in the growing medium.

Table 9. Effect of topdressing a Penncross creeping bentgrass green mowed at 3/16 inch with Great Lakes Minerals topdressing mixes. Study initiated Spring, 1986. Hancock Turfgrass Research Center. Averages of 3 replications.

Treatment			Quality rating (9=best)		
mix	Rate cu ft/m	Frequency	Jul 7	Sept. 21	Nov 3
TDS-50	3	3 weeks	5.7 bd	5.7 bc	6.2 c
	12	Spr, Fall	6.3 b	5.7 bc	7.0 b
80:20	3	3 weeks	5.3 cd	7.3 a	6.2 c
	12	Spr, Fall	7.2 a	5.7 bc	7.8 a
60:20:20	3	3 weeks	5.5 cd	7.5 a	6.2 c
	12	Spr, Fall	7.5 a	5.7 bc	7.8 a
Check	-	-	5.2 d	5.5 c	6.0 c
TDS-50 (Cored)	12	Spr, Fall	6.0 bc	6.0 b	7.0 b

COMPARISON OF SEVERAL AERIFIERS

A comparison ofseveral aerifiers was made in September. The study was done on two sites: one on a perennial rye grass turf growing on a heavy sandy loam soil at the Hancock Turfgrass Research Center and the other on a modified sandy loam student athletic field on campus at M.S.U., which is highly compacted. Aerifiers utilized in the study were those which could be gathered from several companies at the same time. Unfortunately, some commercially available units were not available at the time of the study so these could not be included in the study.

Data collected were limited because of extended rainfall after treatment. The amount of soil removed by hollow tine units is given in Table 10. As would be expected, the Verti-Drain unit removed the most soil because of depth of tine, spacing at 2.5 inches longitudinally and diameter of tine. The new Toro aerifier was also very effective. The Salsco unit is much smaller and naturally removes less soil. These data represent soil removed from a plot area of 4 square feet and 2 samples per plot.

Data were also collected on penetrometer readings to determine relative ability of the various units to loosen the surface soil. These data are still being analyzed. Other units included in the study were the Aer-Way and Verti-Drain solid tine aerifiers.

Table 10. Weight of soil removed from 4 square feet by aerifiers. Loam soil. Hancock Turfgrass Research Center. September, 1986. Averages of 4 replications and 2 measurements per replication.

Aerifier	Dry soil wt. grams
Verti-Drain, 2.5 inch	935 a
Verti-Drain, 4 inch	639 b
Toro	727 ab
Salsco	121 c

LONG TERM NITROGEN FERTILITY STUDIES

Two long-term nitrogen fertility studies were evaluated in 1986. Treatments for these studies are outlined in Table 11 and data shown in Tables 12 and 13. These studies evaluate nitrogen fertility programs comparing carriers, rates and frequencies. These studies have been set up cooperatively with J.M. Vargas, Jr., and the first has been conducted on a Penncross creeping bentgrass green at the Hancock Turfgrass Research Center. Turfgrass Quality ratings data are given in Table 12. Results are about as expected from these treatments. Late fall applications of nitrogen (treatments 1,3,5,7,9 and 11) give better spring color. The 18-4-10 is provided by the Lebanon Chemical Col. and is used as representative complete fertilizer containing some slow release nitrogen. In May 1986 a spotty response was noted to the application of urea, ammonium nitrate and sulfur coated urea. This has been observed in the past. In all other studies with urea or ammonium nitrate we have found it necessary to apply these materials as a spray to prevent this spotty response which occurs in spite of watering immediately after application. The spottiness is caused by a high concentration of soluble nitrogen being released around the fertilizer granular giving greener spots on the greens. This is seen occasionally of annual bluegrass fairway height turf but has not been observed on turfs which are mowed higher.

