

**Tifton 85 Bermudagrass Response to Nitrogen Rates and Sources With and Without Urease
Inhibitor and Poly Coating Treatments**

A report of 2009 research results
And three year cumulative results

Participating companies include (in alphabetical order):

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Increasing environmental restrictions, increasing energy costs for production and use, and international trade are affecting the fertilizer industry. Industry groups are working to improve environmental impacts and efficiency of N fertilizers for crop production. Under most conditions, surface-applied urea fertilizers lose N by volatilization of ammonia. This research was initiated to evaluate N sources, rates, and selected chemical additives developed to prevent or delay N losses from surface-applied urea and urea based N fertilizers.

Materials and Methods

Tifton 85 (*Cynodon* spp.), a sterile pentaploid hybrid cross between a South African plant introduction (PI 290884, Tifton 296), and Tifton 68, a cross between PI 255450 and PI 293606, both from Kenya, is a vegetatively propagated bermudagrass hybrid. Establishment of Tifton 85 rapidly expanded across southern states. With adequate rainfall, Tifton 85 is cut for hay about every four weeks and normally fertilized with surface applied N for each regrowth.

This study was conducted on Darco soil (loamy, siliceous, semiactive thermic Grossarenic Paleudult) that has a four-foot depth of loamy fine sand from the surface to the B-horizon, or depth of the clay layer. Site preparation included removal of bermudagrass stubble on 23 April 2009 and application of 30 lb N, 80 lb P₂O₅, 150 lb K₂O, 30 lb S, and 15 lb Mg/ac on 30 April. Additional K at 100 lb K₂O/ac was applied to the site on 17 July. Plot size was 10 ft wide by 15 ft long with treatments arranged in a randomized complete block design with four replications.

Each N source was applied at 45 and 90 lb of N/ac. Dry N sources were applied by hand. These materials included urea, ESN, Nutrisphere coated urea, Agrotain coated urea, ammonium nitrate, ammonium sulfate, and two separate blends of urea ammonium sulfate, one as 33.5% N and the other 40% N. Fluid N sources were applied using a bicycle-wheel mounted sprayer with a 15-ft boom fitted with flat fan nozzles spaced at 20 inches. Spraying speed was monitored using an attached speedometer. Fluids were placed in five gallon beverage dispensing containers and CO₂ pressurized applications were made 20 inches above the soil surface (Fig. 1). Fluid N sources were UAN, UAN+ 0.5% Nutrisphere, and UAN+ Agrotain. Harvests were made using a Swift Machine forage plot harvester manufactured in Swift Current, Saskatchewan Canada (Fig. 2).



Figure 1. Applying fluid fertilizers.



Figure 2. Harvesting Tifton 85 bermudagrass.

Results

Nitrogen treatment dates, rainfall data, irrigation dates, and harvest dates are indicated in Table 1. After the experimental site was initially fertilized, bermudagrass regrowth on the site was mowed on 8 May. The first N rates from all sources were applied 13 May. Nighttime minimum air temperatures remained cool from 13 May through the end of May with lows below 60 degrees eight nights. Harvests were made approximately four weeks after N fertilizer application for the first three harvests. A management decision was made after the fourth N application to let the Tifton 85 grow for a longer period because of slow growth from cooler nighttime temperatures and shorter day length. The fourth harvest was made approximately seven weeks after fertilization. Rainfall through the growing season was sporadic. Measured rainfall from N application to harvest was 1.31 inches for the first harvest, 0.53 inches for the second harvest, 5.11 inches for the third harvest and 14.79 inches for the seven weeks before the fourth harvest. Supplemental irrigation was supplied three times for the second harvest and once for the fourth harvest. Approximately one half inch of water was applied each irrigation at the first sign of plant wilt. Rainfall was measured within 24 hours of N fertilization after the first and third applications and approximately 10 days passed after the second and fourth N applications before irrigation was warranted. Fury 1.5 EC insecticide (S-Cyano (3-phenoxyphenyl)methyl (\pm) cis/trans 3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropane carboxylate) was applied 29 Sept. to control fall armyworms before damage to the Tifton 85 could occur.

Dry matter yields (DMY) for the 2009 growing season are presented in Table 2. The nitrogen rate main effect was averaged over all N sources. Increasing the rate of N fertilizer increased nitrogen rate main effect DMY throughout the year. Dry matter yields for the year were lowest in the 9 June harvest because of the cool weather. Dry matter yields from the later three harvests were similar for the individual N rates. Applying 45 lb N/ac increased DMY three to almost six times compared to the check plots. In the yearly total, increasing N rate to 45 lb (a total of 180 lb N/ac for the year) increased DMY almost 4.5 times compared to the N check plot. The 90 lb N rate (a total of 360 lb N/ac for the year) increased yield another 2 t/ac over the 45 lb N/ac rate, or 6.25 times the DMY produced in the check plots.

Nitrogen source main effects were averaged over N rates. Dry matter yields in harvest one showed most dry materials producing statistically equal yields of approximately 1 t/ac, and these yields were higher than the liquid UAN based sources. The ESN fertilizer yielded statistically lowest DMY. In the 13 July harvest, all materials produced equal yields of about 1.5 to 1.75 t/ac except the ESN, which was statistically lower at 2,192 lb/ac. The 12 Aug. cutting showed the highest yields of about 1.8 t/ac produced in plots which received Agrotain coated urea and the 40% N blend of urea and ammonium sulfate. Lowest yields were measured in plots that received UAN or ammonium nitrate. Dry matter yields from all other sources were equal. The last harvest of the year showed the ESN plots produced the highest DMY of 3,572 lb/ac. Lowest DMY were from plots receiving urea, and UAN+ 0.5% Nutrisphere. DMY from all other sources were statistically equal. Seasonal total DMY were slightly higher than DMY produced in 2008 and slightly lower than the 2007 DMY. Dry matter yield of almost 6.25 t/ac were grown on plots receiving either the 33.5% or 40% N blends of urea ammonium sulfate, or Agrotain coated urea. Statistically equal yields of slightly less than 6 t/ac were produced in plots receiving either ammonium sulfate, urea, Nutrisphere coated urea, or ammonium nitrate. Dry matter yields of approximately 5 t/ac were measured in plots receiving UAN + Agrotain or ESN. Lowest yields of slightly less than 5 t/ac were grown on plots fertilized with UAN or UAN+ 0.5% Nutrisphere.

