TIFTON 85 BERMUDAGRASS RESPONSE TO POTASSIUM, CHLORIDE AND SULFUR AT TWO NITROGEN RATES

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ABSTRACT

'Tifton 85' is a relatively new bermudagrass (*Cynodon dactylon* (L) Pers.) hybrid with improved nutritive value and yield potential. Limited plant nutrient response data are available for this grass. We designed field research to evaluate the response of Tifton 85 to K, Cl, and S at two N rates. Tifton 85 was sprigged in spring 2001 on limed Darco loamy fine sand (Loamy siliceous semiactive thermic Grossarenic Paleudult) fertilized with 68 lb of N and 180 lb of P_2O_5/ac. After establishment, N rates of 60 and 120 lb/ac applied for each regrowth of bermudagrass were randomized and strip applied as replications across split-plot K, Cl, and S sources applied at 134, 268, and 402 lb K_2O/ac rates on 10- x 18-ft plots. Sources of K were muriate of potash (KCl), potassium sulfate (K_2SO_4), and KCl + elemental sulfur (S). Bermudagrass dry matter (DM) yield was significantly increased at the 134 lb K_2O/ac rate in 2002 and 2003 and was further increased by the 268 lb/ac rate of K_2O in 2004 (P = 0.05). Potassium and S sources had no effect on yield until 2004 when total DM was increased by KCl+S > K_2SO_4 > KCl, indicating that K, Cl, and S deficiencies occurred in this Darco soil. Regression analysis showed that DM yield was optimized by the moderate N rate at 268 lb K_2O/ac, but yields were further increased at the high N rate by the 268 and 402 lb/ac K_2O rates.

INTRODUCTION

Tifton 85 bermudagrass has improved nutritive value and yield potential compared to established hybrids such as 'Coastal'. Many studies have been conducted to determine the K requirements of Coastal bermudagrass. Adams and Twersky (1960) showed that high levels of available soil K reduced Coastal bermudagrass winter injury and indicated that winter survival of this grass was favored by a high ratio of applied K to N. Kiesling et al. (1979) reported that K fertilizer dramatically increased visual stand ratings on Darco and Cuthbert soils, and that rhizome production was increased by added K. Nelson et al. (1983) indicated that K application had no significant effect on Coastal bermudagrass yield on Darco soil, but increased 3-yr average yields on Cuthbert soil. Soil test K levels of both Coastal Plain soils declined at each rate of applied K, suggesting that 300 lb K_2O/ac was inadequate to maintain soil K fertility for Coastal bermudagrass production. Adams et al. (1967) reported no significant difference between KCl and K_2SO_4 with respect to forage yields or K content at the 200 or 800 lb K_2O/ac rates. Miller and Dickens (1996) studied KCl vs. K_2SO_4 applied twice monthly with N and reported high K rates did not increase bermudagrass rhizome cold resistance and therefore may be of no benefit beyond K rates sufficient for optimum yield. Numerous papers reported response of Coastal bermudagrass to K applied as KCl, but none have evaluated the effect of Cl applied as KCl. Objectives for our study were to determine the main and interactive effects of K, Cl, and S fertilization on Tifton 85 bermudagrass yield, stand decline, and disease suppression at moderate and high N rates, and to evaluate the effects of these fertilizers on soil and plant nutrient content.

MATERIALS AND METHODS

Darco soil previously treated with 3.0 t/ac ECCE 100% limestone was re-limed with 2.0 t/ac ECCE 72% limestone and fertilized with 180 lb P_2O_5/ac in April 2001. Treatments were incorporated by disking about 6-inches deep. On 24 April 2001, Tifton 85 was sprigged in rows about 3-ft apart and 3-ft between plants within each row. Sprigging was followed by application of 68 lb N/ac as NH_4NO_3 and 0.5 inches of water. After establishment, main-plot randomized N rates of 60 and 120 lb/ac applied for each regrowth of bermudagrass were strip-applied as replications. Split-plot K sources applied to 10 x 18 ft plots were KCl, K_2SO_4, and KCl+S at K, Cl, and S rates shown in Table 1. After the first season, the K rates were split applied, one-third prior to regrowth initiation in spring and one-third after each of two cuttings. In 2004, the N rates were increased to 80 and 160 lb/ac for each bermudagrass regrowth. Phosphorus was reapplied at 120 lb P_2O_5/ac each spring. Yield estimates were made using a Swift Machine harvester with a 5-ft sickle bar (Figure 1, Swift Current, SK Canada). Cut forage was weighed and sampled for DM and chemical analysis on the harvester. Harvested length of each plot was measured to determine the area. Soil samples for chemical analysis were collected after the 2003 growing season.

