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Yield and Mineral Concentration of HiMag Compared to Other Tall Fescue Cultivars Grown in the Southern Piedmont

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ABSTRACT

HiMag is an experimental cultivar derived from Missouri 96 (Mo96) and Kentucky 31 (K31) tall fescue (*Festuca arundinacea* Schreb.) parentage for increased calcium (Ca), magnesium (Mg), and reduced potassium (K)/(Ca+Mg). Our objective was to determine productivity and mineral characteristics of endophyte-free (E-) HiMag in relation to standard tall fescue cultivars when grown in the Southern Piedmont Land Resource Area. In experiment 1, HiMag (E-) and K31 (E-) were grown at two levels of phosphorus (P), K, and lime additions to both severely eroded, and non-eroded Cecil soil (clayey, kaolinitic, thermic family of Typic Hapludults). Herbage Ca and Mg were greater and K/(Ca+ Mg) and yield were less for HiMag than for K31. Phosphorus and K concentrations were not different. Herbage yields, P, Ca, and Mg concentrations were increased by P, K, and lime additions. In experiment 2, HiMag(E-), K31(E-), endophyte-infected K31(E+), Mo I(E+), Mo II (E+), and AU Triumph (E-) were planted either in a prepared seedbed or planted without tillage into the Cecil soil. HiMag yields were not different from Mo-I, Mo-II or K31(E±), but were less than those of AU Triumph (E-). HiMag yield response to no-till planting, past soil erosion, and fertilizer level was similar to that of K31 (E±). Fertilizer level, and soil condition affected the magnitude of differences in mineral levels in HiMag and K31 (E±), but K/(Ca+Mg) values were more favorable in HiMag. All tall fescue cultivars established equally well in no-till or prepared seedbeds. Aside from a slightly lower first harvest yield there were no important effects of planting no-till versus planting in a prepared seedbed. HiMag's agronomic attributes, while not superior to other cultivars, were sufficient to justify further testing to improve Mg nutrition of grazing animals.

INTRODUCTION

Hypomagnesemic grass tetany is a metabolic disease affecting ruminants. It is caused by an inadequate intake of bioavailable Mg in the animal's diet. Soil-plant-climate-animal factors are involved in its development. Excellent reviews exist on this subject (Rendig and Grunes, 1979; Mayland and Sleper, 1993). Magnesium functions in plants were reviewed by Wilkinson et al. (1990). Hypomagnesemic grass tetany is most likely to occur in lactating ruminants grazing grasses low in Ca and Mg and high in K and water content. These herbage characteristics are associated with rapid plant growth in spring and to a lesser extent during autumn. During this period there is an elevated risk of grass tetany for susceptible ruminants like older, lactating cattle or sheep. Prevention requires that animals consume sufficient Mg on a daily basis. Supplementation via the mineral box is only partially effective because animals may not consume the required amount daily. The most effective method is to provide sufficient Mg in the herbage to meet the animal requirement (Wilkinson et al., 1987). Recent research suggests that development of grasses with more favorable K/(Ca+Mg) is feasible (Mayland and Asay, 1989; Asay and Mayland, 1990; Mayland and Sleper, 1993; Moseley and Baker, 1991; Vogel et al., 1989). Increasing the dietary Mg intake in brood cows not only reduces the risk of grass tetany, but may also benefit the overall performance of the animal (Stuedemann et al., 1983).

HiMag was chosen for these experiments because of its higher Ca, Mg, and lower K/(Ca+Mg). Herbage of this experimental selection should improve Mg nutrition of ruminants, and reduce losses from grass tetany. This research evaluates the agronomic aspects of HiMag relative to standard tall fescue cultivars grown in the Southern Piedmont Land Resource Area. Part of this study examines no-till establishment of these cultivars.

MATERIALS AND METHODS

Experiment 1: Soil Erosion and Fertilizer Effects

This study determined the response of HiMag (E-) and K31(E-) to two levels of fertilizer application on a severely eroded (SE) and noneroded (NE) Cecil soil.

TABLE 1. Total amount of fertilizer and lime applied to micro plots (Experiment 1).

