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Use of an Experimental High-Magnesium Tall Fescue to Reduce Grass Tetany in Cattle

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The Problem

Grass tetany (hypomagnesemia) causes economic losses from death or reduced performance of livestock throughout the world. Attempts to reduce the incidence of grass tetany through application of fertilizer Mg have not generally been successful. Dietary Mg supplementation adds to the annual labor and cost of production and does not always ensure all animals receive adequate amounts of the mineral. Selective breeding of forages for higher levels of Mg and lower tetany ratio may offer a long-term solution to the grass tetany problem.

Objectives of this study were to evaluate an experimental selection of tall fescue, HiMag, for its ability to reduce the risk of grass tetany through higher Mg concentration and lower tetany ratio of forage, and higher blood serum Mg concentrations of beef cattle under grazing conditions.

Literature Summary

Grass tetany is characterized by low blood Mg in livestock resulting from low Mg content of feed or reduced absorption of Mg, usually when grazing early, lush cool-season forages. Forages containing less than 0.20% Mg and a "tetany ratio" [K/(Ca + Mg) as moles of charge (M_c)] greater that 2.2 have higher risk of inducing grass tetany. Progress has been made in breeding cool-season forages with higher Mg concentration and lower tetany ratio. Grazing and feeding studies with high-Mg Italian and perennial ryegrass cultivars in the United Kingdom have resulted in mixed responses with sheep. Initial results with HiMag have shown a favorable mineral concentration and tetany ratio, but no animal responses to grazing HiMag have been reported.

Study Description

Twenty, 1-acre pastures on a predominantly Creldon silt loam soil at the Southwest Research Center near Mt. Vernon, MO, were planted to four endophyte-free tall fescue cultivars, AU Triumph, Kentucky-31, Martin, and Mozark, and the experimental cultivar, HiMag. The study consisted of five individual grazing trials using cross-bred beef steers, dry cows, or cow/calf pairs during three autumn and two spring seasons between 1993 and 1995.

Forages were sampled each season and analyzed for Mg, Ca, K, and P concentration, and the tetany ratio was calculated. Cattle were weighed at the beginning, middle, and end of each trial to determine average change in weight. Blood serum was collected at each weighing for determination of Mg, Ca, K, and P status of the cattle.

Applied Questions

Can cool-season forage grasses be selectively bred to reduce the risk of grass tetany?

Forage from HiMag tall fescue consistently had higher Mg (22%), Ca (18%), and P (9%) concentration than other tall fescue cultivars. Potassium levels were not different among cultivars. This resulted in a lower tetany ratio for HiMag compared with the other cultivars. Higher Mg concentration (>0.20%) and lower tetany ratio (<2.2) suggest that HiMag tall fescue can reduce risk of occurrence of grass tetany.

Full scientific article from which this summary was written begins on page 491 of this issue.

Do cattle grazing HiMag tall fescue show improved Mg status and reduced incidence of grass tetany?

Results of this study were not conclusive. Cattle in two of the five trials did show higher blood serum Mg concentrations on HiMag. However, with the exception of the spring 1995 trial, all cultivars had acceptable Mg content (>0.20% in forage) and tetany ratios (<2.2). Cattle grazing all cultivars had Mg levels above the critical value of 1.7 mg/dL in blood serum. Thus, animals were at low risk for grass tetany and, because blood Mg concentrations were already normal, did not always respond to the higher Mg content of HiMag. No signs of grass tetany were observed in any of the trials.

Recommendations

Based on mineral concentration of the forage, HiMag appears to have a lowered risk for grass tetany. Additional grazing research under conditions that maximize the risk for grass tetany are needed to evaluate animal responses to HiMag.

