Nitrogen Source Study on the Otto Schmeisser-FGCSA Research Green

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During the summer of 1990, the FGCSA in cooperation with the University of Florida built a 20,000-square-foot golf course putting green at the Fort Lauderdale Research and Education Center. The purpose was to develop a field laboratory to be used by turf researchers for their projects and to conduct independent field testing of products that the superintendents wished to evaluate on bermudagrass maintained as a putting green.

The first project, initiated in May 1991 for the FGCSA, was an evaluation of nitrogen sources, primarily slow-release nitrogen sources.

A summary of green construction and the first six months of the nitrogen source study (May through October 1991) was published in the January/February 1992 issue of The Florida Green. In this article, we will summarize results obtained from November 1991 through October 1992.

Study Area and General Maintenance

The section used for this study was the area built with the geotextile material Terrabond substituted for the coarse-sand "choke" layer. The root zone mix was 80% sand and 20% Canadian peat moss as has been all material used for topdressing. The area was planted with Tifdwarf hybrid bermudagrass and has never been overseeded. It is maintained at 3/16 inch height of cut using a walk-behind greens mower with groomer attachments. The area is verticut and topdressed approximately once per month, with depth of verticutting dependent on thatch layer thickness.

Phosphorus is applied as triple super phosphate (0-46-0) twice each year (spring and fall) at 1.5 pounds phosphorus per 1,000 square feet.

The only pesticide used over the entire area during the study period was the natural insecticide

Table 1. Nitrogen analysis of products evaluated in nitrogen source study on the FGCSA Research Green at Fort Lauderdale R.E.C.

		Percentage (%)						
Company	Formulation	Total Nitrogen	Nitrate Nitrogen	Ammoniacal Nitrogen	Water Soluble Org. Nitrogen	Urea Nitrogen	Water Insoluble Nitrogen	Source of Slow-Release Nitrogen
O.M.Scott[ab]	40-0-0	40.2	0	0	10.9	12.1	17.2	Methylene Ureas[c]
Vigoro[a]	25-0-12	25.0	3.5d	1.8	0	2.0	17.7	IBDU[c], SCU[c]
Vigoro[a]	25-0-14	25.0	4.3d	0	0	10.2	10.5	IBDU, SCU
Vigoro[ab]	30-0-0	30.0	0	0	0	15.5	14.5	IBDU, SCU
Vigoro[b]	31-0-0	31.0	0	0	0	9.5	21.5	IBDU
Vigoro[b]	21-0-0	21.0	0	21.0	0	0	0	none, ammonium sulfate
LESCO[b]	46-0-0	46.0	0	0	0	46.0	0	none, urea only
LESCO[b]	29-0-0	29.0	0	0	21.75	7.25	0	SCU
Nor-Am[ab]	40-0-0	40.0	0	0	20.5	5.0	14.5	Methylene Ureas
Nor-Am[ab]	38-0-0	38.0	0	0	7.0	4.0	27.0	Methylene Ureas
Howard[a]	40-0-0	40.0	0	0	28.0	0	12.0	Methylene Ureas
Nitram[b]	34-0-0	34.0	17.0	17.0	0	0	0	none, ammonium sulfate
Cleary[ab]	18-0-0	18.0	0	0	7.2	6.3	4.5	Methylene Ureas,liquid
Traylor/Arcadian[ab]	18-0-0	18.0	0	0	9.0	9.0	0	Triazone, liquid
Greensmiths[a]	28-0-0	28.0	0	0	0	28.0	0	None[e], liquid

[a]Used in the study from November 1991 through April 1992.
[b]Used in the study from May 1992 through October 1992.
[c]Methylene Ureas are urea-formaldehyde reaction products; IBDU™ is isobutylidene diurea; SCU is sulfur coated urea.
[d]Also contains potassium nitrate as nitrogen source.
[e]Dicarbamide dihydrogensulfate (Combination product of urea and sulfuric acid.)

Bacillus thuringiensis endotoxin (Di-Pel, Abbott Laboratories) for control of sod webworms on Dec. 5, 1991 and Sept. 22, 1992. Spot treatments were made for sedge control (Basagran, BASF Corp.) on Jan. 24, Feb. 4 and April 2, 1992; fire ants (Amdro, American Cyanamid Co.) on May 8 and Sept. 3, 1992; and mole crickets (Dursban Bait, Roussel Bio Corp.) on March 7, March 24, July 10, July 25 and Aug. 12,1992.