Fertility Level	Location	Nutrient N†	Applied P‡	K‡	Dolomitic Limestone
		----------------------------kg/ha	----------------------------		
High	Severely Eroded (SE)	403	176	446	4480
Low	Severely Eroded (SE)	403	29	56	none
High	Non Eroded (NE)	403	176	446	2240
Low	Non Eroded (NE)	403	29	56	none

†Applied in 6 equal applications (4 Feb. 92, 13 June 93, 28 Aug. 92, 3 Dec. 93, 24 Feb. 93, and 22 Mar. 93).

‡P and K applied with N except on the low fertility level where an inadvertent application was made on 28 Aug. 92. Potassium level was increased from 56 $kg \cdot ha^{-1}$ to 112 $kg \cdot ha^{-1}$ for the applications made 24 Feb. 93 and 22 Mar. 93.

The two sites were 3.0 km apart and represented extremes of soil erosion found in the Southern Piedmont. The experimental design was a randomized block with fertilizer treatment as main plots, and cultivar as subplots. Replicates from the SE and NE were combined into one analysis of variance.

HiMag and K31 were seeded by hand on 7 November 1991 into micro plots (0.36 m^2) at seeding rate of 18 kg/ha and mulched heavily to provide protection against frost heaving. Shoot growth above 4 cm was harvested on 18 June 1992, 25 August 1992, 17 September 1992, 1 December 1992, 22 March 1993, and 3 May 1993. Yields are reported on an oven-dry basis for five replications. Concentrations of K, Ca, P, and Mg were determined on three replicates by Inductively Coupled Plasma Spectrophotometer (ICP) analyses (courtesy of Chemical Analysis Laboratory, University of Georgia, Athens, GA). All data were subjected to analysis of variance by general linear models procedures (SAS, 1995).

Fertilizer treatments provided two levels of P, K, Ca, and Mg for two contrasting soil conditions commonly found in the Southern Piedmont (Table 1). Surface soils (0-15 cm) at the NE site have very low K, medium P, and soil pH of 5.0. The SE soils are similar, but have very low P (Mehlich Test, Plank, 1989). Liming increased pH of both soils to about 5.8 (Table 2).

Experiment 2: Seedbed Preparation and Cultivar Effects on Yield and Mineral Composition

We compared the performance of HiMag tall fescue with that of five other tall fescue cultivars when planted in conventionally prepared seedbeds (tilled) or when

TABLE 2. Rainfall and average temperature by growth periods for Experiment 2.

Period		Rainfall	Air Temperatures		
Beginning	Ending	cm/period	Maximum	Minimum	Average
1-1-93	3-1-93	26.95	11.6	1.6	6.6
3-2-93	3-29-93	19.51	13.4	3.1	8.3
3-30-93	4-13-93	6.38	19.4	6.2	12.8
4-14-93	5-10-93	3.63	23.4	9.2	16.3
5-11-94	7-13-93	6.60	30.5	17.2	23.9
7-14-93	9-13-93	11.25	32.9	19.8	26.4
9-14-93	11-30-93	25.48	21.5	8.5	15.0
1-1-93	11-30-93	99.80	21.8	9.2	15.5
1-1-94	2-28-94	25.65	10.9	-0.6	5.2
3-1-94	3-23-94	6.63	19.0	3.6	11.3
3-24-94	5-9-94	15.47	23.2	8.9	16.1
5-10-94	7-18-94	42.60	29.8	17.0	23.4
7-19-94	9-13-94	33.53	28.1	17.8	23.0
9-14-94	12-1-94	41.66	21.3	8.9	15.1
12-1-93	12-1-94	165.54	22.1	9.3	15.7

planted by no-till. The five other cultivars were K31(E+), K31(E-), Mo I (70% endophyte infected-eif), Mo II (40% eif), and AU Triumph(E-). The Mo I and Mo II were supplied by Dr. D. Sleper, University of Missouri, and seed of other cultivars was obtained locally. Frequency of endophyte infection was determined by using a grow out test, followed by microscopic examination of plants for endophyte.

Tall fescue cultivars were planted into tilled or no-tilled seedbeds using a Tye Pasture Pleaser[1] with 25-cm row spacing. Surface residue for the no-till treatment was estimated at about 1,000 kg/ha. Plot size was seven rows, each 6.1 m long. The experimental design was a randomized split plot with seedbed preparation as main plots, and cultivars as subplots. Each treatment was replicated four times for yield estimates. Mineral concentrations, however, were only determined on two replications of each treatment. The entire experimental area was fertilized

[1]Proprietary or trade names are used for the convenience of the reader and do not imply endorsement or preference by U.S. Department of Agriculture to the exclusion of other comparable products.