Use of an Experimental High-Magnesium Tall Fescue to Reduce Grass Tetany in Cattle

R. J. Crawford, Jr.,* M. D. Massie, D. A. Sleper, and H. F. Mayland

Grass tetany (hypomagnesemia) continues to be a problem for the livestock industry. An experimental cultivar of tall fescue (*Festuca arundinacea* Shreb.) selected for high Mg concentration, HiMag, was compared against four other cultivars for its ability to increase serum-Mg and reduce the risk of grass tetany. Forage from HiMag contained 22% more Mg, 18.5% more Ca, and 9% more P than other cultivars; K levels were not different. Regardless of cultivar, concentrations of Ca and Mg were lower while K and P were higher during the spring than the autumn. The tetany ratio [K/(Ca + Mg) on M_c basis] was lower for HiMag than for other cultivars (1.34 vs. 1.65); all cultivars had a higher ratio during spring than autumn (1.91 vs. 1.31). In cattle (*Bos taurus*) grazing trials, blood serum from steers grazing HiMag contained 8% more Mg in autumn 1993 but was not different in spring 1994. Blood serum Mg was not different for cows (either dry or nursing calves) during autumn grazing, but approached significance ($P = 0.09$) during the spring 1995 calving season (2.32 vs. 2.07 mg/dL for HiMag vs.other cultivars). Except for differences between calves on HiMag compared with Kentucky-31 in autumn 1995 (58 vs. 43 lb, respectively), animal weight change was not affected by cultivar. Normal forage Mg concentrations (>0.20%) and tetany ratios below 2.2 for all cultivars in every season except spring 1995 may explain the lack of consistent animal response. No clinical symptoms of grass tetany were observed at any time during these studies. However, the higher Mg concentration and lower tetany ratio suggest that HiMag could provide a means of reducing the incidence of grass tetany in livestock during periods when risk of the disorder is high.

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GRASS TETANY is a metabolic disorder in cattle and sheep (*Ovis aries*) usually associated with grazing of cool-season grasses or winter annual forages during cool, wet periods of new lush growth (spring). Although the incidence of grass tetany has declined in some areas with better nutrition and supplementation, outbreaks of grass tetany still occur sporadically. A recent survey in Northern Ireland found grass tetany to affect as many as 33.9% of the animals annually in some herds (McCoy et al., 1993). Economic losses from death or reduced performance of livestock can be considerable (Mayland and Sleper, 1993).

Grass tetany is characterized by hypomagnesemia resulting from low Mg concentration of feed or reduced absorption of Mg (Martens and Rayssiguier, 1983). Levels of 0.20% Mg (dry matter [DM] basis) or more in forage are generally considered adequate to prevent grass tetany (National Research Council, 1996). However, Minson (1990) reported that 65% of cool-season forages contain less than 0.20% Mg. Many factors can reduce Mg absorption from the rumen including K, Na, crude protein, fatty acid, and organic acid content of the forage. In particular, the ratio of K/(Ca + Mg) calculated on a moles of charge (M_c) basis and often identified as the tetany ratio, is important, with risk of grass tetany increasing at a ratio of 2.2 or higher (Butler, 1963; Kemp and t'Hart, 1957).

Attempts to reduce or eliminate the incidence of grass tetany have focused on increasing the intake of Mg by livestock through pasture fertilization or dietary supplementation. Both methods have limitations. Application of dolomitic lime or other sources of fertilizer Mg has not generally increased forage Mg content (Reinbott and Blevins, 1994; Stevens and McAllister, 1985). When offered free-choice, Mg supplements may not be consumed in sufficient quantities unless accompanied by substantial amounts of palatable ingredients (Frye et al.,1977), and the expense and labor of supplementation must be borne every year.

Abbreviation: DM, dry matter.

An alternative to fertilization or supplementation is to increase Mg in the forage through plant breeding (Sleper et al., 1989). Progress has been made in this area with Italian ryegrass (*Lolium multiflorum* Lam.; Moseley and Baker, 1991; Moseley and Griffiths, 1984), perennial ryegrass (*Lolium perenne* L.; Binnie *et al.*, 1996), and tall fescue (Mayland and Sleper, 1993).

The objectives of this study were to compare an experimental high-Mg cultivar of tall fescue, HiMag, to four other released cultivars for its ability to reduce the risk of grass tetany through higher Mg concentration and lower tetany ratio in forage, and higher blood serum Mg concentrations in beef cattle under grazing conditions.