The effects of the early cool weather on suppressing DMY of Tifton 85 at the 45 lb/ac N rate can be seen in Table 3. The lowest DMY of the season, 0.75t/ac or less, were produced in the first harvest. In this 9 June cutting, the 40%, and 33.5% blend of urea and ammonium sulfate, urea, and the Agrotain coated urea produced the highest yields. Statistically equal yields were produced in plots receiving ammonium

nitrate, ammonium sulfate, Nutrisphere coated urea, UAN+ Agrotain, and UAN+ 0.5% Nutrisphere. Lowest DMY were from plots with ESN as the N source. The second harvest again had lowest yields from the ESN fertilized plots. All other dry materials had statistically greater DMY. The 12 Aug. harvest showed no statistical differences due to N source at this 45 lb/ac N rate. Dry matter yield ranged from a high of 3,589 to a low of 2,229 lb/ac. The 19 Oct. harvest had the highest DMY of 3,270 lb/ac in the ESN plots. Statistically equal yields were from plots fertilized with 33.5% urea ammonium sulfate, ammonium sulfate, 40% N urea ammonium sulfate, ammonium nitrate, and Nutrisphere coated urea. Yearly total DMY approaching 5.5 t/ac were produced from the plots receiving either 33.5% N or 40% N from a blend of urea ammonium sulfate. Seasonal total DMY were the lowest at 6,826 lb/ac from plots which had UAN as the N source.

Cool nighttime temperature effects on lower DMY in the first harvest can also be seen at the 90 lb/ac N rate (Table 4.). As it was for the 45 lb/ac N rate, only 10 to 19% of the yearly DMY production came from the first harvest. The highest yield of 2,560 lb/ac was produced by the 40% N urea ammonium sulfate blended material. Statistically equal yields were produced by Agrotain coated urea, Nutrisphere coated urea, ammonium sulfate, ammonium nitrate, urea, 33.5% N urea ammonium sulfate and UAN. The lowest DMY of 1,089 lb/ac was produced in the ESN plots. Dry matter yield from the 13 July harvest showed all other sources producing higher yields than the ESN treated plots, with the 40% N urea ammonium sulfate treatment yielding the highest at 4,360 lb/ac. The 40% N urea ammonium sulfate and the Agrotain coated urea plots had the greatest DMY in the 12 Aug. harvest, with the plots receiving ammonium nitrate having the lowest yields of 3,002 lb/ac. No statistical differences were measured in the fourth harvest as yields ranged from close to 1.5 t/ac to slightly more than 2 t/ac. Seasonal total DMY were highest in plots receiving Agrotain coated urea, 40% N urea ammonium sulfate, and ammonium sulfate, where plots produced more than 7 t/ac for the year. The lowest yields of slightly more than 5.5 t/ac DMY were produced by ESN. Yields from all other plots were statistically equal.

As expected, main effects of N rate and N source showed increasing N rates statistically increased plant N concentrations throughout the season (Table 5). Seasonal averages ranged from 1.37% N in the N check plots to 2.16% N in the 90 lb N/ac plots. There were statistically significant differences in plant N concentrations due to N sources. In the 9 June harvest, highest N concentrations were from plots receiving 33.5% N as urea ammonium sulfate and ammonium nitrate. Equivalent N concentrations were measured in plots fertilized with urea, Agrotain coated urea, Nutrisphere coated urea, the 40% N urea ammonium sulfate blend and ammonium sulfate. Lowest N concentrations were from plots with UAN, ESN, and UAN+ 0.5% Nutrisphere. Plant analysis of second-harvest bermudagrass shows Agrotain coated urea produced the highest plant N concentration at 2.24%, which was significantly higher than the Nutrisphere coated urea and three fluid sources. All other dry N fertilizers produced plant N concentrations equal to plant N concentrations produced by Agrotain coated urea. Plant N concentrations from the 12 Aug. and 19 Oct. harvests are practically identical. Each show the ESN source plots having the highest N concentration. The remaining dry sources produced statistically equal N concentrations and had higher N concentrations than the liquid sources, except for urea in the third cutting. The seasonal average N concentrations showed all dry fertilizer sources produced equal plant N concentrations at approximately 2% N, and this was higher than the plant N concentrations produced by liquid sources.

Tifton 85 plant N concentration response to N sources at the 45 lb N/ac rate showed no statistical differences between N sources in the first harvest with N concentrations ranging from 1.63 to 1.90% (Table 6). In the 13 July harvest, all dry N sources except Nutrisphere coated urea produced higher plant N concentrations than the liquid sources. The 12 Aug. cutting showed the ESN produced higher N concentrations than all other sources except Agrotain coated urea and the two urea ammonium sulfate blends. The fourth harvest again showed plant samples from the ESN plots produced the highest plant N concentration. Lowest plant N was measured in plants from the UAN-treated plots. The seasonal average

at the 45 lb N/ac rate showed the ESN treated plots produced higher plant N concentrations at 1.83% than samples from Nutrisphere coated urea and the three fluid sources.