Table 1. Rates of Cl and S applied with K fertilizer treatments.

Fertilizer potassium rate		Source			
		KCl	K_2SO_4	------------------KCl+S-----------------	
K_2O	K	Cl rate	S rate	Cl rate	S rate
-------lb/ac--------		---lb/ac---			
134	111	107	46	107	46
268	222	214	91	214	91
402	334	322	137	322	137

Fig. 1. Swift Machine forage plot harvester with collection/dump trailer.

Fig. 2. Sulfur deficient bermudagrass at middle right.

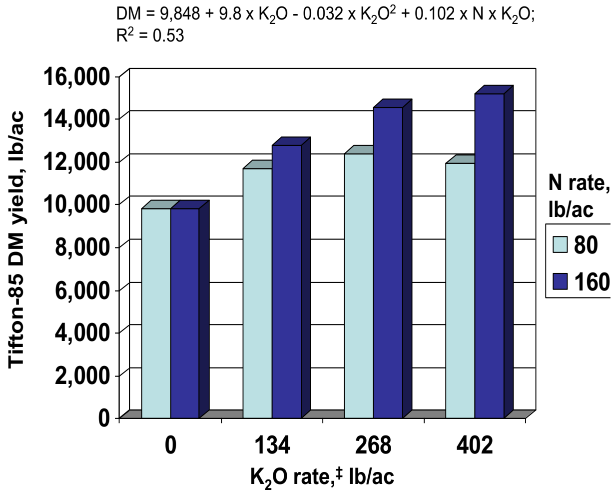

Fig 3. Effect of increased N rate on Tifton 85 bermudagrass response to potassium in 2004.
†N rate applied for each of 5 harvests.
‡K_2O rate split into 3 applications.

RESULTS AND DISCUSSION

The high coefficient of variation for the single harvest in 2001 indicates that stand density was not uniform but did improve in ensuing years (Table 2). A statistically significant increase in total DM occurred at 134 lb K_2O/ac in 2002 and in 2003. Source of K had no significant effect on DM production the first three years. In 2004, K source increased DM yield in the order KCl+S > K_2SO_4 > KCl, indicating that S and Cl had declined to deficient levels in the Darco soil. From the first season, S deficiency was visually evident in bermudagrass that received no S, but DM yield was not affected by S deficiency until the fourth year (Figure 2). In the fourth year, increasing the K rate to 268 lb K_2O/ac increased total DM production compared to the 134 lb K_2O/ac rate, suggesting that Tifton 85 bermudagrass continued to mine K from the Darco soil at the lower application rate. A significant interaction between N and K illustrated that larger amounts of K are required to obtain the higher yields expected when greater amounts of N are applied and plant available water and other nutrients are adequate for increased yields (Figure 3).

Table 2. Tifton 85 bermudagrass dry matter yield response to K, Cl, and S at two N rates.0

Treatments	Dry matter yield by year			
	2001	2002	2003	2004
	-- lb/ac--			
N†, lb/ac				
60	3,779 ns	10,258 ns	12,562 ns	11,693 b‡
120	3,359	11,562	13,703	13,856 a
K§, lb K_2O/ac				
0	3,300 ns	9,118 b	10,831 b	9,614 c
134	3,636	11,111 a	12,983 a	12,469 b
268	3,870	11,156 a	13,338 a	13,246 a
402	3,290	11,060 a	13,844 a	13,662 a
K source				
KCl	4,126 ns	11,230 ns	13,097 ns	12,002 c
K_2SO_4	3,347	10,754	13,498	13,301 b
KCl+S	3,324	11,343	13,570	14,074 a
Coeff. of var.	49.2	17.7	7.8	8.5

†N rates applied at green up and after each cutting. N rates increased to 80 and 160 lb/ac in 2004.
‡Yields within a column and group followed by a dissimilar letter are significantly different (p = 0.05).
§Rates of K were split applied at initiation of regrowth and twice during the growing season in 2002, 2003, and 2004. In 2001, the K rate was applied one-half at growth initiation and one-half on 28 September following the initial harvest.