TABLE 3. Soil test information (Experiment 1).

		PARAMETER				
Fertility Level	Location (Erosion)	pH	P†	K†	Ca	Mg
			--------mg/kg--------			
High	SE	5.8	25	163	1704	268
Low	SE	5.3	5	161	731	176
	Pr>F‡	.01	.01	.92	.01	.13
High	NE	5.1	25	56	307	46
Low	NE	5.7	19	56	101	18
	Pr>F‡	.01	.01	.96	.01	.01

†Values of 20 for P are considered high. Values for K above 100 are considered medium where responses to fertilization are considered unlikely.
‡Probability of a greater F value. Cultivar effects were nonsignificant.

with 112-49-93 kg N-P-K ha^{-1} after seedbed preparation, but prior to planting. Annual fertilizer applications of 168-74-139 kg N-P-K ha^{-1} were made for two years. Herbage dry matter yields (4-cm stubble height) were determined on 3-01-93, 3-29-93, 4-13-93, 5-10-93, 7-13-93, 9-13-93, 11-30-93, 2-28-94, 3-23-94, 5-09-94, 7-18-94, and 12-01-94.

Herbicide applications were made to all plots as follows: Round-up (Glyphosate) was applied at 2.3 L·ha^{-1} on 9-24-92 and paraquat (1, 1-Dimethy-4-4 pyridinum ion) applied on 10-16-92 for vegetation control prior to seeding on 10-21-92. Two, 4-D amine was applied 11-9-92. A mixture of 0.5% Banvel (dicamba: 2-methoxy-3-6-dichlorobenzoic acid), 1.0% Surflan (3-5 dinitro-N^4, N^4-dipropylsulfanilamide), and 2, 4-D Amine was applied on 3-24-93 for summer weed control. Banvel (1.1 L·ha^{-1} and 2, 4-D at 2.3 L·ha^{-1}) were applied 11-10-93. Herbicide application was not necessary in 1994.

The study was discontinued after two years because experimental periods longer than two years were not considered cost effective for yield estimates of tall fescue (Nepal and van Santen, 1992). All plant samples were oven dried and ground through a 1.0-mm screen for chemical analyses. Two replicates of all dates harvested were analyzed by ICP for P, Ca, Mg, and K (ICP analyses were courtesy of the Chemical Analysis Laboratory, University of Georgia, Athens, GA). Data were subjected to analysis of variance by general linear models procedures (SAS, 1995). Rainfall and air temperature for Experiment 2 are given in Table 2.

RESULTS AND DISCUSSION

Experiment 1

Soil test information is given in Table 3. Liming increased pH about 0.5 units to about 5.8 in both soils. There were large differences in extractable P, but little difference in Mehlich extractable K between fertility levels within a given soil. This occurred because large amounts of K were taken up by plants growing on all treatments. However, extractable K was greater in the severely eroded soil, which had a clayey subsoil exposed by previous soil erosion.

The total yield of HiMag was 11% less than that of K31(E-). Increasing the P, K, and lime levels resulted in about 25% more dry matter yield. Interaction effects between cultivar and fertility level were not significant at the 10% level (Table 4). Additional P, K, and lime increased P, Ca, Mg, but did not affect the equivalent ratio (K/Ca+Mg).

HiMag had a greater Ca, Mg concentration and resulting lower equivalent ratio than K31, and, consequently poses a lower risk of causing hypomagnesemic grass tetany. Cultivars did not differ in P concentration (Table 4). Potassium concentrations were greater in tall fescue from the SE location. Analysis of variance information is given in Table 5. Rainfall for the period was 177 cm at the NE location and 169 cm at the SE location. Rainfall was good for all periods except August to September at both locations (data not shown). The study was stopped after one year because of the small plot size and the threat of weed invasion from adjacent areas.

TABLE 4. Effect of soil (severely eroded = SE, not eroded = NE), cultivar, and fertilizer level on yield, P, K, Ca, Mg composition of tall fescue (Experiment 1).