Experimental Plan
November 1991 through April 1992

Each plot was 8 feet by 10 feet (80 square feet) with four replicate plots per nitrogen source treatment. The experimental design was a randomized complete block. The 11 treatments are listed in Table 1. Nitrogen was applied at the rate of 2 pounds per 1000 square feet per month for November through April (winter rate). Nitrogen had been applied at the rate of 1 pound per 1000 square feet per month for May through October (summer rate) for a total of 18 pounds per 1000 square feet each year. This is the average nitrogen rate used in southeastern Florida (see July/August 1992 issue of *The Florida Green*). The 2 pounds monthly nitrogen rate was applied as a 1-pound amount every 2 weeks.

For each application date, the dry formulations were applied first by hand, and immediately irrigated with 0.12 to 0.14 inches of water. Liquid formulations were applied next using a watering can, in the equivalent of 10 gallons water per 1000 square feet.

Potassium (K) was applied as potassium magnesium sulfate (Sulpomag; 0-0-22) every time the nitrogen was applied, at the same rate as the nitrogen to achieve a 1:1 ratio of N:K. Since two Vigoro materials had potassium nitrate as one of their nitrogen sources, the potassium applied to these plots was reduced accordingly to achieve the 1:1 ratio of N:K.

Soil pH was determined for each treatment prior to each nitrogen application. Soil samples (1-inch diameter by 4 inches deep) were obtained from all four replicate plots of the same nitrogen treatment and then pooled together. Soil pH for each pooled sample was determined by mixing soil and deionized water (1:1; v:v), shaking for 30 minutes and measuring pH of the filtrate.

Quality scores were determined based on grass color and density using a scale of 1 to 10 with 10 being a perfect score. On each date, two people rated the plots. Those scores were then averaged together for statistical analysis. The plots

Table 2. Quality scores resulting from nitrogen fertilizers evaluated on the FGCSA Research Green from November 1991 through April 1992 at the winter fertility rate of 2 pounds nitrogen per 1000 square feet per month.*

Company	Formula.	Nov. 21	Dec. 5	Dec. 18	Dec. 31	Jan. 15	Jan. 29	Feb. 12	Feb. 26	Mar. 11	Mar. 24	Apr. 1	Apr. 8	Apr. 22
O.M.Scott	40-0-0	6.5 a	7.2 a	6.4 ab	6.3 ab	6.7 ab	7.0 ab	6.9 bc	7.5 a	7.5 a	7.3 a	7.3 a	7.3 a	7.8 a
Vigoro	25-0-12	6.5 a	7.3 a	6.5 a	6.5 a	6.8 ab	7.0 ab	7.0 ab	7.5 a	7.5 a	7.3 a	7.3 a	7.3 a	7.8 a
Vigoro	25-0-14	6.5 a	7.3 a	6.5 a	6.5 a	6.7 ab	6.9 b	6.9 bc	7.5 a	7.5 a	7.3 a	7.2 a	7.3 a	7.8 a
Vigoro	30-0-0	6.5 a	7.3 a	6.5 a	6.5 a	6.8 ab	7.2 a	7.2 a	7.5 a	7.5 a	7.3 a	7.3 a	7.0 a	7.5 a
LESCO	29-0-0	6.5 a	7.1 a	6.5 a	6.4 ab	6.6 b	6.9 b	7.1 ab	7.5 a	7.5 a	7.3 a	7.3 a	7.1 a	7.7 a
Nor-Am	40-0-0	6.5 a	7.1 a	6.4 ab	6.3 ab	6.8 ab	6.9 b	7.1 ab	7.5 a	7.5 a	7.3 a	7.0 a	7.0 a	7.5 a
Nor-Am	38-0-0	6.4 a	7.3 a	6.4 ab	6.1 ab	6.6 b	6.6 c	6.7 cd	7.5 a	7.5 a	6.3 b	7.3 a	7.3 a	7.8 a
Howard	40-0-0	6.5 a	7.1 a	6.5 a	6.4 ab	6.8 ab	6.9 b	7.1 ab	7.5 a	7.5 a	7.3 a	7.0 a	7.1 a	7.6 a
Cleary	18-0-0	6.3 a	7.0 a	6.3 b	6.0 b	6.7 ab	6.8 bc	7.1 ab	7.5 a	7.5 a	7.3 a	7.3 a	7.3 a	7.8 a
Traylor/ Arcadian	18-0-0	6.5 a	7.3 a	6.5 a	6.5 a	6.8 ab	6.9 b	7.0 ab	7.5 a	7.5 a	7.3 a	7.3 a	7.3 a	7.8 a
Greensmiths	28-0-0	5.3 b	5.8 b	5.0 c	5.0 c	5.8 c	6.2 d	6.5 d	7.5 a	7.5 a	7.3 a	7.0 a	7.0 a	7.4 a
LSD	—	0.3	0.2	0.2	0.4	0.2	0.2	0.3	0	0	0.3	0.4	0.4	0.4