MATERIALS AND METHODS

Pastures

Twenty, 1-acre pastures at the University of Missouri's Southwest Research Center near Mt. Vernon (37°04′N, 93°53′W; elevation +1240 ft) were established on a site consisting of Creldon silt loam (fine, mixed, mesic Mollic Fragiudalf) with smaller areas of Gerald (fine, mixed, mesic Umbric Fragiaqualf) and Hoberg (fine-loamy, siliceous, mesic Mollic Fragiudalf) silt loams. Soil samples taken the year prior to establishment indicated a pH_{salt} of 5.6, high to very high levels of P, K, and Ca (64 [Bray 1], 291, and 2109 lb/acre, respectively), and low Mg (162 lb/acre). Calcitic lime was applied (2 ton/acre) on 17 June 1992 based on soil test recommendations.

Four released tall fescue cultivars, AU Triumph, Kentucky-31, Martin, and Mozark, and an experimental high-Mg selection, HiMag, were randomly assigned to each of four blocks, with one block serving as reserve pastures for acclimation of cattle to the respective cultivars, and three blocks for test pastures. All cultivars were free of the endophyte fungus, *Neotyphodium coenophialum* (Morgan-Jones and Gams) Glenn, Bacon, and Hanlin. Seed was sown on 16 and 17 Sept. 1992 using a Brillion Sure-Stand (Brillion Iron Works, Brillion, WI 54110) grass seeder into a prepared seedbed at 20 to 25 lb/acre. Pastures were mowed during spring and summer of 1993 to eliminate seed head formation and remove excess forage prior to the initiation of grazing trials.

On 23 Apr. 1993, fertilizer was applied at 40-20-40 lb/acre (actual pounds of N-P_2O_5- K_2O). An additional 40 lb N/acre was applied on 4 Sept. 1993. Subsequent additions of fertilizer (maintenance based on expected removal in forage) were as follows: 80-40-80 on 16 Mar. 1994; 60-0-0 on 2 Aug. 1994; 80-0-80 on 23 Mar. 95; 60-0-0 on 2 Aug. 1995.

Individual pastures were separated by permanent fences and subdivided using portable electric fencing. Pastures were strip grazed in such a way as to provide equivalent dry matter availability to all groups of cattle. Prior to placement of cattle on each pasture, four random pasture clippings (each 1 ft by 15 ft) were cut to a height of 2 in. Herbage samples were weighed and dried, and dry forage mass per unit area was determined for each individual pasture. Portable electric fencing was set so that each subdivision provided equivalent amounts of forage mass for 1-wk of grazing based on the weight and number of animals per pasture. This procedure was repeated each week, moving to the next ungrazed area of each pasture throughout each grazing season. In this way, quantitative (yield) differences among cultivars were minimized; any effects were assumed to be due to qualitative differences among tall fescue cultivars.

Grazing Trials

Autumn 1993. Forty-five cross-bred yearling beef steers (initial mean weight 480 lb) were ranked by shrunk weight (feed and water withheld for 16 h), randomly assigned to the five tall fescue cultivars, and placed on reserve pastures for a 7-d acclimation to the respective cultivars starting 5 Oct. 1993. Following acclimation, steers were randomly allocated to the three blocks of test pastures, providing three animals with approximately equal total live weight per pasture replicate. Steers were weighed (shrunk) at the beginning, middle, and end of the 30-d grazing period (12 Oct. to 11 Nov. 1993) to determine average daily gain. Blood samples were collected at the mid-point of the trial (26 Oct. 1993) by jugular venipuncture; forage samples were collected on the same day for mineral analysis.

Spring 1994. Procedures were similar to autumn 1993. Initial mean weight of steers was 508 lb. An 11-d acclimation period beginning 28 Apr. 1994 was followed by a 58-d grazing period (9 May to 6 July 1994). Steers were weighed as described above. Blood samples were collected at the start of the acclimation period and at the beginning, middle, and end of the trial; forage samples were collected 1 d prior to weighing animals.

Autumn 1994. Thirty pregnant, nonlactating Angus and Angus-cross beef cows were ranked by weight (shrunk), assigned to cultivars and placed on reserve pastures on 20 Sept. 1994, followed by a 42-d grazing trial (27 Sept. to 8 Nov. 1994). Procedures for weighing, bleeding, and forage sampling were similar to spring 1994.