The residual effects of the treatments outlined in Table 11 are given in Table 13. The study was discontinued in 1986 but some residual data were taken. The most striking response was the dramatically higher incidence of annual bluegrass seedheads for certain fertility treatments. The higher the nitrogen rate the more seedheads developed. Compare treatments 16 through 20 with rates of nitrogen ranging from 1.0 to 7.5 pounds N per 1000 square annually. Of further interest is the tendency for late fall N applications of certain carriers to result in more seedheads.

Another long term study is the effect of nine different nitrogen fertility programs on three creeping bentgrasses, Emeralds, Penncross and Penneagle. Treatments applied to these turfs which were maintained under greens conditions are given in Table 14. Turfgrass quality ratings are given in Tables 15 through 17 for the three grasses while color ratings are given in Tables 18 through 20. Responses are as would be expected from these treatments. This study will be terminated in 1987.

Table 11. Treatments applied on a Penncross bentgrass green and on annual bluegrass in a fairway nitrogen carrier fertility study at the Hancock Turfgrass Research Center. Treatments initiated in 1982 and revised in 1985. Plot size is 6 feet by 6 feet. Four replications.

Treatment		Month of application							
No.	N Carrier	Nov	Apr	May	June	July	Aug	Sept	Total
		- - - - - - - - - Pounds N per 1000 sq. ft. - - - - - - - -							
1	IBDU	1.0	---	---	0.5	0.5	0.5	1.0	3.5
2	IBDU	---	1.0	1.0	1.0	---	---	1.0	4.0
3	S.C. Urea	1.0	---	---	0.5	0.5	0.5	1.0	3.5
4	S.C. Urea	---	1.0	1.0	1.0	---	---	1.0	4.0
5	Urea	1.0	---	---	0.5	0.5	0.5	1.0	3.5
6	Urea	---	1.0	1.0	1.0	---	---	1.0	4.0
7	Am. Nitrate	1.0	---	---	0.5	0.5	0.5	1.0	3.5
8	Am. Nitrate	---	1.0	1.0	1.0	---	---	1.0	4.0
9	Milorganite	1.0	---	---	0.5	0.5	0.5	1.0	3.5
10	Milorganite	---	1.0	1.0	1.0	---	---	1.0	4.0
11	18-4-10	1.0	---	---	0.5	0.5	0.5	1.0	3.5
12	18-4-10	---	1.0	1.0	1.0	---	---	1.0	4.0
13	18-4-10	---	---	1.0	---	---	---	1.0	2.0
14	18-4-10	---	0.5	1.0	0.5	0.5	0.5	1.0	4.0
15	18-4-10	---	1.0	1.0	1.0	1.0	1.0	1.0	6.0
16	Urea	---	---	0.5	---	---	---	0.5	1.0
17	Urea	---	---	1.0	---	---	---	1.0	2.0
18	Urea	---	0.5	1.0	0.5	0.5	0.5	1.0	4.0
19	Urea	---	1.0	1.0	1.0	1.0	1.0	1.0	6.0
20	Urea	---	1.5	1.5	1.0	1.0	1.0	1.5	7.5

Table 12. Effect of long term nitrogen carrier fertility study on turfgrass quality ratings of Penncross creeping bentgrass. Treatments described in Table 11. Hancock Turfgrass Research Center. Averages of 4 replications.