*Quality scores (color and density) are based on a scale of 1 to 10 with 10 equal to a perfect score. Values are means of four replicate plots. Means within a column followed by the same letter are not significantly different (P=0.05) according to Waller-Duncan k-ratio t-test.

were rated one week after each nitrogen application.

Whenever possible, plots were rated on sunny days between noon and 2 p.m. Some scores are missing, usually due to cultural practices (for example, top dressing) that interfered with the rating procedure. Four local golf course superintendents also rated the plots on Jan. 29, 1992.

Clippings were collected from each plot once each month from a 22-inch (mower-width) by 9-foot area (16.5 square feet), dried at 60° C and weighed. When possible, we tried to rate and collect clippings on the same day or subsequent days.

Experimental Plan for May 1992 through October 1992. The experimental plan was altered in two ways beginning in May 1992. First, four nitrogen sources used in the first year of the study (May 1991 - April 1992) were deleted. Eliminated from the experiment were

Table 3. Quality scores resulting from nitrogen fertilizers evaluated on FGCSA Research Green as rated by local golf course superintendents on January 29, 1992.*

Company	Formulation	Supt. 1	Supt. 2	Supt. 3	Supt. 4	FLREC
O. M. Scott	40-0-0	6.8 ab	6.0 abc	5.3 a	6.0 a	7.0 ab
Vigoro	25-0-12	7.0 a	6.3 ab	5.3 a	6.8 a	7.0 ab
Vigoro	25-0-14	6.8 ab	5.5 bcd	5.3 a	6.5 a	6.9 b
Vigoro	30-0-0	7.3 a	6.5 a	5.8 a	6.8 a	7.2 a
LESCO	29-0-0	6.5 ab	6.0 abc	5.3 a	6.3 a	6.9 b
Nor-Am	40-0-0	7.3 a	6.3 ab	6.3 a	6.5 a	6.9 b
Nor-Am	38-0-0	6.0 ab	5.0 d	5.8 a	6.0 a	6.6 c
Howard	40-0-0	6.3 ab	6.0 abc	6.0 a	6.3 a	6.9 b
Cleary	18-0-0	6.8 ab	5.3 cd	5.8 a	6.0 a	6.8 bc
Traylor/Arcadian	18-0-0	6.5 ab	5.8 abcd	5.3 a	6.0 a	6.9 b
Greensmith	28-0-0	5.3 b	5.0 d	5.0 a	5.8 a	6.2 d
LSD	—	1.7	0.9	1.6	1.3	0.2

*Quality scores (color and density) are based on a scale of 1 to 10 with 10 equal to a perfect score. Values are means of four replicate plots. Means within a column followed by the same letter are not significantly different (P=0.05) according to Waller-Duncan k-ratio t-test.

Vigoro's 25-0-12 and 25-0-14 (so we could apply a uniform potassium application), Howard 40-0-0 (since it is technically the same as Nor-Am 40-0-0), and Greensmiths 28-0-0 (due to "burning" problems at the winter rate). All other treatments remained in the same locations as in the previous year. Added to the experiment were IBDU, uncoated urea, ammonium sulfate and ammonium nitrate (Table 1, *Page 30*). These fertilizers were added to the study to determine their effect on the root rot disease Bermudagrass Decline which had been observed the previous summer on the Tifdwarf area. The fast-release fertilizers were also added for general comparison with the standard slow-release fertilizers.

The second plan alteration concerned nitrogen application rates. Each replicate 80-square-foot plot (8 feet by 10 feet) of each nitrogen treatment was divided into three equal sub-plots (8 feet by 3.3 feet), with each sub-plot receiving a different rate of the nitrogen treatment. The three nitrogen rates were 1 pound, 0.75 pound and 0.5 pound per 1000 square feet per month for May through October (summer rate) and will be 2 pounds, 1.5 pounds and 1 pound per 1000 square feet per month for November through April (winter rate). Thus, one rate was the same as the previous year and the other two rates represented a 25% and 50% decrease in nitrogen.