The highest plant N concentrations at the 90 lb/ac N rate in the first harvest were measured from the ammonium nitrate plots, and lowest in the ESN treated plots (Table 7). Results from the 13 July cutting showed ammonium nitrate, Agrotain coated urea, and urea produced greater plant N concentrations than the liquid sources. The 12 Aug. harvest showed highest plant N concentrations from plots fertilized with ESN, ammonium nitrate, 33.5% urea ammonium sulfate, Nutrisphere coated urea, ammonium sulfate, and the 40% urea ammonium sulfate blend. These concentrations were all greater than the plant N concentrations from the fluid fertilizer treated plots. In the final harvest, highest plant N concentrations occurred in the ESN-treated plots and in the ammonium sulfate treated plots. Lowest concentrations were measured in the liquid N treated plots. In the seasonal average, all plots treated with dry fertilizer material had the highest plant N concentrations ranging from 2.39 to 2.21%.

Nitrogen rate main effects on plant N uptake occurred as expected with increased uptake as N rate was increased (Table 8). This pattern continued throughout the year and in the seasonal total. Nitrogen source main effects on N uptake in the first harvest show all the dry materials except ESN had higher uptake than the liquid fertilizers. The ESN treated plots had the lowest uptake. Agrotain coated urea, urea, ammonium sulfate, the two urea ammonium sulfate blends and Nutrisphere coated urea had the highest plant N uptake in the 13 July harvest. In the 12 Aug. harvest, bermudagrass treated with the 40% N urea ammonium sulfate and the ESN treated plots had the greatest N uptake and the ESN plots again had the highest uptake in the final harvest of the year. Total N uptake showed the dry materials were equal and all were greater than the fluid materials relative to plant N. Seasonal total plant N uptake ranged from 254 to 165 lbs/ac.

Plant N uptake at the 45 lb N/ac rate (Table 9) shows the two urea ammonium sulfate blends, Agrotain coated urea, and urea having the highest plant N uptake the first harvest. In the second cutting, Agrotain coated urea, urea, and the 33.5% urea ammonium sulfate blend have the highest uptake. The 12 Aug. harvest shows plant N uptake for the 40% urea ammonium sulfate was higher than from UAN with all other sources producing equal plant N uptake. Analysis of the 19 Oct. cutting indicates ESN generated the highest plant N uptake and UAN the lowest. The seasonal total shows the three highest sources producing plant N uptake were the two urea ammonium sulfate blends and the Agrotain coated urea with uptake in the 180 to 190 lb/ac range.

Main effects of N source on plant N uptake at the 90 lb N rate show higher uptake produced by the dry N sources (Table 10). In the 9 June harvest, the highest plant N uptake occurred in plots fertilized with the 40% N blend of urea ammonium sulfate, Nutrisphere coated urea, ammonium nitrate, Agrotain coated urea, and urea. Agrotain coated urea also produced the highest plant N uptake in the second harvest, and in the 12 Aug. harvest along with ESN and the 40% N urea ammonium sulfate. The ESN source produced the highest plant N uptake in the year's final harvest. The seasonal total shows bermudagrass fertilized with Agrotain coated urea, ammonium sulfate, and 40% and 33.5% urea ammonium sulfate had statistically higher plant N uptake than grass fertilized with the fluid sources with uptakes greater than 300 lb/acre

Nitrogen uptake efficiency is a calculation based on plant N uptake and the applied N rate. Nitrogen uptake efficiency is a measure of utilization of applied N fertilizer, which in these data were calculated from the above ground vegetation only. Normally uptake efficiency is higher at lower N fertilizer rates, however this was not seen in either the 2008 or the 2009 data presented here (Table 11). In the seasonal average N uptake efficiency N rate main effects, there was no statistical difference between the 45 (69.1%) and 90 lb N/ac rates (70.7%). Seasonal average plant N uptake efficiencies for the N source main effects ranged from a high of 84.4% to a low of 46.8%. All dry N sources had statistically higher

uptake efficiencies than the dry sources. Sources ranked from high to low in the following order: 33.5% N urea/ammonium sulfate, Agrotain coated urea, 40% N urea/ammonium sulfate, ammonium sulfate, ammonium nitrate, urea, Nutrisphere coated urea, and ESN which were all statistically equal and greater than UAN+Agrotain, UAN+0.5% Nutrisphere, and UAN. Seasonal average plant N uptake efficiencies at the 45 lb/ac N rate were highest in plots fertilized with 33.5% N urea/ammonium sulfate at 90.3% efficiency. Efficiencies were equal in plots fertilized with 40% N urea/ammonium sulfate and Agrotain coated urea. Lowest efficiency was from UAN with 36.5% rating. Seasonal average plant N uptake efficiencies at the 90 lb/ac N rate were highest at 82.8% in the Agrotain coated urea plots. Statistically equal efficiencies came from plots receiving dry fertilizer materials. This is excellent N uptake efficiency from application of 90 lb N/acre and indicates these sources proved to be quite efficient at providing N for Tifton 85 bermudagrass which effectively took up this N. Fluid fertilizers had efficiencies in the 50 to 60% range.

