Increasing the magnesium concentration of tall fescue leaves with phosphorus and boron fertilization

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Missouri is number one in tall fescue production among states in the USA, and is number two in cattle numbers and feeder calf production (Missouri Farm Facts, 2003). The beef cattle industry is based on the over 12 million acres of tall fescue pasture in the state. Missouri is also the leading state in tall fescue hay production, however many people are suggesting that it would be better economically for cattle producers to stockpile some tall fescue for winter grazing rather than investing in the harvesting and storage of hay. We have found that phosphorus fertilization of tall fescue pastures in southwestern Missouri is an effective way to increase the magnesium concentration of leaves during the early spring. Based upon our work on grass tetany, we have become concerned about the forage quality of tall fescue pastures and hay, in terms of the magnesium, calcium and phosphorus concentrations in the forage. A search of the literature revealed very little information on the nutrient concentration of stockpiled tall fescue leaves. In our laboratory research, boron nutrition was also found to be important for magnesium uptake by plants. Therefore the objective of this study was to determine if fertilization with both phosphorus and boron would increase tall fescue leaf magnesium concentrations more than phosphorus fertilization alone.

Materials and Methods

A tall fescue plot area was selected on August 9, 2001 at the University of Missouri Southwest Center near Mt. Vernon (Creldon silt loam soil; Fine, mixed, mesic Mollic Fragiudalfs) and this site had the following soil test results: pH 5.4; N.A. 3.0 meq/100g; O.M. 2.9%; Bray I P 7 lbs/acre; Ca 2687 lbs/acre; Mg 247 lbs/acre; K 667 lbs/acre and B 0.26 lbs/acre. Please note two important problems with this soil, P level is very low and should be around 40 lbs/acre, and B level is low and should be 1.0 lb/acre for pastures. These problems are typical of tall fescue pastures in this part of SW Missouri. On August 23, tall fescue on the selected site was cut with a forage chopper and the forage was removed. Then 10' x 25' plots with 5' alleys were prepared and treated with the various quantities of P and B. Each treatment was replicated six times. Phosphorus was applied at rates of 12.5 or 25 lbs P/acre, as triple super phosphate, and boron was added at 0.5 and 1.0 lb B/acre as boric acid. On August 27, nitrogen was applied as topdress 100-0-0. After forage removal in late August, the tall fescue grew and
on October 23, 20 of the most recently collared leaf blades were harvested from each plot. Other leaf harvests were made in late November 2001, early January and early February, mid-March and mid-April 2002. Leaf samples were dried, ground, and digested with nitric acid in a microwave digestion system. These samples were used for flame ionization, atomic absorption analyses of K, Mg and Ca. Phosphorus concentrations in the samples were determined colorimetrically. Fertilization treatments were repeated during the third week of August 2002, and leaf samples were harvested in mid-October, November, December (2002), January, February, March and April (2003). Forage was harvested for hay yields the third weeks of May and August of both years and hay samples were analyzed for macronutrient concentrations.

Results and Discussion

The boron treatments used in this study had very little effect on macronutrient composition of the tall fescue leaves in the fall, winter, and spring. Consequently results from the boron treatments were pooled and, as a result, each point shown for phosphorus was the mean of plots.

The phosphorus treatments were applied the third week of August each year and leaf samples were harvested monthly during fall, winter and spring beginning in October. Phosphorus levels in the leaves dropped from October to February of the first year and from November to February of the second year (Fig. 1). Since the most recently collared leaves were harvested, the decline in phosphorus concentrations may reflect mobilization downward through phloem tissue to the root system. By March of each year, the phosphorus concentration of the leaves increased. Phosphorus treatments increased the leaf phosphorus concentrations, especially in the second year. The diet of a lactating, grazing beef cow requires forage with 2 mg/g dry wt P, and levels of leaf phosphorus were well below this level during winter. However, forage phosphorus levels remained above 2 mg/g dry wt with the 25 lb P/acre treatment except in February of 2003, when the level dropped just below 2 mg/g dry wt. This raises the question about whether or not a higher phosphorus fertilization rate would cause the leaf phosphorus concentrations to remain above 2 mg/g dry wt throughout the winter and into spring in stockpiled tall fescue?
Figure 1. Leaf phosphorus concentrations in stockpiled tall fescue treated with phosphorus fertilizer in August 2001 and 2002. Twenty of the most recently collared leaves were harvested from each plot, and each point represents the mean of 18 plots.

Magnesium concentrations of the stockpiled tall fescue leaves declined in much the same manner as found for phosphorus concentrations (Figs. 1&2). Leaves from plots treated with phosphorus had higher magnesium concentrations than control leaves during fall, winter and spring. By the second season, leaves from plants with the highest phosphorus treatment had 25% higher magnesium concentration than control leaves. During the first winter magnesium concentrations of all leaves fell below 2 mg/g dry wt, the critical concentration required for the diet of a lactating, grazing beef cow. However, during the second winter, leaves from plants treated with the highest phosphorus levels remained above the 2 mg/g dry wt level. During both winter seasons, leaf tissue from plants receiving no phosphorus dropped to 1.5 mg/g dry wt. Again, the question is whether or not higher levels of phosphorus fertilization would result in higher magnesium tissue levels during late winter.
Figure. 2. Leaf magnesium concentrations in stockpiled tall fescue treated with phosphorus fertilizer in late August 2001. Twenty of the most recently collared leaves were harvested from each plot, and each point represents the mean of 18 plots.