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However, the potassium (K), applied as sulpomag (0-0-22), was applied at the same rate as the previous year across all plots - 1 pound K (summer rate) and 2 pounds K (winter rate) per 1000 square feet per month. Thus, the N:K ratio was changed from 1:1 to 1.5:2 and 1:2 for the lower nitrogen rates. Fertilizers were applied every two weeks as described previously.

Soil pH and clipping weights were determined only for the highest rate (1 pound) of nitrogen. Soil pH was determined as before using pooled samples. The area sampled for clipping weights was reduced to a 22-inch (mower-width) by 7-foot area (12.8 square feet). Clipping weights were not determined for May or June, to allow for establishment of the new nitrogen sources. Quality scores were obtained for all plots using the previously described system. These scores were not obtained in May for the reason indicated above. ➥

Table 4. Quality scores resulting from nitrogen fertilizers evaluated on the FGCSA Research Green from May 1992 through October 1992 at the summer fertility rate of 1 pound nitrogen per 1000 square feet per month.*

Company	Formulation	June 2	June 17	July 14	July 27	Aug. 11	Aug. 28	Sept. 11	Oct. 12	Oct. 22
O. M. Scott	40-0-0	6.6 a	5.8 b	5.8 cd	6.8 ab	6.5 ab	7.5 a	7.0 a	6.6 ab	6.3 ab
Vigoro	30-0-0	6.8 a	5.8 b	5.4 d	6.6 cd	6.0 b	7.5 a	7.0 a	7.1 a	6.4 a
Vigoro	31-0-0	6.6 a	5.7 b	5.6 cd	6.8 ab	6.0 b	7.5 a	7.0 a	7.1 a	6.7 a
Vigoro	21-0-0	6.8 a	5.6 bc	5.9 bc	6.8 ab	6.8 a	7.5 a	7.0 a	6.9 a	6.4 a
LESCO	46-0-0	6.8 a	5.9 ab	5.7 cd	6.8 ab	6.0 b	7.5 a	7.0 a	6.9 a	6.2 ab
LESCO	29-0-0	6.6 a	5.7 b	5.7 cd	6.7 ab	6.3 ab	7.5 a	7.0 a	6.8 a	6.3 ab
Nor-Am	40-0-0	6.7 a	5.9 ab	5.9 bc	6.7 ab	6.0 b	7.5 a	7.0 a	6.9 a	6.6 a
Nor-Am	38-0-0	6.6 a	6.4 a	6.4 a	6.8 a	6.8 a	7.5 a	7.0 a	7.0 a	6.3 ab
Nitram	34-0-0	6.8 a	5.1 c	5.6 cd	6.5 c	6.8 a	7.5 a	7.0 a	6.2 b	5.7 b
Cleary	18-0-0	6.6 a	5.8 b	6.3 ab	6.8 a	6.0 a	7.5 a	7.0 a	6.9 a	6.5 a
Traylor /Arcadian	18-0-0	6.6 a	5.9 ab	5.8 cd	6.8 ab	6.5 ab	7.5 a	7.0 a	7.0 a	6.7 a
LSD	—	0.2	0.5	0.4	0.2	0.6	0	0	0.4	0.6

*Quality scores (color and density) are based on a scale of 1 to 10 with 10 equal to a perfect score. Values are means of four replicate plots. Means within a column followed by the same letter are not significantly different (P=0.05) according to Waller-Duncan k-ratio t-test.

Table 5. Clipping weights (grams) resluting from nitrogen fertilizers evaluated on FGCSA Research Green at the winter fertility rate (November 1991 through April 1992) and summer fertility rate (May 1992 through October 1992).*