Spring 1995. Thirty Angus and Angus-cross beef cows were ranked by weight, assigned to cultivars, and placed on reserve pastures on 12 Apr. 1995. Following a 7-d acclimation period, two cows were assigned to each pasture for the 42-d grazing trial (19 Apr. to 31 May 1995). Eighteen cows had calved prior to placement on reserves; the remaining 12 cows calved between 21 Apr. and 15 May 1995 during the trial. Procedures for weighing and bleeding cows, and for forage sampling were similar to spring 1994. Calves were all sired by a single Simmental bull. Calves were weighed at birth and thereafter on scheduled weigh dates; however, calf weight data were not included in the analysis because not all calves had been born prior to initiation of the study. Blood samples were not collected from calves for the same reason.

Autumn 1995. Fifteen Angus and Angus-cross cows and their Simmental-sired, spring- born calves were ranked by weight, assigned to cultivars, and placed on reserve pastures on 19 Sept. 1995. Following an 8-d acclimation period, one cow/calf pair was assigned to each pasture for the 27-d grazing trial (27 Sept. to 24 Oct. 1995). Procedures for weighing and bleeding cows and calves, and for forage sampling were similar to spring 1994.

Table 1. Magnesium concentration (dry matter basis) of plant tissue from five tall fescue cultivars.

Cultivar	Individual seasons† A93	S94	A94	S95	A96	Spring mean	Autumn mean	Overall mean
	%, DM basis							
AU Triumph	0.25ab	0.21c	0.26b	0.19c	0.24b	0.20b	0.25b	0.23b
HiMag	0.28a	0.29a	0.31a	0.25a	0.28a	0.27a	0.29a	0.28a
Kentucky-31	0.22b	0.23b	0.25b	0.20c	0.24b	0.21b	0.24b	0.23b
Martin	0.23b	0.22bc	0.26b	0.21b	0.25b	0.22b	0.25b	0.23b
Mozark	0.25ab	0.22bc	0.26b	0.20c	0.24b	0.21b	0.25b	0.23b
$LSD_{0.05}$	0.031	0.018	0.019	0.016	0.018	0.015	0.009	0.010
Pr > F	*	***	***	***	**	***	***	***
Season mean‡						0.22	0.26	
Specific contrasts (Pr > F)								
HiMag vs. Kentucky-31	**	***	***	***	**	**	**	***
HiMag vs. others	**	***	***	***	***	**	**	***

*, **, ***Within columns, means that share a common letter are not different at $P < 0.05$, < 0.01, < 0.001.
† S = spring, A = autumn; 9× = year.
‡ Effect of season is significant (LSD = 0.005; $P < 0.001$).

Analyses

Plant tissue and blood serum. One mL of serum or 0.02 oz (0.5 g) plant tissue were digested with 10 mL 1:3 $HClO_4 \cdot HNO_3$ contained in 75 mL long tubes using Tecator 2040 (Tecator, A Perstorp Analytical Company, Höganäs, Sweden) digestion blocks. Blocks were heated from ambient to 248°F (120°C) and maintained for 20 min. Block temperature was automatically increased in steps and then maintained for given times as follows: 293°F (145°C) for 45 min, 347°F (175°C) for 120 min, 356°F (180°C) for 25 min, and 428°F (220°C) for 25 min. Mineralization of serum and plant tissue was completed at 356°F (180°C). Plant digests were diluted to 50 mL total volume using deionized water.

Iron was determined on plant digests using atomic absorption to test for possible soil contamination of samples, which would affect other mineral concentrations. Plant tissue Fe in excess of 400 ppm is considered to originate from exogenous soil contamination. Samples having in excess of 1000 ppm would be noticeably dirty with silicon crystals often observed in the digestion flasks. Plant samples from this study had <300 ppm Fe, indicative of very clean samples. Therefore, it was not necessary to discard any forage samples or correct other mineral levels for contamination by soil.