Parameter		Yield	P	Element K	Ca	Mg	Ratio K/Ca+Mg
		Mg/ha	g/kg				
BLOCK	SE	9.7 a*	3.0 a	37.6 a	4.6 a	3.0 a	2.03 b
	NE	10.1 a	3.1 a	35.0 b	4.0 b	2.8 b	2.08 a
CULTIVAR	HIMAG	9.3 b	3.1 a	36.2 a	4.5 a	3.1 a	1.94 b
	K31	10.5 a	3.0 a	36.5 a	4.0 b	2.7 b	2.17 a
FERTILIZER	High	11.0 a	3.4 a	37.2 a	4.5 a	3.0 a	2.04 a
	Low	8.8 b	2.7 b	35.4 a	4.0 b	2.9 b	2.08 a

*Pairs of means with different letters are significantly different from each other at ($P<0.01$) level. Interaction between cultivar and fertility level was not significant at ($P>.05$) level for any of the parameters.

TABLE 5. Analysis of variance information for yield, P, K, Ca, Mg, and K/(Ca+Mg) ratio (Experiment 1).

Source of Variation	dF	Parameter measured Yield	P	K	Ca	Mg	K/(Ca+Mg)
		------------	------------	Pr>F	------------	------------	------------
Date	5	.0001	.0001	.0001	.0001	.0001	.0001
Block	9†	.2434	.0162	.0023	.0001	.0041	.3464
Fertilizer	1	.0001	.0001	.0001	.0001	.1266	.2438
Date*Fert.	5	.0001	.0001	.0001	.3660	.0144	.0001
Cultivar	1	.0058	.1634	.5372	.0001	.0001	.0001
Date*cult.	5	.4850	.7712	.9373	.1272	.0070	.5786
Fert*cult.	1	.1698	.0650	.0798	.4240	.9397	.2272
Dt.* Cv* Fert	5	.5888	.0255	.6656	.8951	.3614	.7206

†Degrees of freedom for block are 5 for parameters involving mineral concentration.

Experiment 2

Soil test results for 1993 and 1994 are given in Table 6. Soil pH and soil K declined from 1993 to the end of 1994. Potassium levels in the soil did not increase even with the addition of 336 kg K ha^{-1}. Relatively high yields and K removals in harvested forage were considered to be the primary reason. Herbage dry matter of 14 Mg·ha^{-1}, containing 30 g K kg^{-1} removes 420 kg K ha^{-1}. Only 371 kg K ha^{-1} was applied during the experimental period. These results emphasize the high K requirement of the tall fescue receiving ample N fertilization.

TABLE 6. Soil test results as affected by date of sampling (Experiment 2).*

Time of Sampling	pH	P	K	Ca	Mg
		------------	mg/kg	------------	------------
3-01-93	6.1	20	82	346	30
2-01-94	5.8	26	77	315	26
12-14-94	5.6	28	64	320	28

*There were no significant effects of method of planting, or cultivars on soil test results.

TABLE 7. Forage yields as affected by cultivar, tillage at planting, and year (Experiment 2).

	1993		1994		Average	
Cultivar	NT†	T†	NT	T	NT	T
	Mg/ha					
K-31(E+)	4.9	4.9	9.4	9.6	7.1	7.2
K-31(E-)	4.8	3.4	9.3	10.8	7.1	7.1
HIMAG(E-)	4.3	3.3	9.5	9.9	6.9	6.6
Mo-I(E+)	4.1	3.3	8.4	9.5	6.1	6.4
Mo-II(E+)	3.7	3.3	8.4	9.5	6.1	6.4
AU-Triumph (E-)	5.8	3.8	10.1	10.3	7.9	7.1
Average	4.6†	3.7	9.4	9.9	7.0	6.8
LSD.05‡	0.9		NS		NS	

†Tillage effect was significant at 0.10 level in 1993. Interaction of tillage and cultivar was significant at 0.07 level in 1993.

‡Least significant difference at 0.05 level for comparing any two means within the 12 means for 1993.

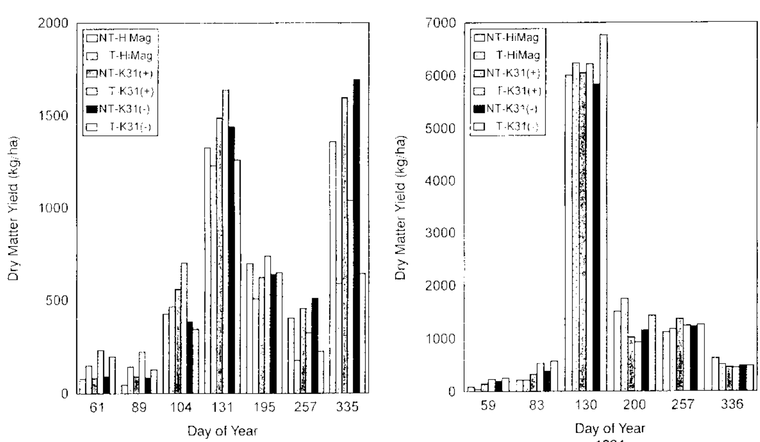

FIGURE 1. Effect of seedbed preparation and dates of harvest on 1993 and 1994 dry matter forage yields of HiMag and K31(±) (NT=no-till, T=tilled).