Treatment	Visual turfgrass quality rating (9 = best)								
No.	5/12	6/5	6/12	6/24	7/8	8/7	9/9	9/19	10/16
1	6.0 bd	7.3 ab	5.4 gh	5.4 gh	5.6 fg	6.4 eg	7.0 de	7.1 e	7.9 a
2	5.0 dg	6.9 ac	7.4 be	5.6 be	7.4 bd	6.6 df	6.5 ef	6.1 fg	7.5 cd
3	6.6 ac	6.0 be	5.4 gh	5.3 h	5.6 fg	6.8 df	6.1 fg	5.9 fh	8.0 bc
4	4.6 eg	5.4 df	6.0 fh	6.1 fh	6.9 ce	6.9 df	5.1 i	5.5 gh	7.5 cd
5	6.9 ab	6.5 ad	5.3 gh	5.5 h	7.0 cd	8.0 ad	7.8 bc	7.8 cd	8.0 bc
6	5.4 cf	6.5 ad	8.5 ab	8.3 ac	8.5 a	7.0 bf	5.4 hi	5.6 gh	8.3 ab
7	7.5 a	7.1 ac	5.1 h	5.5 gh	6.4 dh	7.9 ac	7.8 bc	7.5 de	8.5 ab
8	5.4 cf	7.0 ac	7.9 ac	7.8 ad	8.3 ab	7.3 ae	5.0 i	5.3 hi	8.4 ab
9	4.8 dg	6.5 ad	6.5 dg	6.6 df	5.6 fg	7.1 af	6.4 eg	6.1 fg	8.0 bc
10	4.6 eg	6.5 ad	7.0 cf	7.5 ce	6.9 cd	7.1 af	6.0 fh	5.9 fh	7.3 cd
11	6.0 bd	5.8 cd	5.1 h	5.4 gh	5.4 fg	6.1 fg	5.8 gh	5.6 gh	7.4 cd
12	6.8 ab	6.9 ac	6.3 eh	6.9 df	7.4 bd	6.8 df	5.4 hi	5.4 gi	7.4 cd
13	4.5 fg	4.9 ef	6.0 fh	6.9 df	6.3 eg	5.6 g	4.9 i	4.8 ij	7.1 d
14	5.9 be	6.3 ed	6.6 cg	7.4 ce	7.5 ac	6.9 cf	6.5 ef	6.4 f	7.5 cd
15	6.6 ac	7.5 a	7.8 ad	7.5 ce	7.6 ac	8.1 a	7.4 cd	8.3 ac	7.8 bd
16	4.6 eg	4.9 ef	5.5 gh	6.4 fh	5.3 g	5.5 g	4.8 i	4.1 k	7.1 d
17	4.0 g	4.6 f	5.1 h	7.8 ad	6.0 eg	5.5 g	4.8 i	4.4 ik	7.9 bc
18	4.6 eg	6.9 ac	8.9 a	8.4 ab	8.4 ab	7.6 ad	8.4 ab	8.1 bd	8.5 ab
19	6.1 bd	7.3 ab	8.8 a	8.6 ad	8.5 a	8.1 a	8.5 a	8.8 a	8.8 a
20	6.9 ab	7.6 a	8.6 ab	8.8 a	8.4 ab	7.6 ad	8.4 ab	8.5 ab	8.3 ab

Table 13. Effect of residual nitrogen carrier fertility treatments as outlined in Table 11 on visual turf quality ratings and relative seedhead production of annual bluegrass. Hancock Turfgrass Research Center. Averages of 4 replications.

Treatment		Quality rating (9=best)	Relative seedheads (9=most)
No.	N Carrier	Apr 4	May 16
1	IBDU	2.8 ce	4.6 bf
2	IBDU	2.3 ef	6.6 gi
3	S. coated urea	3.4 ac	4.6 bf
4	S. coated urea	2.1 ef	6.1 fh
5	urea	3.9 a	5.0 bf
6	urea	2.1 ef	5.8 eg
7	ammonium nitrate	3.6 ab	4.4 bf
8	ammonium nitrate	2.3 ef	4.1 be
9	milorganite	3.1 d	3.5 bc
10	milorganite	2.1 ef	4.4 bf
11	18-4-10	3.3 ac	4.5 bf
12	18-4-10	2.4 ef	4.0 bc
13	18-4-10	2.5 df	2.9 ab
14	18-4-10	2.3 ef	3.4 ac
15	18-4-10	2.0 f	5.4 dg
16	urea	2.8 ce	1.9 a
17	urea	2.6 df	4.4 bf
18	urea	2.3 ef	5.3 dg
19	urea	2.3 ef	7.4 hi
20	urea	2.5 df	7.9 i

Table 14. Long-term nitrogen fertility program treatments which have been applied to Penncross, Penneagle or Emerald creeping bentgrass turfs mowed at 3/16 inch. Treatments initiated in 1982. All plots receive 2 pounds K_2O per 1000 sq. ft. annually. Hancock Turfgrass Research Center. Averages of 3 replications.