The 2009 growing season was the third year of this experiment. Table 12 presents the N rate and N source main effects for the three year total DMY and plant N uptakes, and the three year average plant N concentrations and N uptake efficiencies. Only those sources which were used during the 2007, 2008, and 2009 seasons were included in this analysis. The DMY increased with increasing N rates. Applying 45 lb of N/ac increased DMY almost 10 t/ac over the N check during the three years. Applying 90 lb N/ac/cutting increased DMY by slightly more than 12,000 lb/ac over the 45 lb/ac N rate. The 90 lb/ac N rate increased yield 16 t/ac more than the check treatment. The greatest Tifton 85 DMY were produced by the Agrotain coated urea (37,835 lb/ac) and ammonium nitrate (36,962 lb/ac) sources. These sources produced statistically higher dry matter yields than UAN+ Agrotain, UAN+ 0.5% Nutrisphere, UAN, and ESN. The two urea ammonium sulfate blends, Nutrisphere coated urea, and urea produced statistically equal DMY as Agrotain coated urea and ammonium nitrate. Average plant N concentrations increased from 1.37% in the N check plots, to 1.61% in the 45 lb N/ac plots, to slightly over 2% in the high N rate plots. Source main effects show the highest three year average plant N concentrations were from plots fertilized with ammonium nitrate (1.95%) and Agrotain coated urea (1.93%). Statistically equal plant N concentrations were measured in plots using ESN and 33.5% N urea ammonium sulfate as the N source. Analysis of the N rate main effects on the three year total plant N uptake show an increase in uptake as N rate increases. Data indicate uptakes of 113.9 lb/ac in the check plots, to 456.9 lb/ac in the 45 lb/ac N plots, to 821.4 lb/ac in the high N plots in three years. Source main effect analyses show Agrotain coated urea and ammonium nitrate produced the greatest plant N uptake. Statistically similar plant N uptake came from plots fertilized with either of the two urea ammonium sulfate blends. No statistically significant differences were measured for the three year average uptake efficiency due to N rates, with both measuring about 65%. Source main effect analysis showed N uptake efficiencies approaching 80% from both Agrotain coated urea (79.6%) and ammonium nitrate (78.1%). Equivalent efficiencies of approximately 70% came from plots fertilized with either of the two urea ammonium sulfate blends or urea. Remaining sources ranked in the following order: Nutrisphere coated urea, ESN, UAN+Agrotain, UAN+0.5% Nutrisphere and UAN.

Table 13 presents the N source main effects for the three year total DMY and plant N uptake, and the three year average plant N concentrations and N uptake efficiencies for the 45 lb N/ac rate. The three year total DMY was highest in plots fertilized with ammonium nitrate (15.9 t/ac DMY), Agrotain coated urea (15.8 t/ac DMY), and the 33.5% N urea ammonium sulfate blend (15.7 t/ac DMY), and lowest in plots fertilized with UAN (11.9 t/ac DMY). All other sources produced statistically equivalent yields in the 15.3 to 12.3 t/ac DMY range. Greatest average plant N concentration over the three year study was shown to be from plots fertilized with ESN, Agrotain coated urea, 33.5% urea ammonium sulfate, and ammonium nitrate with concentrations in the 1.73 to 1.67% range. Statistically equal N concentrations were measured in the 40% N urea/ammonium nitrate and urea plots. Lowest average N concentrations were measured in the liquid fertilizer plots. Plant N uptake was highest from plots fertilized with Agrotain coated urea, 33.5% urea ammonium sulfate, or ammonium nitrate. Equal N uptakes were

measured in plots receiving 40% N urea ammonium sulfate, urea, Nutrisphere coated urea, or ESN as the fertilizer source. Lowest three year average N uptakes were from the UAN plots. Plant N uptake efficiencies were greatest from the Agrotain coated urea, 33.5% urea ammonium sulfate, ammonium nitrate and 40% urea ammonium sulfate plots, with efficiencies from these first three in the 80% range. Statistically equal plant N uptake efficiencies in the 70 to 60% range were measured in the urea, Nutrisphere coated urea and ESN fertilized plots. Lowest N uptake efficiency at this 45 lb N/ac rate was in the UAN plots. Using an 80% uptake efficiency, calculations show 36 lb of N from each 45 lb N/ac application was utilized by the Tifton 85. This is excellent N uptake efficiency and indicates these sources proved to be quite efficient at providing N for Tifton 85 bermudagrass which effectively took up this N.

Table 14 presents the N source main effects for the three year total DMY and plant N uptake, and the three year average plant N concentrations and N uptake efficiencies for the 90 lb N/ac rate. Highest DMY was produced in plots fertilized with Agrotain coated urea (22.0 t DMY/ac); the 40% N blend of urea ammonium sulfate (21.1 t DMY/ac) and ammonium nitrate (21.0 t DMY/ac). These three sources all produced more yield than ESN, and equivalent yields to all other remaining sources. Analysis of the three year average plant N concentrations showed the highest concentration of 2.22% from plots fertilized with ammonium nitrate. Equivalent plant N concentration came from the Agrotain coated urea treated plots. The fluid sources had the lowest plant N in the 1.85 to 1.90% ranges. Highest plant N uptake for the three years came from plots fertilized with Agrotain coated urea. Equal uptakes were measured in the ammonium nitrate, and 40% N urea ammonium sulfate plots. Agrotain coated urea fertilized plots also had the highest average N uptake efficiency, with a rate of utilizing 77.9% of the N fertilizer applied. Statistically equal plant N uptake efficiencies came from plots fertilized with ammonium nitrate (76.8%), the 40% N blend of urea ammonium sulfate (70.0%), Nutrisphere coated urea (68.5%), and the 33.5% N blend of urea ammonium sulfate (67.9%). The remaining sources were urea (66.6%), ESN (59.2%), UAN+ Agrotain (58.7%), UAN+ 0.5% Nutrisphere (57.3%), and UAN (56.4%). Calculations using 77.9% uptake efficiency show 70 lb N from each 90 lb N/ac application was utilized by the bermudagrass. This is excellent N uptake efficiency from application of 90 lb N/acre and again indicates these sources proved to be quite efficient at providing N for Tifton 85 bermudagrass which effectively took up this N.

Table 1. Rainfall, treatment, and harvest history of site, 2009.

Dates	April	May	June	July	August	September	October
1					1.10"		0.54"
2	0.29"			Irrigated [‡]		Irrigated [‡]	
3		1.42"	0.14"				
4							2.12"
5				0.53"			
6							
7							
8		Mowed					
9			1 st harvest				
10							3.53"
11		0.05"	1.54"		0.13"		
12	0.68"				3 rd harvest		
13		Applied N 0.10"		2 nd harvest		4.21"	2.50"
14							
15			Applied N			0.60"	
16				Applied N			
17	1.88"	0.37"		100 lb K ₂ O [†] 0.94"			
18					0.35"	0.75"	
19							4 th harvest
20				0.28"			
21				0.33"			
22						0.41"	
23	Mowed	0.70"					
24					Applied N	0.13"	
25	0.05"		Irrigated [‡]				
26							
27				0.65"			
28	0.24"						
29	0.16"					sprayed Fury	
30	Blanket Treatment [†]		Irrigated [‡]	1.60"			
31				0.08"			
Total	3.30"	2.64"	1.68"	4.41"	1.58"	6.10"	8.69" to 4 th harvest

[†]Applied 30 lb N, 80 lb P₂O₅, 150 lb K₂O, 30 lb S, and 15 lb Mg/ac to experimental area. Additional K at rate of 100 lb K₂O/ac applied to experimental area on 17 July.