Phosphorus was determined by the ammonium metavanadate-ammonium molybdate procedure (Greweling, 1976). Aliquots of the digests were diluted 10× with LaCl to provide a final 0.03 oz (900 mg) La/L. This La-spiked solution was analyzed for K by atomic emission and Ca and Mg by atomic absorption (Richards, 1993).

Sera digests were diluted to 50 mL total volume and total serum P determined as above. Total P will differ from reported "normal" blood P values and were used to look at possible impact of changes in other minerals on blood P concentrations. A 1:1 dilution, providing a 0.02 oz (500 mg) La/L spiked solution, was used for K, Ca, and Mg analysis. Percentage recovery (± std dev) of standard reference material (NIST 1572) Citrus Leaves no. 1572 was Fe = 98% ± 0.1, K = 97% ± 5, Ca = 94% ± 6, Mg = 113% ± 2, P = 100% ± 0.

Concentrations of minerals in forage were expressed as percentage on dry matter basis; blood serum minerals were in mg/dL. The ratio of K/(Ca + Mg) was calculated on a moles of charge (M_c) basis (Kemp and t'Hart, 1957).

Statistics. Each trial was a randomized complete block design with three blocks and five cultivars per block. Forage data were analyzed using means of replicate samples from each pasture. Forage data were also pooled across all trials to examine overall and seasonal effects.

Because different classes of animals were used, results of each grazing trial was analyzed individually. Animal data were analyzed using individual animals as replicates. Blood analyses were adjusted using pre-trial blood values as a covariate except for the autumn 1993 trial where only one blood sample was collected. Analysis of variance, least square means and mean separations (least-significant-difference test) were performed using the GLM procedure of the SAS System (SAS Institute, SAS Campus Dr., Cary, NC 27513) for Windows 6.11. Planned, nonorthogonal contrasts were used to answer specific questions regarding differences between HiMag vs. Kentucky-31 or HiMag vs. other cultivars.

RESULTS

Forages. Across all trials, forage from HiMag consistently showed higher levels of Mg (Table 1). Overall, Mg concentrations were 22% higher ($P < 0.001$) when HiMag was compared with Kentucky-31 and other tall fescue cultivars (0.28 vs.0.23%, respectively). Concentrations of Mg were lower ($P < 0.001$) for all cultivars in spring than in autumn forage samples (0.22 vs. 0.26%, respectively). In only one instance (spring 1995 AU Triumph samples) did Mg concentration fall below the critical value of 0.20%.

Overall differences in Ca and P concentrations (Table 2) followed patterns similar to Mg, with HiMag containing 18.5% more Ca (0.48 vs. 0.40%, respectively) and 9% more P (0.31 vs. 28%, respectively) than other cultivars. Calcium concentrations for all cultivars were lower ($P < 0.001$) in spring (0.38%) than autumn (0.45%) forage, while P was higher ($P < 0.001$) in spring (0.31%) than autumn (0.28%) forage. Potassium concentrations (Table 2) were not different among cultivars, but were higher ($P < 0.001$) in spring than in autumn forage samples (2.69 vs. 2.21%, respectively).

Table 2. Contrast means† for mineral concentrations (dry matter basis) of plant tissue from five tall fescue cultivars.

Cultivar	Individual seasons‡					Spring mean	Autumn mean	Overall mean
	A93	S94	A94	S95	A96			
	%, DM basis							
Calcium								
HiMag	0.45	0.49	0.47	0.40	0.56	0.45	0.50	0.48
Kentucky-31	0.38**	0.43**	0.42**	0.34**	0.51**	0.38***	0.45**	0.42**
Others	0.38***	0.39***	0.42***	0.33***	0.50**	0.36***	0.44***	0.40***
Potassium								
HiMag	2.00	2.53	2.70	2.86	1.67	2.70	2.15	2.40
Kentucky-31	2.13ns	2.56ns	2.80ns	2.90ns	1.68ns	2.73ns	2.22ns	2.46ns
Others	2.04ns	2.48ns	2.75ns	2.89ns	1.75ns	2.69ns	2.22ns	2.44ns
Phosphorus								
HiMag	0.32	0.32	0.33	0.35	0.24	0.33	0.29	0.31
Kentucky-31	0.31ns	0.30*	0.34ns	0.33*	0.23ns	0.32**	0.29ns	0.30*
Others	0.31ns	0.28***	0.31*	0.32***	0.23ns	0.30***	0.27*	0.28***