Company	Ratio	Nov. 19	Dec. 17	Jan. 29	Feb. 26	Apr. 1	Apr. 22	July 29	Aug. 27	Sept. 23	Oct. 28
O. M. Scott	40-0-0	5.201 a	1.785 a	5.456 abc	10.944 ab	4.548 a	8.542 a	8.082 bcd	6.433 a	8.651 abc	2.052 ab
Vigoro	25-0-12	5.852 a	1.900 a	4.560 c	10.283 ab	5.223 a	9.670 a	—**	—	—	—
Vigoro	25-0-14	4.652 a	2.104 a	4.554 c	10.171 ab	4.508 a	9.076 a	—	—	—	—
Vigoro	30-0-0	5.480 a	2.198 a	4.875 bc	10.122 ab	4.895 a	9.299 a	6.975 cde	6.326 ab	7.205 bcd	2.620 ab
Vigoro	31-0-0	—	—	—	—	—	—	6.604 de	6.789 a	7.007 cd	2.868 a
Vigoro	21-0-0	—	—	—	—	—	—	9.462 a	6.955 a	9.572 a	2.410 ab
LESCO	46-0-0	—	—	—	—	—	—	6.786 de	6.778 a	9.399 a	1.893 ab
LESCO	29-0-0	4.337 a	2.229 a	4.507 c	10.304 ab	4.482 a	8.504 a	7.298 cde	6.657 a	9.914 a	2.787 ab
Nor-Am	40-0-0	4.644 a	2.028 a	5.183 abc	9.416 b	3.931 a	7.756 a	7.276 cde	6.292 ab	8.838 ab	2.056 ab
Nor-Am	38-0-0	4.136 a	1.859 a	5.095 abc	9.500 b	4.267 a	8.548 a	8.682 ab	6.081 ab	7.450 bcd	1.653 ab
Howard	40-0-0	5.605 a	1.942 a	6.985 a	10.240 ab	4.655 a	8.331 a	—	—	—	—
Nitram	34-0-0	—	—	—	—	—	—	6.535 e	6.191 ab	9.862 a	1.833 ab
Cleary	18-0-0	5.089 a	1.803 a	5.090 abc	9.998 ab	4.589 a	9.906 a	8.296 abc	6.264 ab	7.555 bcd	1.620 b
Traylor /Acadian	18-0-0	6.174 a	2.282 a	6.495 abc	12.253 a	5.209 a	9.994 a	7.022 cde	5.106 b	6.790 d	1.642 ab
Greensmiths	28-0-0	4.448 a	2.140 a	5.208 abc	10.226 ab	3.692 a	7.070 a	—	—	—	—
LSD	—	2.480	0.732	1.912	2.482	1.787	3.025	1.354	1.289	1.815	1.228

*Values are means of four replicate plots. Means within a column followed by the same letter are not significantly different (P=0.05) according to Waller-Duncan k-ratio t-test. **Not tested during this 6-month study period.

Results and Discussion

When comparing quality and quantity scores for each date, please note that values in the column for that date that are followed by the same letter are not statistically different from each other.

You will note that at the end of each column, there is a value called LSD which means "Least Significant Difference". The LSD value is a value that the treatment must exceed to be considered significantly different.

In the footnote for these tables, it is indicated that "P=0.05". This indicates we are 95% confident that means exceeding the LSD value (for each column) are in fact different and that the observed variation is not due to random chance.

The best explanation of statistical analysis and reasons for replications, test design, etc. can be found in December 1990 issue of *Golf Course Management* in an article entitled "Developing a Test Program on the Golf Course" by Dr. Nick Christians.

Table 2 *(Page 32)* lists the quality scores for nitrogen sources evaluated from November 1991 through April 1992 at the 2-pound winter rate. The primary difference was the poor quality expressed by plots treated with Greensmith's N-pHURIC product (18-0-0/liquid) which is a combination of urea and sulfuric acid. The grass was "burned" by this product when applied as described earlier. It was necessary to increase the amount of water used to apply this product from 10 gallons to 33 gallons per 1000 square feet to eliminate the "burning" effect. By the end of February, this problem had been solved.

After this time, there were no significant differences among treatments, except on March 24 when the quality of the Nor-Am methylene urea product (38-0-0) was obviously less than the other products.

Since four local golf course superin-

tendents were at the FLREC on a quality-rating date (Jan. 29, 1992), they were asked to also rate the plots using our 1-10 scale. Table 3 *(Page 34)* is a summary of their results as compared to the rating by the FLREC staff. This simply illustrates that each superintendent has different quality standards and/or perceptions of quality.

The only thing we all agreed on was the poor quality of the Greensmith product due to the "burning" effect described earlier.

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Table 4 *(Page 35)* lists the quality scores for the highest nitrogen rate (1 pound summer rate) for the nitrogen sources evaluated from May 1992 through October 1992.