[‡]Supplemental irrigation applied as needed during season using well water at approximately 0.50" per application.

Table 2. Tifton 85 bermudagrass dry matter yield response to main effects of N rates and sources in 2009.

Nitrogen rate lb/ac [†]	Harvest date								Total	
	9-June		13-July		12-Aug.		19-Oct.			
	-----Dry matter yields, lbs/ac-----									
0	297	c [‡]	520	c	517	c	768	c	2,102	c
45	1,308	b	2,613	b	2,940	b	2,308	b	9,168	b
90	2,084	a	3,978	a	3,516	a	3,574	a	13,152	a
Source										
Urea	1,978	a	3,684	a	3,233	ab	2,542	c	11,437	abc
ESN	856	c	2,192	b	3,351	ab	3,572	a	9,971	bc
UAN	1,386	b	2,998	a	2,815	b	2,635	bc	9,834	c
UAN + 0.5% Nutrisphere	1,292	b	3,064	a	2,998	ab	2,422	c	9,776	c
UAN + Agrotain	1,228	b	3,333	a	3,015	ab	2,676	bc	10,252	bc
Nutrisphere coated urea	1,965	a	3,415	a	3,104	ab	2,901	abc	11,385	abc
Agrotain coated urea	2,061	a	3,628	a	3,692	a	2,972	abc	12,354	a
Ammonium Nitrate	1,920	a	3,224	a	2,862	b	3,006	abc	11,011	abc
Urea/am sulfate 33.5% N	1,896	a	3,541	a	3,536	ab	3,399	ab	12,371	a
Urea/am sulfate 40% N	2,116	a	3,588	a	3,713	a	3,025	abc	12,443	a
Ammonium Sulfate	1,958	a	3,586	a	3,186	ab	3,199	abc	11,929	ab
R ²	0.85		0.87		0.84		0.84		0.90	
c.v.	20.8		16.2		15.2		17.2		12.4	

[†] Nitrogen rates applied for each bermudagrass regrowth- 0, 180, 360 lb total N/ac for the four harvests.

[‡] Yields in a column and group followed by a similar or no letter are not significantly different at p = 0.05.

Table 3. Tifton 85 bermudagrass dry matter yield response to 45 lb/ac N rate[†] and sources in 2009.

Nitrogen source	Harvest date								Total	
	9-June		13-July		12-Aug.		19-Oct.			
	-----Dry matter yields, lbs/ac-----									
Urea	1,636	a [‡]	3,269	a	2,832		1,777	b	9,514	ab
ESN	623	c	1,627	b	3,176		3,270	a	8,695	ab
UAN	828	bc	2,080	ab	2,229		1,690	b	6,826	b
UAN + 0.5% Nutrisphere	941	abc	2,062	ab	2,590		1,889	b	7,483	ab
UAN + Agrotain	945	abc	2,433	ab	2,329		1,892	b	7,599	ab
Nutrisphere coated urea	1,459	ab	2,778	a	3,028		2,367	ab	9,630	ab
Agrotain coated urea	1,618	a	3,126	a	3,381		2,156	b	10,281	ab
Ammonium Nitrate	1,506	ab	2,704	a	2,721		2,431	ab	9,363	ab
Urea/am sulfate 33.5% N	1,670	a	3,000	a	3,589		2,713	ab	10,971	a
Urea/am sulfate 40% N	1,672	a	2,817	a	3,563		2,592	ab	10,644	a
Ammonium Sulfate	1,486	ab	,851	a	2,896		2,613	ab	9,847	ab
R ²	0.66		0.58		0.49		0.60		0.52	
c.v.	25.1		19.4		19.8		20.6		16.8	

[†] Nitrogen rate applied for each bermudagrass regrowth- 180 lb total N/ac for the four harvests.

[‡] Yields in a column and group followed by a similar or no letter are not significantly different at p = 0.05.

Table 4. Tifton 85 bermudagrass dry matter yield response to 90 lb/ac N rate[†] and sources in 2009.

Nitrogen source	Harvest date								Total	
	9-June		13-July		12-Aug.		19-Oct.			
	----- Dry matter yields, lbs/ac -----									
Urea	2,321	ab [‡]	4,099	a	3,632	ab	3,307		13,359	ab
ESN	1,089	d	2,758	b	3,526	ab	3,874		11,247	b
UAN	1,943	abc	3,917	a	3,402	ab	3,580		12,841	ab
UAN + 0.5% Nutrisphere	1,642	bcd	4,066	a	3,406	ab	2,956		12,069	ab
UAN + Agrotain	1,510	cd	4,233	a	3,702	ab	3,460		12,905	ab
Nutrisphere coated urea	2,471	a	4,053	a	3,181	ab	3,435		13,140	ab
Agrotain coated urea	2,504	a	4,131	a	4,004	a	3,789		14,426	a
Ammonium Nitrate	2,334	ab	3,744	a	3,002	b	3,580		12,660	ab
Urea/am sulfate 33.5% N	2,121	abc	4,082	a	3,482	ab	4,086		13,771	ab
Urea/am sulfate 40% N	2,560	a	4,360	a	3,864	a	3,459		14,242	a
Ammonium Sulfate	2,430	a	4,321	a	3,476	ab	3,785		14,012	a
R ²	0.74		0.53		0.49		0.37		0.52	
c.v.	16.4		13.0		9.9		14.01		8.7	

[†] Nitrogen rate applied for each bermudagrass regrowth- 360 lb total N/ac for the four harvests.