Increasing the K rate increased plant K concentration (Table 3). At low application rates, KCl increased plant K concentration compared to K_2SO_4 and KCl+S. At the high rate, plant K was highest at 2.8% with application of KCl+S and was lowest at 2.6% in plants treated with KCl (data not shown). However, when averaged over N and K rates, there was no K-source difference in plant K levels. As expected, increasing DM yields increased uptake of K by the bermudagrass.

Table 3. Tifton 85 bermudagrass K, Cl, S, and N concentrations and uptake- 2004 data.

Treatments	K		Cl		S		N	
	Conc.	Uptake	Conc.	Uptake	Conc.	Uptake	Conc.	Uptake
	%	lb/ac	%	lb/ac	%	lb/ac	%	lb/ac
N†, lb/ac								
80	2.22 ns	258 b‡	.186 a	22.7	0.29 a	34	2.23 b	249 b
160	2.15	301 a	.150 b	21.1	0.27 b	38	2.84 a	383 a
K§, lb K_2O/ac								
0	1.26 d	114 d	.090 c	7.8 d	0.18 d	16 d	2.80 a	268 c
134	1.81 c	219 c	.157 b	19.9 c	0.24 c	29 c	2.53 b	308 b
268	2.38 b	309 b	.182 a	24.0 b	0.29 b	38 b	2.49 b	325 ab
402	2.67 a	365 a	.191 a	26.8 a	0.34 a	48 a	2.49 b	332 a
K source								
KCl	2.30 ns	273 c	.238 a	29.5 b	0.18 c	19 c	2.62 a	310 b
K_2SO_4	2.20	297 b	.069 c	8.1 c	0.37 a	50 a	2.45 b	322 ab
KCl+S	2.33	323 a	.224 b	33.0 a	0.33 b	46 b	2.44 b	333 a

†N rates applied at green up and after each cutting.
‡Yields within a column and group followed by a dissimilar letter are significantly different ($p = 0.05$).
§Rates of K split applied at initiation of regrowth and twice during the growing season.

Plant Cl concentration was highest in the order KCl > KCl+S > K_2SO_4 and declined with increasing N rate. As the rate of K was increased to 402 lb K_2O/ac, Cl concentration in plants increased to 0.19%. However, at similar K rate increases applied as K_2SO_4, plant Cl concentration declined from 0.09 to 0.06% (data not shown). Plant Cl uptake increased with higher K rates. Plant S levels from all K sources declined with increasing N rates and were elevated from 0.18 to 0.34% with higher K rates. When applied as K_2SO_4, plant S increased from 0.18 to 0.44%, but remained constant at 0.18% as the rate of K as KCl was raised (data not shown). Plant N averaged over K rates and sources increased with increasing N rate and declined as yield was increased with applied K. Nitrogen uptake was increased as bermudagrass DM yield was raised by higher N and K rates and adding S with applied KCl. The seasonal average main effect N:S ratio declined from 17.3 to 9.4 as the K rate was increased from zero to 402 lb K_2O/ac and increased from 9.3 to 13.2 as the N rate was raised from 80 to 160 lb/ac per cutting. Seasonal average main effect N:S ratios due to source were 16.3 for KCl, 7.5 for K_2SO_4, and 8.1 for KCl+S.

In general, increasing K rates from zero to 402 lb K_2O/ac significantly increased extractable soil K in the 0- to 6-in depth (Table 4), and at depths to 24-inches after 3 yr of treatment (data for depths below 6 inches are not shown). At depths deeper than 24 inches, higher K rates were needed to increase extractable soil K. However, regardless of any significant increases in extractable soil K, all surface depth K levels remained in the very low soil test rating category. Higher yields at constant rates of K decreased surface depth levels of extractable soil K. Extractable S levels were increased where KCl+S was applied and at the highest K rate. Soil Cl levels declined to 2 ppm when Cl was not included in the K treatment. Soil pH significantly declined with the KCl+S treatments and at high N compared to the moderate N rate. This increase in acidity reflects the oxidation of elemental S and is an indication of the increased nitrification and greater potential leaching of nitrate and basic cations from soil treated with the high N rate. Extractable levels of P, Ca, and Mg appear to be unaffected by treatment. The lack of significant differences in Ca and Mg likely is due to the solubilizing of unreacted particles of ECCE 72% limestone by the acid extracting solution used.