Seven of the eleven products were the same as used in the November 1991 through April 1992. This would also be the second year that these seven products have been evaluated at the summer fertility rate. The results can be compared to those reported in the January/February 1992 issue of The Florida Green.

From June through September, the product with the most consistent quality ratings was the Nor-Am methylene urea product (38-0-0). There were no observed differences between any nitrogen source treatment on Aug. 28 and Sept. 11. No above-ground symptoms of Bermudagrass Decline were ever observed on the Tifdwarf area, so no evaluation could be made concerning the effect of nitrogen sources on this disease. However, the roots did exhibit initial symptoms of a root decline beginning in October, indicating the plants would be highly susceptible to any stress imposed on the area. It was at this time that we began to observe distinct necrotic (brown) patches (2-inch diameter) associated with specific plots in the nitrogen source study. They were not observed on any other portion of the research green and were not due to a specific plant pathogen or insect. Since the patches stopped and started at plot boundaries, we believe we were observing a fertilizer burn, albeit a strange one.

The ammonium nitrate (34-0-0) plots were affected the most (3 out of 4 replicate main plots), but other random plots (1 or 2 replications) of both slow-release and fast-release nitrogen sources had these patches also.

In general, as the rate of nitrogen decreased for a particular nitrogen

Table 6. Soil pH values associated with nitrogen fertilizer treatments evaluated on FGCSA Research Green at the winter fertility rate (November 1991 through April 1992) and summer fertility rate (May 1992 through October 1992).*

Company	Formulation	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
O. M. Scott	40-0-0	6.6	6.9	6.3	6.4	6.3	6.9	7.2	6.5	6.2	6.6	6.9	6.7
Vigoro	25-0-12	6.8	6.7	6.4	6.4	6.4	6.7	—**	—	—	—	—	—
Vigoro	25-0-14	6.7	6.6	6.5	6.6	6.3	6.6	—	—	—	—	—	—
Vigoro	30-0-0	6.5	6.5	6.3	6.5	6.2	6.6	6.8	7.1	6.0	6.8	6.8	6.8
Vigoro	31-0-0	—	—	—	—	—	—	7.0	6.4	6.0	6.8	6.9	6.6
Vigoro	21-0-0	—	—	—	—	—	—	7.2	7.1	6.0	6.5	6.8	6.1
LESCO	46-0-0	—	—	—	—	—	—	7.0	6.7	6.0	6.7	6.9	6.4
LESCO	29-0-0	6.2	6.3	5.6	5.6	5.8	5.9	6.2	6.6	6.0	6.1	6.5	6.3
Nor-Am	40-0-0	6.5	6.5	6.4	6.5	6.4	6.7	7.0	7.1	6.0	6.6	6.8	6.6
Nor-Am	38-0-0	6.6	6.6	6.4	6.7	6.5	6.9	6.9	7.0	6.0	6.7	7.0	6.7
Howard	40-0-0	6.7	6.7	6.5	6.6	6.4	7.0	—	—	—	—	—	—
Nitram	34-0-0	—	—	—	—	—	—	6.8	7.0	6.2	6.5	6.7	6.4
Cleary	18-0-0	6.9	6.5	6.4	6.6	6.3	7.1	7.0	7.0	5.9	6.5	6.8	6.6
Traylor /Arcadian	18-0-0	6.7	6.4	6.3	6.6	6.3	6.6	7.2	7.0	6.0	6.8	6.9	6.5
Greensmiths	28-0-0	6.4	6.3	6.0	6.3	5.9	6.3	—	—	—	—	—	—

*Values represent results of pooled samples from all four replicate plots of each nitrogen source treatment. Therefore, no statistical analysis were performed.

**Not tested during this 6 month study period.

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source, the number of necrotic patches increased! Again, there was no particular logic to the locational occurrence of the necrotic patches, but they were present and may have been indicative of an underlying stress problem such as the initial root decline symptoms.

Table 5 *(Page 38)* is a summary of the clipping weights obtained for the entire year: November 1991 - April 1992 at the winter 2-pound N rate and May 1992 - October 1992 at the summer 1-pound N rate. Again, there was no obvious trends in relationship to the nitrogen sources. The low clipping weights in December can be attributed to cool weather. The low weight in October correlates with the appearance of the necrotic patches and perhaps confirms that the grass was under a physiological stress at this time.

