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Adequate Soil Phosphorus Decreases the Grass Tetany Potential of Tall Fescue Pasture

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Abstract

Grass tetany is a nutritional disease of ruminants caused by low dietary Mg. Previous research has shown that early spring P-fertilization increases the leaf Mg concentration of tall fescue (*Festuca arundinacea* Schreb.) hay. However, little is known about how P-fertilization alters the mineral concentration of tall fescue under grazing. Our objective was to compare, under grazing, the Mg, K, Ca, and P concentration of tall fescue when soil P was considered either adequate or low. The treatments were tall fescue grown on soil fertilized to achieve 30 lb/acre P (P-fertilized) or left unfertilized at 6 lb/acre P (Control). Three cow/calf pairs grazed each pasture from 15 February to 11 April, 2000, and 6 March to 1 May, 2001. Forage samples were collected at the start of grazing and at 14 day intervals thereafter. Under grazing, fertilization with P increased tall fescue forage Mg, K, and Ca concentration once spring growth started. However, the ratio of K/(Ca+Mg) never approached the critical level thought to induce grass tetany. These results suggest that fertilizing tall fescue pastures to an adequate soil P level improves the amount of dietary Mg available to ruminants during early spring and decreases the grass tetany potential of the forage.

Grass tetany is a nutritional disease that kills or affects approximately 350000 beef cows in the USA each year (6). Grass tetany typically occurs when cattle are moved from a winter diet of hay or stockpiled forage to lush, cool-season or winter annual grass pastures in early spring (11) (Fig. 1). Most research indicates that grass tetany is caused by a dietary Mg deficiency. When forage Mg concentration is below 0.20% dry matter (DM), the balance between Mg, Ca, and K in the animal is upset and grass tetany can occur (7). In addition to the low forage Mg concentration, the high water content in spring growth of cool-season or winter annual grass pastures makes it difficult for grazing cattle to consume adequate amounts of Mg (2). Other forage mineral concentrations have been implicated with the disease in addition to Mg. These include a forage Ca concentration less than 0.4% and/or a forage K level above 3.0% DM (20).

A **B**

Fig. 1. (A) Tall fescue (*Festuca arundinaceae* Schreb.) beginning spring growth. (B) Mixtures of cereal rye (*Secale cereale* L.) and annual ryegrass (*Lolium multiflorum* Lam.) can contain too low Mg levels for grazing beef cows in lactation.

Grass tetany is not always controlled by Mg supplementation (19). The disease is also difficult to diagnose in its early stages because symptoms are not always evident (10). Recent work to increase the amount of dietary Mg to grazing cattle has focused on boosting the early spring Mg concentration of grasses such as tall fescue (*Festuca arundinacea* Schreb.) (4,17,18). By increasing herbage Mg concentration, cattle might consume appropriate levels of Mg while grazing. Thus, producers would be less dependent upon unreliable supplements to provide cattle with enough dietary Mg.

Recent research indicates that the Mg concentration of tall fescue leaves is dependant on soil P level (17,18). In these experiments, tall fescue was grown on plots that had between 8 and 97 lb/acre available P and received 0 or 25 lb/acre triple-super phosphate in early spring. When available soil P was 8 or 15 lb/acre and no P-fertilization occurred, leaf Mg concentration was 0.21% DM. Fertilization of these low P soils with 25 lb/acre P increased leaf Mg concentration to over 0.25% DM. In these experiments, 15 lb/acre Mg fertilization with $MgCl_2$ only increased tall fescue leaf Mg concentration when 25 lb/acre P was also applied or when soil P was greater than 26 lb/acre (18).

The impact of soil P on tall fescue forage Mg concentration could be an important consideration across the southeastern quarter of the United States. It is reported that half of the soils in this region test medium, low, or very low for soil P (5). In addition, more than 24 million acres of tall fescue are grown in this area (1) where grass tetany is a common disease. To determine if P-fertilization of tall fescue pastures increases the amount of dietary Mg available to cows, experiments are needed to determine if the Mg uptake of tall fescue is enhanced under grazing conditions. Our objective was to compare, under grazing conditions, the Mg, K, Ca, and P concentration of tall fescue forage when soil P was considered either adequate (30 lb/acre) or low (6 lb/acre).