*, **, ***, ns Significant at $P < 0.05$, < 0.01, < 0.001, and not significant, respectively; significance levels indicated for particular contrast mean compared with HiMag mean.
† Contrasts are for comparison of HiMag vs. Kentucky-31 or HiMag vs. other tall fescue cultivars (AU Triumph, Kentucky-31, Martin, and Mozark).
‡ S = spring, A = autumn; 9× = year.

Table 3. Tetany ratio† (moles of charge basis) of plant tissue from five tall fescue cultivars.

Cultivar	Individual seasons‡					Spring mean	Autumn mean	Overall mean
	A93	S94	A94	S95	A96			
	Ratio, M_c basis							
AU Triumph	1.36	1.77a	1.74a	2.39a	1.01a	2.08a	1.37a	1.70a
HiMag	1.13	1.33b	1.42b	1.82c	0.85b	1.58c	1.13b	1.34b
Kentucky-31	1.47	1.64a	1.72a	2.28ab	0.96ab	1.96ab	1.36a	1.64a
Martin	1.27	1.70a	1.69a	2.11b	1.00ab	1.90b	1.33a	1.60a
Mozark	1.37	1.73a	1.65ab	2.33a	1.09a	2.03ab	1.37a	1.67a
$LSD_{0.05}$	0.285	0.239	0.231	0.190	0.151	0.173	0.168	0.152
Pr > F	ns	*	(0.066)	***	(0.062)	**	(0.051)	**
Season Mean§						1.91	1.31	
Specific contrasts (Pr > F)								
HiMag vs. K31	*	*	*	***	ns	***	*	**
HiMag vs. others	*	**	**	***	*	***	**	***

*, **, ***, ns Significant at $P < 0.05$, < 0.01, < 0.001, and not significant, respectively; for $P > 0.05$ and < 0.10, actual value is given in parentheses. Within columns, means that share a common letter are not different.
† Tetany ratio = K/(Ca + Mg) on moles of charge (M_c) basis.
‡ S = spring, A = autumn; 9× = year.
§ Effect of season is significant (LSD = 0.049; $P < 0.001$).

The higher Mg and Ca, together with no difference in K, resulted in a significantly lower ($P < 0.01$) tetany ratio (Table 3) for HiMag than for other cultivars (1.34 vs. 1.65, respectively). The ratio was also higher for all cultivars in spring samples than autumn forage samples (1.91 vs. 1.31). Only during spring 1995 did tetany ratios rise slightly higher than the critical value of 2.2 for AU Triumph, Kentucky-31, and Mozark cultivars.

Grazing Trials

Autumn 1993. Blood serum (Table 4) from steers grazing HiMag had 8% more Mg (2.7 mg/dL) than those grazing Kentucky-31 (2.5 mg/dL) or other tall fescue cultivars (mean of other cultivars = 2.5 mg/dL), although all cultivars were within the normal physiological range. Phosphorus concentrations in blood serum were also higher ($P < 0.05$) for steers grazing HiMag than for those grazing Kentucky-31. Differences in Ca concentration approached significance ($P = 0.06$), with steers on Kentucky-31 having higher levels than those grazing HiMag. Potassium concentrations in blood serum were not affected by cultivar. Change in body weight (Table 4) was also not affected by cultivar of tall fescue being grazed.

Spring 1994. Blood serum concentrations of Mg, Ca, K, and P were not different among steers grazing the five cultivars and were within normal physiological ranges (Table 4). Change in weight was very low for all steers; in particular, weight changes for more than half of the steers were negative during the second half of this trial. The reason for these low gains is not known, but may have been related to dry weather (5.85 in. below average precipitation for May and June) and advancing forage maturity, particularly during the latter part of the trial (June to July). Cultivar had no effect on average daily gain.