Table 6 *(above)* is a summary of soil pH values obtained for the entire year. Although soil pH was determined twice each month, only one value per month is provided since the results were very similar. It should be noted that the water used for irrigation has moderate to high calcium carbonate levels and the pH averages 7.5-8.0. The greatest difference in pH values occurred between June and

July. This may be due to the fact that we had 11.5 inches of rain from June 22 to June 29.

In general, sulfur-coated urea (LESCO 29-0-0) had the lowest soil pH values. However, it would be expected that, over time, the ammonium sulfate (21-0-0) would also result in lower soil pH values. This trend appeared to be developing by October. This is not surprising since elemental sulfur and the ammonium ion are both acid-forming materials. Note that it is the ammonium ion and not the sulfate ion in ammonium sulfate that is acid forming.

Table 7 *(Page 40)* summarizes the quality scores for the nitrogen sources evaluated at three different nitrogen rates from May through October 1992. Again, the most noticeable differences in quality between nitrogen sources and rates were in October when the necrotic patches were dominant. Quality scores obtained would suggest that there may be few differences between nitrogen sources (fast-release and slow-release) or nitrogen rates when the potassium application rate is kept constant.

Remember that the potassium (K) rate was 1 pound per 1000 square feet per month across all nitrogen rates resulting in different N:K ratios for each nitrogen rate treatment. The results could be quite different if the potassium rate was reduced to achieve a N:K ratio of 1:1 for all treatments. Also, these results must be viewed as preliminary since they are only from one six-month study period. The experiment must be continued for a valid assessment to be made.

It is important to remember that each golf course is different in terms of amount of play (winter vs. summer) and expected quality and speed on putting greens. The research green does not receive any play and so is not stressed in this manner.

As can be observed in Table 3, the individual superintendent's quality expectations differ also. The other factor that often determines quality is the course's budget. The bottom line is that each superintendent must be a good consumer to obtain the best product for the needs of their particular course. Each golf course situation is unique, and you must decide what is most appropriate for your situation.

We would like to thank the following companies who have donated material and equipment for maintenance of the research green: DeBra Turf, Golf Agronomics, Hector Turf, Liqua-Tech, NuCrane Equipment Co., and Vigoro Industries. In addition, we would like to thank the equipment dealers and turfgrass suppliers who support the SFGCSA Turfgrass Exposition each year as funds raised from that event are also used to support research at the FLREC.

Table 7. Quality scores resulting from nitrogen fertilizers evaluated on the FGCSA Research Green from May 1992 through October 1992 at three rates of nitrogen - 1 pound (A), 0.75 pound (B) and 0.5 pound (C) per 1000 square feet per month.*