Grazing Experiment Testing Tall Fescue Mineral Concentration

The grazing portion of the experiment was conducted from 15 February to 11 April, 2000, and from 6 March to 1 May, 2001. The location was the University of Missouri Southwest Research and Education Center near Mt. Vernon, MO (37°04'N, 93°53'W; elevation 1150 ft). The soil series was a Creldon silty clay loam (fine, mixed, mesic Mollic Fragiudalf). An area low in soil P was divided into three blocks, each with two 2.0-acre pastures of established 'Kentucky 31' tall fescue that received one of the following treatments:

- Cows grazing tall fescue grown on a soil with an adequate level of P (30 lb/acre) (P-fertilized);
- Cows grazing tall fescue grown on a soil low in P (6 lb/acre) (Control).

Pastures in the P-fertilized treatment were broadcast fertilized in early February and late August with calcium orthophosphate (triple-super phosphate; 46% P_2O_5 by mass) beginning in February, 1999 and ending in February, 2001. The total amount of P_2O_5 applied ranged between 286 and 313 lb/acre. These applications raised soil P to the level considered adequate for tall fescue forage production (13). All pastures were treated with 120 lb N/acre as ammonium nitrate and 300 lb K_2O/acre as potassium chloride 14 days prior to the start of grazing each year. In addition, ammonium nitrate was broadcast in July, 1999 and 2000 at 60 lb N/acre to promote fall growth after pastures were cut for hay. Table 1 shows the soil pH, K, Ca, Mg, and P levels of the pastures during the experiment.

Table 1. Soil pH, K, Ca, Mg, and P levels of P-fertilized and Control tall fescue pastures. Data were pooled across two years from samples taken before and after the experimental period each year.

Treatment	pH	K	Ca	Mg	P
		----- lb/acre -----			
P-fertilized	5.9	415	2248	185	30
Control	6.0	396	2184	176	6
LSD (0.10)	ns	ns	ns	ns	3

Pasture Management

Grazing occurred during the typical grass tetany season, which begins approximately three weeks before new growth starts and ends six to eight weeks later (10). Three lactating cows with calves grazed each pasture to simulate a typical grazing system in the early spring. The cows grazed stockpiled tall fescue early in the study and actively-growing grass after spring growth began. Equal amounts of forage were allocated to animals grazing the pastures using the put-and-take method so that forage availability was equal for both treatments.

Forage Sampling and Analyses

Forage samples were harvested with a sickle-bar mower. They were collected at the start of grazing and at 14 day intervals thereafter. Six 1.0-ft-x-15.0-ft strips were cut from each pasture to a residual height of 2 in. Forage from the six strips was combined and sub-samples were collected. Sub-samples were dried at 122° F for four days in a forced-air oven for dry matter determination. The sub-samples were ground through a 0.04 in screen using a cyclone mill. Plant tissue was analyzed for K by flame emission; Mg and Ca by atomic absorption; and P by colorimetry (15).

Statistical Analyses

All data were pooled across years because error variance was homogeneous. The model used to analyze the data was a split-plot in time (9). Main plots were two pasture treatments and split plots were five harvest dates. All hypotheses were tested at the 0.10 alpha level. Means for all data were separated using least significant difference. Means are presented by treatment and date because treatment by date interactions occurred.

Magnesium Concentration of Tall Fescue Forage

Forage from both treatments showed low but equal Mg concentrations for the first 14 days of the experiment (Fig. 2). Research from West Virginia has shown that stockpiled tall fescue has a seasonal low in Mg concentration during mid-February (3). The lack of a treatment difference early in our study was likely a result of Mg leaching from the leaves over winter and little grass growth. However, by day 28, the Mg concentration of the Control was 0.13% DM, which was 15% less than at day zero. In contrast, the P-fertilized treatment did not decline in forage Mg concentration during this time. Other research has shown that cattle suffer from this syndrome early in spring as grass begins new growth (2,8). Our results suggest that if soil P is low, Mg concentration in tall fescue declines as spring growth is initiated. The Mg concentration in grass grown on soil with an adequate level of P does not decline as spring growth begins.

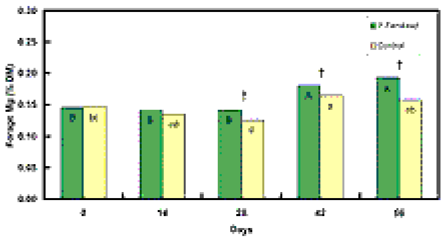

Fig. 2. Magnesium concentration of forage in P-fertilized and Control tall fescue pastures grazed for 56 days in the early spring. Data are pooled across 2000 and 2001. Single cross (†) indicates that treatments were significantly different within a date. Different capital letters indicate significant differences within the P-fertilized treatment over time. Different lower case letters indicate significant differences within the Control treatment over time.