[‡] Yields in a column and group followed by a similar or no letter are not significantly different at p = 0.05.

Table 5. Tifton 85 bermudagrass plant N response to main effects of N rates and sources in 2009.

Nitrogen rate lb/ac [†]	Harvest date								Average	
	9-June		13-July		12-Aug.		19-Oct.			
	----- Plant N concentration, % -----									
0	1.41	c [‡]	1.22	c	1.30	c	1.56	c	1.37	c
45	1.75	b	1.70	b	1.46	b	1.78	b	1.67	b
90	2.27	a	2.17	a	2.08	a	2.12	a	2.16	a
Source										
Urea	2.12	ab	2.04	ab	1.72	bc	1.98	b	1.97	a
ESN	1.81	c	2.01	ab	2.05	a	2.28	a	2.04	a
UAN	1.83	c	1.54	c	1.54	c	1.68	c	1.65	b
UAN + 0.5% Nutrisphere	1.81	c	1.66	c	1.55	c	1.73	c	1.69	b
UAN + Agrotain	1.89	bc	1.66	c	1.58	c	1.79	c	1.73	b
Nutrisphere coated urea	2.10	ab	1.93	b	1.80	b	1.99	b	1.95	a
Agrotain coated urea	2.12	ab	2.24	a	1.79	b	1.98	b	2.03	a
Ammonium Nitrate	2.19	a	2.16	ab	1.85	b	2.01	b	2.05	a
Urea/am sulfate 33.5% N	2.20	a	2.02	ab	1.89	b	2.01	b	2.03	a
Urea/am sulfate 40% N	2.10	ab	2.00	ab	1.87	b	1.96	b	1.98	a
Ammonium Sulfate	1.94	abc	2.03	ab	1.82	b	2.06	b	1.96	a
R ²	0.86		0.88		0.91		0.90		0.95	
c.v.	8.5		8.5		7.8		5.3		4.8	

[†] Nitrogen rates applied for each bermudagrass regrowth- 0, 180, 360 lb total N/ac for the four harvests.

[‡] Yields in a column and group followed by a similar or no letter are not significantly different at p = 0.05.

Table 6. Tifton 85 bermudagrass plant N response to 45 lb/ac N rate[†] and sources 2009.

Nitrogen source	Harvest date								Average	
	9-June		13-July		12-Aug.		19-Oct.			
	-----Plant N concentrations, %-----									
Urea	1.81		1.75	a [‡]	1.40	b	1.85	b	1.70	ab
ESN	1.68		1.79	a	1.76	a	2.09	a	1.83	a
UAN	1.63		1.33	c	1.28	b	1.53	c	1.44	c
UAN + 0.5% Nutrisphere	1.64		1.44	bc	1.34	b	1.63	bc	1.51	c
UAN + Agrotain	1.64		1.45	bc	1.34	b	1.67	bc	1.52	c
Nutrisphere coated urea	1.75		1.67	ab	1.38	b	1.83	b	1.66	b
Agrotain coated urea	1.85		1.96	a	1.53	ab	1.86	b	1.80	ab
Ammonium Nitrate	1.79		1.81	a	1.43	b	1.84	b	1.72	ab
Urea/am sulfate 33.5% N	1.90		1.83	a	1.56	ab	1.78	b	1.77	ab
Urea/am sulfate 40% N	1.82		1.84	a	1.60	ab	1.75	b	1.75	ab
Ammonium Sulfate	1.75		1.80	a	1.44	b	1.79	b	1.69	ab
R ²	0.49		0.76		0.60		0.76		0.84	
c.v.	7.8		8.0		9.3		5.6		3.9	

[†] Nitrogen rate applied for each bermudagrass regrowth- 180 lb total N/ac for the four harvests.

[‡] Yields in a column and group followed by a similar or no letter are not significantly different at p = 0.05.

Table 7. Tifton 85 bermudagrass plant N response to 90 lb/ac N rate[†] and sources in 2009.

Nitrogen source	Harvest date								Average	
	9-June		13-July		12-Aug.		19-Oct.			
	-----Plant N concentrations, %-----									
Urea	2.44	ab [‡]	2.34	a	2.05	ab	2.12	b	2.24	a
ESN	1.93	d	2.23	ab	2.35	a	2.47	a	2.25	a
UAN	2.04	bcd	1.76	c	1.81	bc	1.82	c	1.86	b
UAN + 0.5% Nutrisphere	1.98	cd	1.89	bc	1.75	c	1.84	c	1.86	b
UAN + Agrotain	2.15	abcd	1.87	bc	1.83	bc	1.91	c	1.94	b
Nutrisphere coated urea	2.44	ab	2.18	ab	2.22	a	2.14	b	2.25	a
Agrotain coated urea	2.40	abc	2.52	a	2.06	ab	2.10	b	2.27	a
Ammonium Nitrate	2.59	a	2.52	a	2.28	a	2.18	b	2.39	a
Urea/am sulfate 33.5% N	2.50	ab	2.20	ab	2.23	a	2.24	b	2.29	a
Urea/am sulfate 40% N	2.39	abc	2.16	ab	2.13	a	2.16	b	2.21	a
Ammonium Sulfate	2.14	abcd	2.27	ab	2.21	a	2.33	ab	2.23	a
R ²	0.66		0.69		0.73		0.84		0.78	
c.v.	8.9		9.1		7.1		4.9		5.3	

[†] Nitrogen rate applied for each bermudagrass regrowth- 360 lb total N/ac for the four harvests.

[‡] Yields in a column and group followed by a similar or no letter are not significantly different at p = 0.05.

Table 8. Tifton 85 bermudagrass plant N uptake response to main effects of N rates and sources in 2009.