Table 4. Extractable plant nutrient levels and pH in 0- to 6-in depth of Darco soil after the 2003 growing season†.

Treatments	Soil pH and nutrient levels after three years of treatments						
	pH†	K	SO_4-S	Cl	P	Ca	Mg
		------------------------------------ppm------------------------------------					
N‡, lb/ac							
60	6.8 a§	34 a	12 ns	4 ns	84 ns	976 ns	40 ns
120	6.2 b	22 b	14	4	77	717	38
K¶, lb K_2O/ac							
0	6.4 ns	17 c	11 b	4 ns	89 ns	768 ns	34 ns
134	6.5	19 c	11 b	3	83	842	40
268	6.6	30 b	12 b	4	77	891	40
402	6.5	39 a	17 a	5	80	833	39
K source							
KCl	6.6 a	33 a	11 b	4 a	77 ns	871 ns	39 ns
K_2SO_4	6.7 a	30 a	12 b	2 b	81	882	40
KCl+S	6.3 b	24 b	17 a	5 a	81	813	

†pH in 1:2 soil: water; P by Mehlich III extraction and colorimetric analysis; Ca and Mg by Mehlich III extraction and atomic absorbance; S by extraction with ammonium acetate-acetic acid and turbidometric analysis; and Cl by extraction with 0.01 M $Ca(NO_3)_2 \cdot H_2O$ using thiocyanate-ferric nitrate color development.
‡N rates applied at initiation of spring regrowth and after each cutting.
§Yields within a column and group followed by a dissimilar letter are significantly different (p = 0.05).
¶Rates of K split applied at initiation of regrowth and twice during the growing season.

The efficiency of K uptake by Tifton 85 bermudagrass declined from 94.6 to 87.8 and 75.2%, respectively, as the rate of applied K was increased from 111 to 222 and 334 lb/ac. This decline in uptake efficiency as the K rate was increased indicates that losses of measurable K occurred by root uptake, fixation, or leaching from the surface 6-inch depth. Root uptake likely accounts for the largest amount of unaccountable K as Kiesling et al. (1979) reported that rhizome production in Coastal bermudagrass was significantly increased by higher K rates. The next largest avenue for loss of K from this surface depth may be due to leaching with nitrate, Cl, and SO_4, but this is only conjecture since the untreated check plot soil was still able to supply 114 lb K/ac for uptake by bermudagrass after three seasons of production. A large amount of K provided to bermudagrass in the check plot likely was absorbed by plant roots exploring soil much deeper than the surface six inches. Loamy fine sand occurs to a depth of 54 inches in Darco soil and this sand can have from zero to 15% clay, so a very low cation exchange capacity would be expected to correspond to low K fixation.

Efficiency of N uptake could not be determined in this study because of lack of a zero N treatment, but at high N rates, efficiency of applied N in bermudagrass production is known to be less than 50%. Uptake efficiency for S (<24%) was low and for Cl (<6%) extremely low, indicating that an excess of Cl is applied with K for bermudagrass production.

At the zero K rate, bermudagrass stand decline was visually detected in the initial spring regrowth and decreased stand density was observed throughout the growing season, but only a minor incidence of the disease *Helminthosporium* leaf spot was observed in one season. The low disease incidence could not be correlated with a particular treatment. Also, winter low temperatures were relatively mild during this four-year study, so stand decline observed in the low K-treated plots may be related primarily to low plant-available soil K.

SUMMARY

Results after 4 years of study indicated that Tifton 85 bermudagrass DM yields on Darco soil were increased by K sources in the order KCl+S > K_2SO_4 > KCl. The main effect DM yields were significantly increased at 268 lb K_2O/ac. The yield curve peaked near 268 lb K_2O/ac at the 80 lb N/ac per regrowth treatment while DM yield continued to increase at 402 lb K_2O/ac when the N rate was increased to 160 lb/ac for each cutting of grass. Regardless of the significant increases in soil K with addition of K, these soil K levels were all in the very low category and the bermudagrass depended on applied K for adequate growth. In addition to K and N, S and Cl were needed for increased yields of Tifton 85 bermudagrass on this Darco soil.

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