Autumn 1994. Blood serum concentrations of Mg, Ca, K, and P were not different among dry cows grazing the five cultivars (Table 4) and were within normal physiological ranges. Cow body weights increased approximately 134 lb during the 42-d trial and were not affected by cultivar being grazed.

Spring 1995. Blood serum levels of Ca, K, and P for pre- and early post-partum cows grazing the different cultivars were not affected by tall fescue cultivar (Table 4). Differences in serum Mg concentrations for cows grazing HiMag (2.3 mg/dL) vs. other cultivars (mean of other cultivars = 2.1 mg/dL) approached significance ($P = 0.09$).

Table 4. Contrast means† for blood serum mineral concentrations and weight gain‡ of cattle grazing five tall fescue cultivars.

Trial Contrast	Mineral concentration of serum Mg	 Ca	 K	 P	Mean weight change‡
	mg/dL				lb
Autumn 1993 (30 d)—steers					
HiMag	2.7	9.4	27.6	11.9	+30
K-31	2.5*	10.7(0.06)	25.1ns	10.8*	+27ns
Others	2.5**	9.9ns	24.9ns	11.4ns	+27ns
Spring 1994 (58 d)—steers					
HiMag	2.5	10.4	31.7	11.8	+ 7
K-31	2.5ns	10.6ns	30.4ns	12.3ns	+20ns
Others	2.5ns	10.4ns	30.7ns	12.0ns	+ 9ns
Autumn 1994 (42 d— dry cows					
HiMag	2.4	10.1	24.4	12.3	+140
K-31	2.3ns	10.3ns	24.7ns	12.3ns	+146ns
Others	2.3ns	10.2ns	25.1ns	12.1ns	+133ns
Spring (42 d) 1995—cows					
HiMag	2.3	8.8	20.6	12.2	+66
K-31	2.1ns	8.8ns	20.6ns	12.8ns	+71ns
Others	2.1(0.09)	8.6ns	20.9ns	12.4ns	+49ns
Autumn 1995 (27 d)—cows					
HiMag	2.3	8.5	20.2	13.8	+47
K-31	2.3ns	8.6ns	19.9ns	13.4ns	+49ns
Others	2.4ns	8.6ns	19.7ns	12.9(0.05)	+52ns
—Calves					
HiMag	2.2	9.0	22.5	18.5	+58
K-31	2.2ns	8.8ns	23.6ns	18.7ns	+43*
Others	2.2ns	8.9ns	24.2(0.05)	17.9ns	+52ns

*, **, ***, ns Significant at $P < 0.05$, < 0.01, < 0.001, and not significant for $P > 0.05$ and < 0.10, respectively. Actual value is given in parentheses. Significance levels indicated for particular contrast mean compared with HiMag mean.

† Contrasts are for comparison of HiMag vs. Kentucky-31 or HiMag vs. other tall fescue cultivars (AU Triumph, Kentucky-31, Martin, and Mozark).

‡ Weight change expressed as pounds of weight change for that period.

Because calving season was in progress at the start of the study, only post-partum weight changes were analyzed. This avoided the large weight loss expected at calving that would have biased the data for those cows that had not calved prior to initiation of the trial. Mean post-partum weight change was 53 lb and was not affected by variety. Similarly, because all calves had not been born at the start of this trial, calf weights and weight change were not analyzed.

Autumn 1995. Magnesium levels in blood serum from cows and their spring-born calves were not affected by tall fescue cultivar during autumn grazing (Table 4). Phosphorus levels were higher ($P = 0.05$) for cows grazing HiMag, and calves grazing HiMag had lower blood serum potassium ($P = 0.05$) than those grazing other tall fescue cultivars. Body weights for cows increased an average of 51 lb/head and were not differentially affected by tall fescue cultivar. Calves on HiMag pastures had larger positive weight change ($P < 0.05$) than calves grazing Kentucky-31 (58 vs. 43 lb, respectively).