Nitrogen rate lb/ac [†]	Harvest date								Total	
	9-June		13-July		12-Aug.		19-Oct.			
	-----Plant N uptake, lb/ac-----									
0	4.1	c‡	6.3	c	6.7	c	11.9	c	29.0	c
45	23.2	b	44.7	b	43.6	b	41.6	b	153.1	b
90	47.9	a	86.3	a	72.9	a	76.0	a	283.2	a
Source										
Urea	43.0	a	76.3	a	57.2	abc	51.2	cde	227.6	a
ESN	15.7	c	45.2	c	68.9	a	82.1	a	212.0	a
UAN	26.5	b	48.2	c	45.0	c	45.5	de	165.1	b
UAN + 0.5% Nutrisphere	24.0	b	53.1	c	47.0	c	42.7	e	166.8	b
UAN + Agrotain	23.6	b	57.1	bc	49.4	c	48.8	cde	178.9	b
Nutrisphere coated urea	42.9	a	67.3	ab	56.0	abc	58.4	bcd	224.6	a
Agrotain coated urea	44.8	a	82.4	a	67.3	ab	59.9	bcd	254.3	a
Ammonium Nitrate	43.5	a	70.4	ab	53.5	bc	61.1	bc	228.5	a
Urea/am sulfate 33.5% N	42.1	a	72.2	a	66.8	ab	69.6	b	250.7	a
Urea/am sulfate 40% N	45.7	a	73.4	a	70.7	a	60.1	bcd	249.9	a
Ammonium Sulfate	39.4	a	74.9	a	59.2	abc	67.4	b	240.9	a
R ²	0.91		0.91		0.88		0.89		0.93	
c.v.	20.3		17.9		17.4		17.8		13.5	

[†] Nitrogen rates applied for each bermudagrass regrowth- 0, 180, 360 lb total N/ac for the four harvests.

[‡] Yields in a column and group followed by a similar or no letter are not significantly different at p = 0.05.

Table 9. Tifton 85 bermudagrass plant N uptake response to 45 lb/ac N rate[†] and sources in the 2009 season.

Nitrogen source	Harvest date								Total	
	9-June		13-July		12-Aug.		19-Oct.			
	-----Plant N uptake, lb/ac-----									
Urea	29.6	a‡	57.0	a	39.6	ab	33.0	bc	159.2	ab
ESN	10.5	c	28.4	c	55.5	ab	68.3	a	162.8	ab
UAN	13.4	c	27.6	c	28.5	b	25.9	c	95.3	c
UAN + 0.5% Nutrisphere	15.4	bc	29.6	c	34.7	ab	30.6	bc	110.4	bc
UAN + Agrotain	15.5	bc	35.1	bc	31.2	ab	31.5	bc	113.3	bc
Nutrisphere coated urea	25.6	ab	46.3	ab	41.8	ab	43.4	bc	157.1	ab
Agrotain coated urea	29.6	a	60.8	a	51.8	ab	40.1	bc	182.3	a
Ammonium Nitrate	27.1	ab	47.9	ab	38.9	ab	45.1	bc	158.9	ab
Urea/am sulfate 33.5% N	31.8	a	55.0	a	56.3	ab	47.9	b	190.9	a
Urea/am sulfate 40% N	30.4	a	52.3	ab	59.3	a	45.2	bc	187.1	a
Ammonium Sulfate	26.3	ab	51.4	ab	41.9	ab	46.6	bc	166.3	ab
R ²	0.70		0.74		0.54		0.70		0.64	
c.v.	26.4		19.2		27.4		21.8		18.8	

[†] Nitrogen rates applied for each bermudagrass regrowth- 180 lb total N/ac for the four harvests.

[‡] Yields in a column and group followed by a similar or no letter are not significantly different at p = 0.05.

Table 10. Tifton 85 bermudagrass plant N uptake response to 90 lb/ac N rate[†] and sources in the 2009 season.

Nitrogen source	Harvest date								Total	
	9-June		13-July		12-Aug.		19-Oct.			
	-----Plant N uptake, lb/ac -----									
Urea	56.3	a‡	95.5	ab	74.7	abc	69.5	bcd	296.0	ab
ESN	20.9	d	62.1	c	82.4	a	95.7	a	261.1	abc
UAN	39.6	bc	68.8	bc	61.4	bc	65.2	cd	234.9	c
UAN + 0.5% Nutrisphere	32.7	cd	76.6	abc	59.3	c	54.7	d	223.3	c
UAN + Agrotain	31.7	cd	79.1	abc	67.7	abc	66.1	bcd	244.6	bc
Nutrisphere coated urea	60.2	a	88.3	abc	70.2	abc	73.4	abcd	292.1	ab
Agrotain coated urea	59.9	a	104.0	a	82.7	a	79.7	abcd	326.3	a
Ammonium Nitrate	60.0	a	93.0	ab	68.1	abc	77.1	abcd	298.1	ab
Urea/am sulfate 33.5% N	52.4	ab	89.5	abc	77.3	ab	91.4	ab	310.6	a
Urea/am sulfate 40% N	61.0	a	94.5	ab	82.1	a	75.0	abcd	312.7	a
Ammonium Sulfate	52.5	ab	98.3	ab	76.6	ab	88.1	abc	315.5	a
R ²	0.83		0.59		0.66		0.63		0.70	
c.v.	16.1		15.3		10.0		14.5		10.1	

[†] Nitrogen rate applied for each bermudagrass regrowth- 360 lb total N/ac for the four harvests.

[‡] Yields in a column and group followed by a similar or no letter are not significantly different at p = 0.05.

Table 11. Tifton 85 bermudagrass plant N uptake efficiency response to main effects of N rates and sources for 2009.