TABLE 8. Analysis of variance information for harvest yields 1993 and 1994 (Experiment 2).

	Source of Variation (dF)		
Date of Harvest	Tillage (1)	Cultivar (5)	Cv* Tillage (5)
	Pr>F		
3-01-93	.0190	.0001	.1948
3-29-93	.0590	.0001	.1902
4-13-93	.7249	.0001	.1902
5-10-93	.7480	.1430	.3651
7-13-93	.6590	.0171	.0610
9-13-93	.0063	.0001	.1358
11-30-93	.0046	.0066	.2781
Total Yield	.1048	.0003	.0596
2-28-94	.7474	.0001	.4329
3-23-94	.0927	.0001	.5553
5-10-94	.5009	.0002	.2643
7-18-94	.1307	.0001	.2962
9-13-94	.6408	.4674	.8513
12-01-94	.7912	.0001	.0456
Total Yield	.3547	.0900	.3215

AU Triumph yielded significantly more than HiMag, Mo I, Mo II, and about the same as K31(E+), and K31(E-) on an annual basis. Establishment-year yields were about one-half those of the second year (Table 7). Year by cultivar interactions were not significant (P>F=0.14). Cultivars planted no-till yielded significantly more than those planted in prepared seedbeds in 1993, however, dry matter yields on the two tillage treatments were not different in 1994. Individual-harvest date yields indicate that yields were lower for no-till in the first spring, and higher for no-till in late summer and fall (Figure 1).

Analysis of variance information for yields of individual harvests is given in Table 8. Lower soil temperatures were considered the cause for lower spring yields while increased water conservation in late summer was the probable cause for the higher yields at the final two harvests in 1993. Tall fescue cultivar yield response to planting method was similar except that K31(E+) yields were higher than K31(E-) in 1993 but were similar in 1994. Consequently, there was no difference in yield based on the two year average. This may be related to increased

TABLE 9. Analysis of variance information for mineral concentrations (Experiment 2).

Source of Variation	dF	Parameter Measured Mg	Ca	K	K/ (Ca+Mg)	P
		-------------------Pr>F-------------------				
Date	12	.0001	.0001	.0001	.0001	.0001
Block	1	.0013	.1010	.0629	.1174	.9194
Tillage	1	.0497	.0189	.7255	.0342	.0142
Tillage* Date	12	.0002	.0853	.0001	.0014	.0001
Cultivar	5	.0001	.0001	.0001	.0001	.0001
Cultivar* Date	60	.0001	.0001	.0001	.0001	.0057
Cultivar* Tillage	5	.0115	.0812	.6206	.1950	.0299
Cv.* Date* Till.	60	.2052	.0024	.4301	.2345	.9288

drought resistance of endophyte infected tall fescue as has been suggested by West and Gwinn (1993). Although less than completely infected with the endophyte, cultivars Mo-I and Mo-II yielded similarly to the non-infected cultivars. Cultivar by method of planting interaction approached significance in 1993 (P>=0.0596). Rainfall amounts and distribution were more favorable in 1994 than in 1993 (Table 2).

TABLE 10. Average P, K, Ca, Mg, and K/(Ca+Mg) ratios of the tall fescue cultivars (Experiment 2).