From day 28 until the end of the experiment, forage Mg concentrations of the P-fertilized treatment were 0.14 to 0.19% DM. These values were 9 to 19% greater than those of the Control (Fig. 2). Our results show a lower Mg concentration in the P-fertilized treatment than those reported by Reinbott and Blevins (18). They reported that fertilization with P increased the leaf Mg concentrations of tall fescue by 18 to 27%. One reason for this difference may be that their samples were collected from the youngest fully expanded leaves, while our samples were collected from whole plants of grazed pastures.

The NRC recommends that forage Mg levels be above 0.20% DM to protect cattle from grass tetany (16). Our data show that the forage Mg concentrations in both treatments were below the established safe level. However, forage samples included the older, lower portions of grazed plants. Our results also show that forage Mg concentration increased over time for both treatments. As the experiment progressed, grass began spring growth and likely contained a greater proportion of new leaf material. Our observations in conjunction with those of Reinbott and Blevins (18) indicate that new leaf growth may contain the greatest concentration of Mg, though we did not compare Mg concentrations between old and new leaf growth. Perhaps the most important finding from these data is that under the grazing conditions associated with grass tetany, fertilization with P increased the Mg concentration of tall fescue. Therefore, cattlemen may be able to decrease the incidence of grass tetany by increasing the P-fertility of their soils.

Potassium Concentration of Tall Fescue Forage

At the first two sampling dates, the P-fertilized and Control treatments showed equal forage K concentrations and averaged 0.92 and 0.85% DM, respectively (Fig. 3). However, starting at day 28 and continuing through the phase of rapid grass growth, the P-fertilized treatment had K concentrations that ranged between 1.03 and 2.0% DM. These values were 8 to 25% greater than K concentrations in the Control (Fig. 3). Grass tetany has been associated with forage K concentrations greater than 3.0% DM (20). Despite the high levels of K fertilization required each year, the risk of grass tetany from elevated forage K concentration was low.

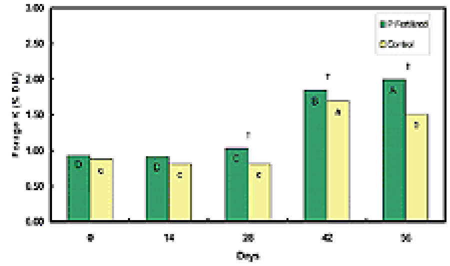

Fig. 3. Potassium concentration of forage in P-fertilized and Control tall fescue pastures grazed for 56 days in the early spring. Data are pooled across 2000 and 2001. Single cross (†) indicates that treatments were significantly different within a date. Different capital letters indicate significant differences within the P-fertilized treatment over time. Different lower case letters indicate significant differences within the Control treatment over time.

Calcium Concentration of Tall Fescue Forage

Forage from both treatments did not differ in Ca concentration during the first 28 days of grazing (Fig. 4). However, after rapid spring growth began, the P-fertilized treatment contained 10 and 15% greater Ca concentrations than the Control. Although this study was conducted under grazing conditions, our findings agree with those of Reinbott and Blevins (18). Their work indicated that the concentration of Ca in tall fescue leaves increased from 0.48 to 0.55% DM after low P soils received 25 lb/acre P. The uptake and translocation of Ca in tall fescue responds to fertilization with P in a similar manner as that of Mg. Therefore, cattlemen raising soil P to an appropriate level may help to ensure that their cattle have enough Ca in the diet in addition to Mg, further reducing the risk of grass tetany.

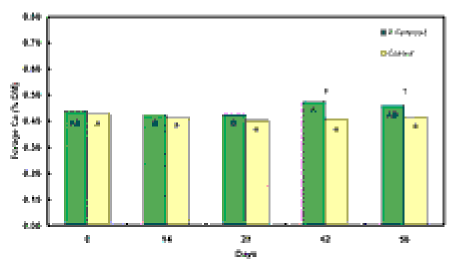

Fig. 4. Calcium concentration of forage in P-fertilized and Control tall fescue pastures grazed for 56 days in the early spring. Data are pooled across 2000 and 2001. Single cross (†) indicates that treatments were significantly different within a date. Different capital letters indicate significant differences within the P-fertilized treatment over time. Different lower case letters indicate significant differences within the Control treatment over time.