DISCUSSION

Forages containing levels above 0.20% Mg and having a tetany ratio of less than 2.2 have a low risk of grass tetany. Results from forage analyses in this study indicate that it is possible to breed for a lower incidence of grass tetany in tall fescue by selecting for higher Mg and Ca levels relative to K level. This confirms work reported earlier by Mayland and Sleper (1993) on the initial selection and development of the HiMag experimental cultivar. Other species of cool-season forages, including Italian ryegrass (Moseley and Baker, 1991) and perennial ryegrass (Binnie et al., 1996), have also been bred successfully for these traits.

Responses of various classes of livestock grazing HiMag tall fescue at different times of the year were not consistent. Steers grazing HiMag showed higher blood serum Mg levels in the autumn, but not in the spring when risk of grass tetany is generally higher. Mineral content of serum from autumn-grazing dry cows was not affected by cultivar. Cows calving in the spring tended to have higher blood serum Mg levels from HiMag, but autumn grazing cows and their calves did not.

Working with Italian ryegrass, Moseley and Griffiths (1984) also found mixed animal responses. Despite 44% higher Mg in forage and 85% higher total intake of Mg by sheep grazing a high-Mg sward, no difference was seen in blood plasma Mg levels; all blood mineral concentrations were within the normal range. In later work under conditions designed to "maximize the potential" for hypomagnesemia, Moseley and Baker (1991) were able to show higher forage and blood Mg and a concomitant reduction from 21% to 2.5% in the incidence of grass tetany with the high-Mg ryegrass. Ewes grazing a high-Mg perennial ryegrass had higher serum Mg levels than those grazing a low-Mg cultivar, while those offered similar forages in an indoor feeding trial had blood levels that were not significantly different (Binnie et al, 1996).

Blood serum Mg concentrations of 1.7 to 3.0 mg/dL are considered normal for beef cattle (Fraser, 1986). Levels below 1.0 to 1.2 mg/dL in the serum are diagnostic for grass tetany (National Research Council, 1996). Levels of Mg in cerebro-spinal fluid may be depressed and result in grass tetany symptoms even though serum levels are in the normal range. Although we did not measure Mg in cerebro-spinal fluid, blood serum Mg concentrations >2.0 mg/dL and absence of visual grass tetany symptoms suggests that the animals in this study were not hypomagnesemic.

While grass tetany can occur in any age and class of livestock, older cows tend to be most affected, particularly those in heavy lactation or under other stress (Fraser, 1986). In the present study, steers and dry cows were used initially as a preliminary screening tool to observe possible changes in serum-Mg levels with the different tall fescue varieties, not necessarily to cause grass tetany per se. Later in the study, early post-partum cows were tested under conditions expected to result in higher potential risk of grass tetany.

It is important to note that for the trials reported in this study, plant Mg concentrations for most cultivars were above 0.20% and the tetany ratio was below 2.2. Only during the spring 1995 trial did the forage Mg drop slightly below this threshold for one cultivar (0.19% for AU Triumph) and the tetany ratio rose slightly above the critical value for three cultivars (2.39, 2.28, and 2.33 for AU Triumph, Kentucky-31, and Mozark, respectively). At no time during these trials were any symptoms of grass tetany observed.

Because most forage concentrations for Mg, Ca, and K and tetany ratio fell in the "normal" range for all cultivars, the actual risk of grass tetany in the present study was low. It is not surprising then that an animal response was not observed in all trials. In those cases in which a response was observed in serum-Mg levels, the effect of HiMag tall fescue was positive. The lack of a consistent response emphasizes the problems associated not only with trying to predict when grass tetany will occur, but also with conducting research on a problem that is sporadic in nature.

SUMMARY AND CONCLUSIONS

Selective plant breeding was successful in producing an experimental tall fescue cultivar, HiMag, containing higher Mg and Ca concentrations relative to K in the forage. Magnesium concentrations consistently above the 0.20% threshold and a tetany ratio below 2.2 suggest that HiMag has potential to reduce the risk of grass tetany. Grazing trials showed a trend toward higher blood serum Mg concentrations in some trials. In trials where risk of grass tetany was low due to an acceptable mineral content and tetany ratio in all cultivars, no animal response was observed, nor would it be expected. Additional research, conducted under conditions that maximize the potential risk for grass tetany, is needed.

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