Cultivar	Mineral Element P	K	Ca	Mg	K/Ca + Mg)
	---------------g/kg---------------				
HIMAG(E-)	3.5	31.4	5.08	2.87	1.74
K31(E+)	3.6	32.5	4.84	2.53	1.99
K31(E-)	3.5	32.6	4.84	2.40	2.05
Mo I(E+)	3.5	33.6	4.51	2.47	2.07
Mo II(E+)	3.2	32.9	4.78	2.47	2.07
Au Triumph (E-)	3.2	32.4	4.30	2.37	2.18
LSD.05	0.1	2.2	0.12	0.05	0.07

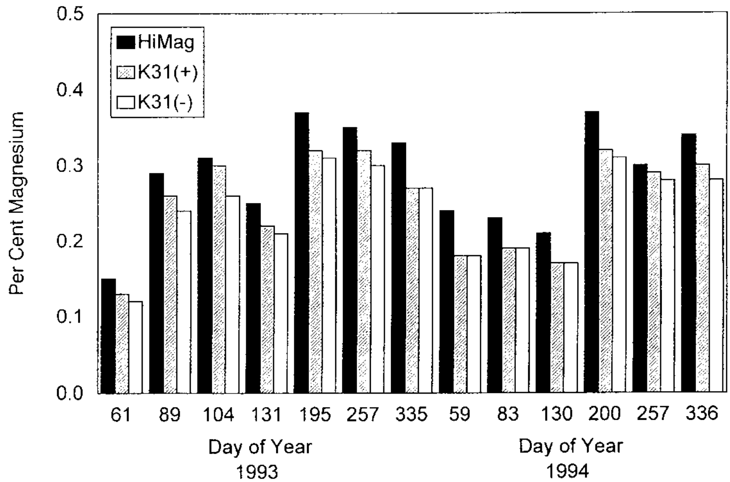

FIGURE 2. Effect of date of sampling on Mg concentration of HiMag compared to K31(E±) tall fescue.

Mineral Composition

HiMag had higher Ca, and Mg concentrations than the other cultivars. This coupled with little or no difference in K concentrations resulted in much lower K/(Ca+Mg) equivalent ratios (Tables 9, 10). Improvement in K/(Ca+Mg) values was most evident during spring forage growth in both years. Figure 2 shows the changes in Mg concentrations over the two year period of the study. Calcium and

TABLE 11. Magnesium concentrations of tall fescue cultivars sampled in early season (Experiment 2) (LSD.05=0.2).

	Dates of Sample Harvest			
Cultivar	3-01-93	3-29-93	2-28-94	3-23-94
	gMg/kg			
HIMAG (E-)	1.5	2.9	2.4	2.4
K-31(E+)	1.3	2.6	1.9	2.0
K-31(E-)	1.2	2.4	1.9	2.0
Mo I (E+)	1.2	2.3	1.9	1.8
Mo II (E+)	1.2	2.3	1.9	1.9
Au-Triumph (E+)	1.1	2.4	1.8	1.8

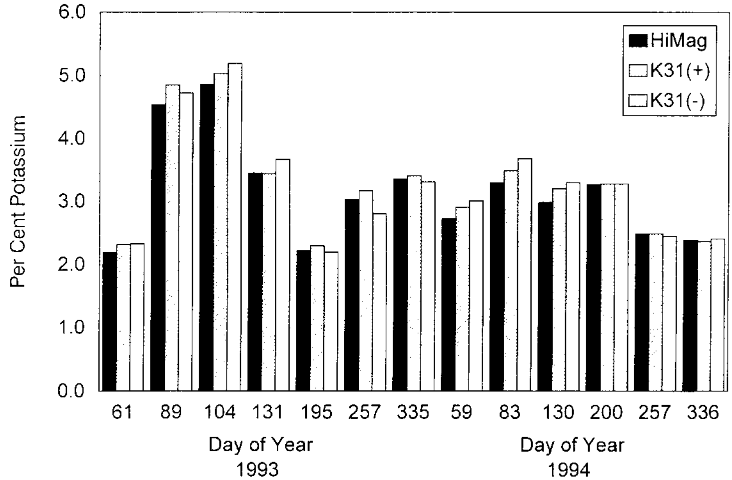

FIGURE 3. Effect of date of sampling on K concentration of HiMag compared to K31(E±) tall fescue.

Mg concentrations were highest in mid-summer. The Mg and Ca concentrations of HiMag were significantly higher than those of five other tall fescue cultivars tested. This is particularly important in that this differential in Mg concentration was maintained through the critical spring period (Table 11). The incidence of grass tetany normally is highest during the February through May period in the mid-South. Smaller and less consistent differences in Mg concentration occurred between other cultivars.