Company	Formulation	N Level	June 2	June 17	July 14	July 27	Aug. 11	Aug. 28	Sept. 11	Oct. 12	Oct. 22
O. M. Scott	40-0-0	A	6.6 ab	5.8 b	5.8 cd	6.8 ab	6.5 ab	7.5 a	7.0 a	6.6 a-f	6.3 a-e
		B	6.6 ab	5.8 b	5.8 cd	6.8 ab	6.3 ab	7.5 a	7.0 a	6.4 d-h	6.1 a-f
		C	6.6 ab	5.8 b	5.8 cd	6.7 abc	6.3 ab	7.5 a	7.0 a	6.4 d-h	5.9 b-g
Vigoro	30-0-0	A	6.8 a	5.8 b	5.4 ef	6.6 bcd	6.0 b	7.5 a	7.0 a	7.1 ab	6.4 a-d
		B	6.7 a	5.8 b	5.4 ef	6.6 bcd	6.0 b	7.5 a	7.0 a	6.8 a-e	6.4 a-d
		C	6.6 ab	5.8 b	5.4 ef	6.4 d	6.0 b	7.5 a	7.0 a	6.7 a-f	6.2 a-e
Vigoro	31-0-0	A	6.6 ab	5.7 b	5.6 def	6.8 ab	6.0 b	7.5 a	7.0 a	7.1 ab	6.7 a
		B	6.6 ab	5.7 b	5.6 def	6.8 ab	6.0 b	7.5 a	7.0 a	7.1 ab	6.6 ab
		C	6.6 ab	5.8 b	5.6 def	6.8 ab	6.0 b	7.5 a	7.0 a	6.8 a-e	6.3 a-e
Vigoro	21-0-0	A	6.8 a	5.6 b	5.9 bc	6.8 ab	6.8 a	7.5 a	7.0 a	6.9 a-d	6.4 a-d
		B	6.6 ab	5.6 b	5.9 bc	6.8 ab	6.5 ab	7.5 a	7.0 a	6.8 a-e	6.3 a-e
		C	6.6 ab	5.6 b	5.8 cd	6.8 ab	6.3 ab	7.5 a	7.0 a	6.7 a-f	6.0 a-g
LESCO	46-0-0	A	6.8 ab	5.9 b	5.7 c-f	6.8 ab	6.0 b	7.5 a	7.0 a	6.9 a-d	6.2 a-e
		B	6.8 ab	5.9 b	5.7 c-f	6.8 ab	6.0 b	7.5 a	7.0 a	6.8 a-e	6.1 a-f
		C	6.5 abc	5.9 b	5.6 def	6.6 bcd	6.0 b	7.5 a	7.0 a	6.6 a-f	5.9 b-g
LESCO	29-0-0	A	6.6 ab	5.7 b	5.7 c-f	6.7 abc	6.3 ab	7.5 a	7.0 a	6.8 a-e	6.3 a-e
		B	6.6 ab	5.7 b	5.6 def	6.4 d	6.0 b	7.5 a	7.0 a	6.5 c-g	5.8 c-g
		C	6.5 abc	5.7 b	5.6 def	6.5 cd	6.0 b	7.5 a	7.0 a	6.2 fgh	5.3 fg
Nor-Am	40-0-0	A	6.7 a	5.9 ab	5.9 bc	6.7 abc	6.0 b	7.5 a	7.0 a	6.9 a-d	6.6 ab
		B	6.6 ab	5.9 ab	5.8 cd	6.6 bcd	6.0 b	7.5 a	7.0 a	6.8 a-e	6.4 a-d
		C	6.5 abc	5.9 ab	5.8 cd	6.6 bcd	6.0 b	7.5 a	7.0 a	6.6 a-f	6.3 a-e
Nor-Am	38-0-0	A	6.6 ab	6.4 a	6.4 a	6.8 ab	6.8 a	7.5 a	7.0 a	7.0 abc	6.3 a-e
		B	6.7 a	6.4 a	6.4 a	6.8 ab	6.3 ab	7.5 a	7.0 a	6.9 a-d	6.3 a-e
		C	6.6 ab	6.4 a	6.4 a	6.8 ab	6.3 ab	7.5 a	7.0 a	6.7 a-f	5.9 b-g
Nitram	34-0-0	A	6.8 a	5.1 c	5.6 def	6.5 cd	6.8 a	7.5 a	7.0 a	6.2 fgh	5.7 d-g
		B	5.9 e	5.1 c	5.6 def	6.4 d	6.0 b	7.5 a	7.0 a	6.0 gh	5.5 efg
		C	6.1 cde	5.1 c	5.6 def	6.4 d	6.0 b	7.5 a	7.0 a	5.9 h	5.3 fg
Cleary	18-0-0	A	6.6 ab	5.8 b	6.3 ab	6.8 a	6.0 b	7.5 a	7.0 a	6.9 a-d	6.5 abc
		B	6.2 b-e	5.8 b	6.3 ab	6.8 a	6.3 ab	7.5 a	7.0 a	6.6 a-f	6.0 a-g
		C	6.4 a-d	5.8 b	6.3 ab	6.8 a	6.3 ab	7.5 a	7.0 a	6.7 a-f	5.9 b-g
Traylor /Arcadian	18-0-0	A	6.6 ab	5.9 ab	5.8 cd	6.8 a	6.5 ab	7.5 a	7.0 a	7.0 abc	6.7 a
		B	6.2 b-e	6.0 ab	5.8 cd	6.8 a	6.3 ab	7.5 a	7.0 a	6.9 a-d	6.6 ab
		C	6.1 cde	6.0 ab	5.6 def	6.6 bcd	6.0 b	7.5 a	7.0 a	6.8 a-e	6.2 a-e
LSD	—	—	0.4	0.5	0.4	0.2	0.6	0	0	0.5	0.8

*Quality scores (color and density) are based on a scale of 1 to 10 with 10 equal to a perfect score. Values are means of four replicate plots. Means within a column followed by the same letter are not significantly different (P=0.05) according to Waller-Duncan k-ratio t-test.