	Seasonal average	Seasonal average at the 45 lb/ac N rate [†]	Seasonal average at the 90 lb/ac N rate [†]
Nitrogen rate, lb/ac [†]	-----Plant N uptake efficiency, %-----		
45	69.1‡	-----	-----
90	70.7	-----	-----
Source			
Urea	73.5 a	72.7 ab	74.3 ab
ESN	69.7 a	74.7 ab	64.7 abc
UAN	46.8 b	36.5 c	57.0 c
UAN + 0.5% Nutrisphere	49.3 b	44.9 bc	53.8 c
UAN + Agrotain	53.1 b	46.5 bc	59.7 bc
Nutrisphere coated urea	72.4 a	71.6 ab	73.3 ab
Agrotain coated urea	84.1 a	85.5 a	82.8 a
Ammonium Nitrate	73.8 a	72.6 ab	75.0 ab
Urea/am sulfate 33.5% N	84.4 a	90.3 a	78.4 a
Urea/am sulfate 40% N	83.6 a	88.2 a	79.0 a
Ammonium Sulfate	78.2 a	76.7 ab	79.8 a
R ²	0.64	0.64	0.70
c.v.	18.7	24.3	11.5

[†] Nitrogen rates applied for each bermudagrass regrowth.

[‡] Yields in a column and group followed by a similar or no letter are not significantly different at p = 0.05.

Table 12. Tifton 85 bermudagrass response to main effects of N rates and sources for the 2007, 2008, and 2009 season.

Nitrogen rate, lb/ac [†]	3 year total DMY (lbs/ac)	3 year average plant N (%)	3 year total plant N uptake (lbs/ac)	3 year average uptake efficiency (%)
0	8,344 c‡	1.37 c	113.9 c	-----
45	28,217 b	1.61 b	456.9 b	64.3
90	40,370 a	2.03 a	821.4 a	65.9
Source				
Urea	34,572 abcd	1.84 bc	647.1 bc	67.4 abc
ESN	30,204 e	1.90 ab	583.3 cd	59.3 cde
UAN	31,629 de	1.66 d	541.5 d	49.1 e
UAN + 0.5% Nutrisphere	32,304 cde	1.70 d	561.8 d	52.4 e
UAN + Agrotain	32,666 bcde	1.71 d	574.9 cd	54.1 de
Nutrisphere coated urea	34,244 abcd	1.82 c	638.9 bc	64.9 bcd
Agrotain coated urea	37,835 a	1.93 a	743.5 a	79.6 a
Ammonium Nitrate	36,962 a	1.95 a	732.0 a	78.1 a
Urea/am sulfate 33.5% N	36,034 abc	1.88 abc	685.4 ab	73.8 ab
Urea/am sulfate 40% N	36,484 ab	1.84 bc	683.1 ab	72.4 ab
R ²	0.95	0.97	0.97	0.69
c.v.	8.4	3.1	9.0	14.0

[†] Nitrogen rates applied for each bermudagrass regrowth.

[‡] Yields in a column and group followed by a similar or no letter are not significantly different at p = 0.05.

Table 13. Tifton 85 bermudagrass response to 45 lb/ac N rate[†] and sources in the 2007, 2008, and 2009 season.

Source	3 year total DMY (lbs/ac)	3 year average plant N (%)	3 year total plant N uptake (lbs/ac)	3 year average uptake efficiency (%)
Urea	29,026 ab‡	1.63 ab	471.3 abc	68.2 ab
ESN	24,662 ab	1.73 a	424.4 abc	59.4 abc
UAN	23,833 b	1.47 c	349.7 c	41.8 c
UAN + 0.5% Nutrisphere	25,406 ab	1.50 c	380.8 bc	47.5 bc
UAN + Agrotain	25,782 ab	1.51 c	391.2 bc	49.4 bc
Nutrisphere coated urea	27,835 ab	1.56 bc	435.0 abc	61.4 abc
Agrotain coated urea	31,660 a	1.72 a	542.7 a	81.4 a
Ammonium Nitrate	31,846 a	1.67 a	532.0 a	79.4 a
Urea/am sulfate 33.5% N	31,454 a	1.70 a	534.5 a	79.8 a
Urea/am sulfate 40% N	30,668 ab	1.64 ab	507.6 ab	74.9 a
R ²	0.57	0.84	0.67	0.67
c.v.	11.1	3.2	12.9	18.8

[†] Nitrogen rate applied for each bermudagrass regrowth.

[‡] Yields in a column and group followed by a similar or no letter are not significantly different at p = 0.05.

Table 14. Tifton 85 bermudagrass response to 90 lb/ac N rate[†] and sources in the 2007, 2008, and 2009 season.

Source	3 year total DMY (lbs/ac)	3 year average plant N (%)	3 year total plant N uptake (lbs/ac)	3 year average uptake efficiency (%)
Urea	40,118 ab [‡]	2.05 b	822.8 cd	66.6 bcd
ESN	35,747 b	2.08 b	742.3 d	59.2 cd
UAN	39,425 ab	1.86 c	733.3 d	56.4 d
UAN + 0.5% Nutrisphere	39,202 ab	1.89 c	742.8	57.3 d
UAN + Agrotain	39,549 ab	1.92 c	758.5 cd	58.7 cd
Nutrisphere coated urea	40,653 ab	2.07 b	842.8 bcd	68.5 abc
Agrotain coated urea	44,011 a	2.15 ab	944.2 a	77.9 a
Ammonium Nitrate	42,078 a	2.22 a	932.0 ab	76.8 ab
Urea/am sulfate 33.5% N	40,615 ab	2.06 b	836.3 bcd	67.9 abc
Urea/am sulfate 40% N	42,300 a	2.03 b	858.7 abc	70.0 ab
R ²	0.57	0.83	0.76	0.78
c.v.	5.8	3.0	6.3	7.6

[†] Nitrogen rate applied for each bermudagrass regrowth.

[‡] Yields in a column and group followed by a similar or no letter are not significantly different at p = 0.05.