Calcium concentrations were also higher for HiMag compared to other tall fescue cultivars in this study. Seasonal fluctuations were similar within other cultivars. Potassium concentrations varied seasonally and generally in an opposite direction to Ca and Mg. Potassium concentrations were substantially lower in 1994 than 1993 (Figure 3). This was considered to be a result of greater growth (growth dilution) and a slightly lower level of available soil K in 1994. Potassium concentrations were sufficient for near maximum growth (greater than 23 $g \cdot kg^{-1}$). The seasonal distribution of the K/(Ca+Mg) ratio, and the consistently lower ratio for HiMag are illustrated in Figure 4. Magnesium concentration of HiMag was also highest during this period.

The higher Mg concentration during this period is extremely relevant to reducing the risk of hypomagnesemic grass tetany. The K/(Ca+Mg) values, on moles of charge basis, greater that 2.2 pose an exponentially greater risk of causing grass tetany in ruminants. However, the K/(Ca+Mg) ratios of both HiMag and K31 were above the critical ratio of 2.2 where the risk of hypomagnesemia is considered

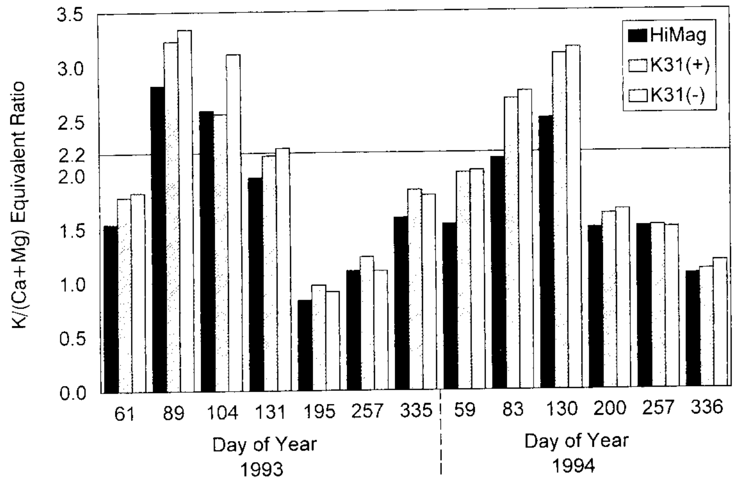

FIGURE 4. Effect of date of sampling on K (Ca+Mg) of HiMag and K31 (E±) tall fescue.

to increase rapidly. The reduction in the ratio along with increased Mg concentration should help to reduce the risk of grass tetany. Magnesium concentrations in the range of 2.0 to 2.5 $g \cdot kg^{-1}$ are considered safe. Even though HiMag Mg concentrations were higher than those of other cultivars, concentrations were still less than the safe level particularly during early spring (Table 11). Initial yields and nutrient concentrations were slightly lower on no-till than prepared seedbeds. This may be associated with a probable lower soil temperature (not measured). The postulated lower soil temperature under no-till may also account for slightly lower plant Mg concentration under no-till in early spring. Reinbott and Blevins (1994) reported that applying P fertilizers to tall fescue growing on a Creldon Silty Clay Loam increased Ca and Mg concentrations. The results of this study do not support this relationship even when increased P concentrations resulted from the P applications.

SUMMARY AND CONCLUSIONS

HiMag dry matter yields were similar to those of other tall fescue cultivars on Cecil soils in the Southern Piedmont Land Resource Area (Watkinsville, GA). HiMag's response to no-till was similar to that of other tall fescue cultivars. All cultivars appeared to persist equally well over the two year experimental period. After two years of frequent mowing, each of the tested cultivars maintained stand density and good regrowth characteristics.

Calcium and Mg concentrations were significantly higher for HiMag than for the other tall fescue cultivars whether grown on severely eroded or non-eroded soils, fertilized at two levels of P, K, and lime, harvested at different seasons, or planted in prepared seedbeds or no-till. However, early spring HiMag forage samples had K/(Ca+Mg) values that were less than other cultivars tested, but which still exceeded the critical ratio of 2.2 above which there is an exponential increase in the occurrence of grass tetany. The improvement in cation composition of HiMag was substantial. Further research is needed to show whether the improvement was enough to justify the cultivar's use for this purpose. The increased Ca+Mg concentration and presence of sufficient agronomic attributes suggests that grazing trials are needed to determine the efficacy of HiMag in preventing hypomagnesemia in grazing ruminants, and the overall improvement in Ca and Mg nutrition on animal performance and pasture productivity.

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