Treatment No.	Carrier	N rate lbs/1000	Month of application Apr	May	June	July	Aug	Sept	Nov
1	Urea	1	-	0.5	-	-	-	0.5	-
2	Urea	2	-	1.0	-	-	-	1.0	-
3	Urea	3	-	1.0	0.5	0.5	-	1.0	-
4	Urea	4	-	1.0	1.0	-	1.0	1.0	-
5	Urea	6	1.0	1.0	1.0	1.0	1.0	1.0	-
6	Urea	8	1.25	1.25	1.25	1.25	1.25	1.25	-
7	Urea	4	-	-	1.0	0.5	-	1.0	1.5
8	Milorganite	4	-	-	1.0	0.5	-	1.0	1.5
9	Ammonium nitrate	4	-	1.0	1.0	1.0	-	1.0	-

Table 15. Effect of long-term nitrogen fertility program on turfgrass visual quality rating of Emerald creeping bentgrass mowed at 3/16 inch. Hancock Turfgrass Research Center. Treatments initiated in 1982. See Table 14 for description of treatments. Averages of 3 replications.

Treatment No.	N Rates lbs/1000	Turfgrass Quality Rating (9 = best) 5/14	6/5	6/12	6/24	7/7	8/7	9/9	9/18	10/16
1	1	4.0 c	4.2 d	5.7 de	6.3 cd	4.0 c	4.0 d	4.8 d	4.5 e	7.5 a
2	2	4.5 c	4.3 d	7.2 bc	7.2 bc	5.8 ac	5.0 cd	4.7 d	4.5 e	7.8 a
3	3	4.3 c	4.2 d	8.0 ab	7.2 bc	7.3 ab	8.0 a	5.5 c	5.2 de	8.3 a
4	4	4.5 c	5.0 c	8.0 ab	7.5 ab	7.2 ab	6.3 bc	8.2 a	7.5 b	8.7 a
5	6	5.8 b	6.3 ab	8.7 a	8.3 a	7.5 ab	8.2 a	8.5 a	8.7 a	8.3 a
6	8	6.8 a	6.7 a	8.5 a	8.3 a	7.7 a	8.2 a	8.5 a	8.2 ab	8.3 a
7	4	5.7 b	5.8 b	5.0 e	5.5 d	7.3 ab	8.8 a	6.2 b	6.3 c	8.8 a
8	4	5.2 b	6.5 a	6.5 cd	6.0 d	5.8 ac	7.3 ab	5.8 bc	5.7 d	7.5 a
9	4	4.5 c	5.0 c	7.7 ab	8.0 ab	5.5 bc	8.0 a	5.7 bc	5.8 cd	7.5 a

Table 16. Effect of long-term nitrogen fertility program on turfgrass visual quality ratings of Penncross creeping bentgrass turf mowed at 3/16 inch. Hancock Turfgrass Research Center. Averages of 3 replications. See Table 14 for description of treatments.

Treatment No.	N Rate lbs/1000	Turfgrass Quality Rating (9 = best) 5/14	6/5	6/12	6/24	7/7	8/7	9/9	9/18	10/16
1	1	3.0 a	4.2 c	7.3 b	6.0 c	4.0 c	4.2 c	5.0 e	4.7 e	7.5 c
2	2	3.0 d	4.3 c	8.5 ab	7.8 ab	4.7 c	4.3 c	5.0 e	5.0 de	7.7 bc
3	3	3.3 d	4.7 c	8.3 ab	7.5 b	6.7 b	6.7 ab	5.8 de	5.5 de	8.3 ab
4	4	3.5 d	4.3 c	8.7 a	7.5 b	7.7 ab	5.7 bc	8.2 ab	7.7 b	8.3 ab
5	6	6.0 b	6.2 b	8.8 a	8.7 a	8.5 a	8.0 a	8.8 a	8.8 a	8.7 a
6	8	6.8 a	6.0 b	8.7 a	8.7 a	8.8 a	7.8 a	8.8 a	8.8 a	9.0 a
7	4	6.8 a	7.2 a	5.5 c	6.3 c	6.8 b	7.7 a	6.5 cd	6.5 c	8.7 a
8	4	4.8 c	7.5 a	7.3 b	7.5 b	5.0 c	5.7 bc	5.5 de	5.8 cd	7.2 c
9	4	3.2 d	4.5 c	8.3 ab	7.3 b	7.5 ab	7.7 a	7.2 bc	6.7 c	8.5 a