The most striking point about the calcium concentration of leaves of stockpiled tall fescue plants is that they were level throughout the two-year study (Fig. 3). This is an important observation, however, since calcium is not phloem mobile in plants and is not re-translocated during late fall and winter months. The fact that calcium concentrations remained level throughout the year, supports the proposal that the decline in phosphorus and magnesium levels was a result of re-mobilization during late fall and early winter. By the second year, the phosphorus treatments had an impact on the calcium levels of the leaves. The 25 lbs P/acre phosphorus treatment increased the leaf calcium concentration by 25% over the control. The leaf calcium concentrations were above those required for the diet of a lactating, grazing beef cow throughout the year.
Figure 3. Leaf calcium concentrations in stockpiled tall fescue treated with phosphorus fertilizer in late August 2001. Twenty of the most recently collared leaves were harvested from each plot, and each point represents the mean of 18 plots.

Leaf potassium concentrations declined during fall and winter until March, again indicating re-mobilization (Fig. 4). In the fall of both years, the leaf potassium concentrations responded to the potassium treatments, but there was little response during the remainder of the year. Potassium levels in the leaves were well above those required in the diet of a grazing, lactating beef cow through each month of both years.
Figure 4. Leaf potassium concentrations in stockpiled tall fescue treated with phosphorus fertilizer in late August 2001. Twenty of the most recently collared leaves were harvested from each plot, and each point represents the mean of 18 plots.

Hay production of the tall fescue responded to phosphorus fertilization treatments with the high treatment increasing annual hay yield by 1500 lbs/acre compared to the control (Fig. 5). Hay yield in 2002 was higher than that found in 2003 reflecting the lower rainfall in the second year.
Figure 5. Hay yields for 2002 and 2003 following treatment of tall fescue plots with 0, 12.5 or 25 lbs P/acre. Hay yield for each was a sum of both hay harvested the third week in May and the third week in August of each year. Yields results are the average from 18 plots with each treatment.

Phosphorus concentration of the hay was very responsive to the phosphorus fertilization treatments at each sampling date (Fig. 6). The high phosphorus fertilization treatment increased the phosphorus concentration of the hay by over 35% compared to the control.
Figure 6. Phosphorus concentration of hay from plots treated with 0, 12.5 or 25 lbs P/acre.

The hay harvest in May 2002 showed no response in magnesium concentration with phosphorus treatment (Fig. 7). However in August 2002 and for both harvests in 2003, phosphorus treatments increased the magnesium concentrations of the hay.
Figure 7. Magnesium concentration of tall fescue hay treated with 0, 12.5 or 25 lbs P/acre.

The calcium concentration of hay from tall fescue plots treated with the 25 lbs P/acre were a little higher than those from control plots at all sampling dates (Fig. 8).
Figure 8. Calcium concentration of tall fescue hay treated with 0, 12.5 or 25 lbs P/acre.

Potassium concentrations of tall fescue hay showed very little response to phosphorus fertilization treatments in this two years study (Fig. 9).
The soil test Bray I P levels was 8 lbs P/acre, and after two years of the Bray I P level dropped to 5 lbs P/acre. With P fertilization treatments, the Bray I P level increased to 8 and 12 with the 12.5 and 25 lbs P/acre treatments, respectively (Fig. 10). The Bray II analysis revealed the bulk of the phosphorus fertilizer added in the study with an increase of about 8 and 30 lbs P/acre for the 12.5 and 25 lbs P/acre treatments, respectively. Therefore for the 25 and 50 lbs P/acre added during the two year study to the treated plots, Bray I and Bray II totally accounted for 11 and 38 lbs P/acre of the 25 and 50 lbs P/acre applied. Bray I and II analyses accounted for 44% of the phosphorus applied with the 12.5 lbs P/acre applications and 76% of that applied with the 25 lbs P/acre rate.
Figure 10. Soil test Bray I and Bray II phosphorus levels of plots treated with 0, 12.5 or 15 lbs P/acre and sampled at the end of the two-year experiment.

Summary

Tall fescue growing in established pastures on Creldon soil in Southwestern Missouri was very responsive to phosphorus fertilization. Phosphorus treatments increased phosphorus, magnesium and calcium concentrations of stockpiled tall fescue leaves and hay, and increased hay yields by 1500 lbs/acre. Tall fescue apparently mobilized nutrients, except calcium, during late fall and early winter causing a decrease in leaf concentrations of phosphorus, magnesium and potassium. The phosphorus and magnesium concentrations of leaves dropped to levels in February that were too low for grazing, lactating beef cows, and levels were especially low in leaves from plots not treated with phosphorus.