K/(Ca + Mg) Ratio of Tall Fescue Forage

The K/(Ca + Mg) ratio (tetany ratio), calculated on a moles-of-charge basis, estimates the potential for forage to induce grass tetany. Cattle grazing forage with a tetany ratio greater than 2.2 are at risk of the disease (8). The P-fertilized treatment had tetany ratios of 0.85 and 1.39 on days 28 and 56, respectively, which were approximately 15% greater than the Control (Fig. 5). The P-fertilized treatment had greater K concentrations than the Control on these days, which increased the tetany ratio above the Control. Perhaps the most important information from these data is that tetany ratios in both treatments were not considered dangerous to grazing livestock (8).

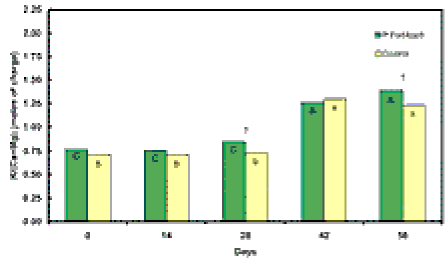

Fig. 5. Ratio of K/(Ca+Mg) in forage from P-fertilized and Control tall fescue pastures grazed for 56 days in the early spring. Data are pooled across 2000 and 2001. Single cross (†) indicates that treatments were significantly different within a date. Different capital letters indicate significant differences within the P-fertilized treatment over time. Different lower case letters indicate significant differences within the Control treatment over time.

Phosphorus Concentration of Tall Fescue Forage

Treatment differences in P concentration were present at all five harvest dates. Phosphorus concentrations in the P-fertilized treatment ranged between 0.12 and 0.21% DM throughout the trial (Fig. 6). These levels were 30 to 50% greater than those of the Control. Results from our study agree with work done by Reinbott and Blevins (17,18) and Moyer et al. (14), who showed uptake of P by tall fescue was largely a function of soil P.

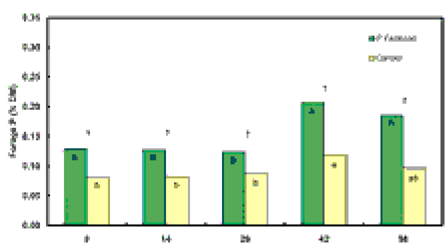

Fig. 6. Phosphorus concentration of forage in P-fertilized and Control tall fescue pastures grazed for 56 days in the early spring. Data are pooled across 2000 and 2001. Single cross (†) indicates that treatments were significantly different within a date. Different capital letters indicate significant differences within the P-fertilized treatment over time. Different lower case letters indicate significant differences within the Control treatment over time.

In addition to the Mg concentration measured in tall fescue leaves, the effects of fertilization with P on tall fescue growth were visually detected each spring (Fig. 7). Phosphorus-fertilized pastures tended to “green-up” earlier than Control pastures. Perhaps this results from earlier initiation of chlorophyll production in spring. If plants have adequate P, one model suggests that Mg uptake is enhanced by phosphorylation of Mg transport proteins on the root plasmalemma (17). Phosphorylation activates these proteins and Mg enters the plant root more readily. Thus, Mg can be assimilated into the porphyrin ring of the chlorophyll molecule. By contrast, later in the summer, the Control treatment retained a darker green color, which is a typical P deficiency symptom. Leaf expansion and extension are decreased under conditions of low soil P and therefore chlorophyll is denser in the leaves, giving the grass a darker green color (12).

Fig. 7. Photograph taken on 17 April, 2001, showing the visual effects of P-fertilization. Soil P level of the pasture on the right is 30 lb/acre while that of the left pasture is 6 lb/acre. Note the brighter green color in the pasture on the right, which may signify earlier production of chlorophyll at spring green-up.

Conclusions

Under grazing conditions near the time grass tetany problems often occur, tall fescue forage from P-fertilized pastures had higher Mg concentrations than forage from Control pastures. While forage K concentration and the ratio of K/(Ca+Mg) were increased by fertilization with P, they did not approach the levels associated with grass tetany. Therefore, cattlemen could fertilize tall fescue pastures with P to improve the uptake of Mg in the forage and help protect beef cows against grass tetany.

Acknowledgement

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