Table 17. Effect of long-term nitrogen fertility program on visual turfgrass quality rating of Penneagle creeping bentgrass mowed at 3/16 inch. Hancock Turfgrass Research Center. Treatments initiated in 1982. See Table 14 for description of treatments. Averages of 3 replications.

Treatment No.	N Rate lbs/1000	Turfgrass Quality Rating (9 = best) 5/14	6/5	6/12	6/24	7/7	8/7	9/9	9/18	10/16
1	1	4.0 e	4.7 e	5.5 d	6.0 e	4.0 d	4.3 c	5.0 c	5.0 e	7.3 a
2	2	4.2 de	4.5 e	8.0 c	7.7 c	5.3 c	4.8 c	6.8 ab	6.7 bd	8.5 a
3	3	4.8 cd	5.3 de	8.2 bc	7.7 c	7.0 b	8.2 a	5.8 bc	5.5 de	8.7 a
4	4	5.0 c	5.8 cd	8.5 ab	8.2 bc	7.3 b	6.2 b	7.0 ab	7.5 ab	8.0 a
5	6	6.2 b	7.0 ab	8.8 a	9.0 a	7.5 ab	8.0 a	8.0 a	8.5 a	8.3 a
6	8	7.0 a	7.0 ab	8.7 a	8.8 ab	8.0 a	8.0 a	8.2 a	8.7 a	7.7 a
7	4	6.0 b	6.7 bc	5.5 d	6.2 de	8.0 a	8.5 a	8.3 a	8.8 a	8.2 a
8	4	5.3 c	7.8 a	5.8 d	6.8 d	5.7 c	6.5 b	6.0 ab	5.8 ce	8.3 a
9	4	5.2 c	5.7 d	8.3 bc	8.0 c	7.2 b	7.8 a	6.8 ab	7.3 ac	8.3 a

Table 18. Effect of long-term nitrogen fertility program on turfgrass color rating of Emerald creeping bentgrass turf mowed at 3/16 inch. Hancock Turfgrass Research Center. Treatments initiated in 1982. See Table 14 for description of treatments. Averages of 3 replications.

Treatment No.	N Rate lbs/1000	Turf Color Rating (9 = dark green) 4/14	5/14	6/5	6/12	7/7	8/7	9/9	9/18	10/16
1	1	2.0 d	4.0 c	4.0 f	7.0 b	4.3 d	4.5 e	5.3 c	5.0 d	7.5 bc
2	2	2.3 cd	4.0 c	4.2 ef	8.2 a	5.7 bc	5.0 de	5.2 c	4.8 d	7.8 ac
3	3	2.0 d	4.2 c	4.2 ef	8.2 a	6.8 ac	7.7 ab	5.8 bc	5.8 c	8.0 ac
4	4	3.0 bc	4.2 c	4.3 ef	8.5 a	7.0 ab	6.2 cd	7.7 a	7.0 b	7.8 ac
5	6	2.8 bc	6.0 b	5.5 bc	8.8 a	7.3 a	7.7 ab	8.2 a	7.7 a	8.2 ab
6	8	3.0 bc	6.5 a	6.2 a	8.8 a	7.2 a	7.8 ab	8.2 a	8.0 a	7.8 ac
7	4	6.8 a	5.7 b	5.0 cd	5.5 c	7.5 a	8.5 a	6.2 b	6.0 c	8.5 a
8	4	3.3 b	5.2 c	6.0 ab	7.0 b	5.8 bc	6.8 bc	5.8 bc	5.8 c	7.3 c
9	4	2.8 c	4.7 d	4.8 de	8.3 a	5.5 cd	7.5 ac	6.2 b	5.7 c	7.5 bc

Table 19. Effect of long-term nitrogen fertility program on turfgrass color ratings of Penncross creeping bentgrass turf mowed at 3/16 inch. Hancock Turfgrass Research Center. See Table 14 for description of treatments. Averages of 3 replications.

Treatment No.	N Rate lbs/1000	Turf Color Rating (9 = dark green) 4/4	5/14	6/5	6/12	7/7	8/7	9/9	9/18	10/16
1	1	2.0 d	4.3 c	4.5 c	7.8 b	4.3 d	4.3 d	5.2 e	5.2 c	7.7 b
2	2	2.5 cd	5.0 bc	4.7 c	8.8 a	5.7 c	4.7 d	5.3 e	5.3 c	8.3 ab
3	3	2.3 d	4.7 bc	4.5 c	8.3 ab	7.3 ab	6.8 bc	6.0 d	6.3 b	8.3 ab
4	4	3.0 bc	4.8 bc	4.8 c	8.8 a	8.0 a	5.5 cd	8.0 b	8.7 a	8.3 ab
5	6	3.5 b	7.3 a	6.2 b	9.0 a	8.5 a	8.7 a	8.5 ab	8.8 a	8.8 a
6	8	3.5 b	7.5 a	6.3 b	9.0 a	8.3 a	8.3 ab	8.8 a	8.7 a	8.7 ab
7	4	6.3 a	7.3 a	6.7 b	6.5 c	6.5 bc	8.3 ab	6.7 a	6.8 b	8.8 a
8	4	3.5 b	5.3 b	7.8 a	7.7 b	6.0 bc	5.7 cd	6.0 d	6.7 b	7.7 b
9	4	3.0 bc	4.8 bc	4.8 c	8.3 ab	8.0 a	8.3 ab	7.0 c	7.0 b	8.7 ab

Table 20. Effect of long-term nitrogen ferility program on turfgrass color ratings of Penneagle creeping bentgrass mowed at 3/16 inch. Hancock Turfgrass Research Center. Treatments initiated in 1982. Hancock Turfgrass Research Center. See Table 14 for description of treatments. Averages of 3 replications.

Treatment No.	N Rate lbs/1000	Turf Color Rating (9 = dark green) 4/4	5/14	6/5	6/12	7/7	8/7	9/9	9/18	10/16
1	1	2.0 d	4.0 ef	4.5 e	6.8 c	4.0 c	5.2 e	5.5 d	5.2 c	7.7 b
2	2	2.0 d	3.8 f	4.7 de	8.7 a	5.2 b	4.7 e	6.5 cd	5.3 c	8.3 ab
3	3	2.5 d	3.7 f	4.8 de	8.7 a	7.2 a	7.5 c	5.7 d	6.3 b	8.3 ab
4	4	2.7 cd	4.5 de	5.3 cd	8.8 a	7.5 a	6.0 d	7.2 ac	8.7 a	8.3 ab
5	6	3.3 bc	6.3 b	6.3 b	9.0 a	7.5 a	8.0 bc	7.2 ac	8.8 a	8.8 a
6	8	3.5 b	7.7 a	7.0 a	9.0 a	7.3 a	8.3 ab	8.2 a	8.7 a	8.7 ab
7	4	7.0 a	6.5 b	5.8 bc	5.8 d	7.7 a	8.7 a	8.0 ab	6.8 b	8.8 a
8	4	3.3 bc	5.3 c	7.0 a	7.5 b	5.8 b	6.5 d	5.8 d	6.7 b	7.7 b
9	4	2.5 d	4.8 cd	5.0 de	8.8 a	7.0 a	8.3 ab	6.8 bd	7.0 b	8.7 ab