Effects of Season and Soil Available Phosphorus Content on the Phosphorus Concentration of the Forage in Cool-Season Grass Pastures of Southeastern Iowa

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Katrina Pille, Graduate Student, Agricultural Education and Studies; Jim Russell, Professor of Animal Science

Summary and Implications

A 5-month study was conducted to evaluate the relationship between soil available phosphorus (P) and forage P concentrations in May, July, and September 2011. Four cool-season pastures were sampled at the Iowa State University McNay Research Farm near Chariton, Iowa. Forage samples were hand-clipped to ground level from a 0.25-m^2 square and soil samples were collected to a depth of 5 inches within (400 ft or less) and outside (700 ft) of previously established congregation areas along one transect within each pasture. Forage P concentration increased with increasing soil available P content and decreased late in the grazing season. On average, the P concentrations of the forages exceeded the P requirement of lactating beef cows throughout the grazing season. A model of monthly forage P concentration predicted that the probability that P supplementation of cows would be necessary wouldn't increase until October.

Introduction

Phosphorus (P) is the second most limiting nutrient to nitrogen in agriculture production in most regions of the world. Both plants and animals require P as an essential nutrient. Phosphorus can exist in soils in inorganic (bound, fixed, or labile) and organic (bound) forms. The availability of P to plants is attributed to many factors including soil pH, compaction, aeration, moisture, temperature, texture, organic matter, crop residues, plant root systems, and mycorrhizae. The concentration of available P of soils in Iowa relates to history of P inputs as fertilizer or manure and P removal as harvested crops. In pastures, available P concentrations in the soil are likely to increase as a result of fertilization or nutritional supplementation of the cows and recycling of forage nutrients unless forage is removed as hay. Increasing soil available P concentrations to optimum levels (16-20 ppm Bray-1 P) will increase forage production and may increase forage P concentration.

Lactating cows require P for bone mineralization or growth, energy metabolism, fatty acid transport, milk secretion, phospholipid synthesis, amino acid metabolism, protein synthesis, and microbial growth and digestion within the rumen. As a result of these requirements, cows fed P-deficient diets over extended periods may have impaired reproduction. Therefore, free choice P supplementation of beef cows throughout the year has commonly been practiced as a safety measure to ensure reproductive performance. However, as the cost of P supplements has increased nearly five-fold in the last decade, there is the need to develop and implement strategic P supplementation plans based on the P concentration of pasture forages to minimize P supplementation to only those amounts needed to meet requirements. Use of such plans would not only reduce the economic costs of P supplementation, but also reduce the risks of P loading and eutrophication of surface water resources.

In this study, we hypothesized that the concentration of forage P present in cool-season grass pastures would be related to the concentration of soil available P and would meet the needs of beef cows if the concentration of soil available P was in the optimum range. Therefore, a project was conducted to evaluate the effects of soil available P content on the P concentration of the forage in cool-season grass pastures in different months in southern Iowa.

Materials and Methods

In 2011, four 10-ac cool-season grass pastures located at the Iowa State University McNay Memorial Research and Demonstration farm near Chariton, IA (lat 40°58'23"N, long 93°25'23") were used for this project.. Sampling sites within the pastures were determined by establishing the location of one existing congregation area in each pasture. Of the four congregation areas, three were used as winter hay feeding sites and one was located adjacent to a water source. Fiberglass rods were inserted along one transect at distances of 100, 400, and 700 ft from the congregation area within each of the four pastures to mark the sampling sites. On May 31, July 22, and September 22, a forage sample was hand-clipped to ground level from a 0.25-m^2 square and soils were sampled to a depth of 5 inches at each sampling site. Samples were collected from the area immediately west, south and east of each fiberglass pole in May, July, and September, respectively. Samples were frozen to -18°C until analysis. Soil samples were analyzed for Bray-1 P at the Iowa State University Soil and Plant Analysis Laboratory (Ames, IA). Forage samples were analyzed for total P at the Minnesota Valley Testing Laboratories, INC (Nevada, IA).

Data were analyzed by GLM to evaluate the effects of distance from the congregation area and month on forage P and soil available P concentrations. Regression analysis was conducted using forage P concentration as the dependent variable and soil available P concentration as the independent variable within each sampling date to establish the relationship of forage P and soil available P concentrations. Regression analysis was also used to calculate the probability of the forage P concentration being below the P requirements of an 1170 lb mature March-calving beef cow with a peak milk production of 18 lb at each date.

Results and Discussion

As expected, the Bray-1 P concentration of soils at a distance of 100 ft from the congregation areas exceeded ($P<0.05$) those from distances of 400 or 700 ft (Table 1). While there was considerable variation in soil Bray-1 P concentration between distances within months, mean soil Bray-1 P did not differ between months. In spite of the variation in soil Bray-1 P concentration, the majority of the samples were significantly above the "optimum" level of 20 ppm for Bray-1 P for cool season pastures. Only three out of 36 soil samples tested were in the "very low" range for soil Bray-1 P. The high concentrations of soil Bray-1 P likely relate to deposition of P in the manure of cattle supplemented with hay and minerals as the pastures used in this project did not have a recent history of P fertilization and most had been used for at least one hay harvest per year.

In spite of the spatial variation in soil Bray-1 P concentration, the P concentration in the forage samples were not significantly affected by distance from the congregation area. However, as expected, the P concentration of the forage was greater ($P<0.05$) in May than in July and greater ($P<0.05$) in July than September. The lack of the effect of distance on forage P concentration may have related to the high levels of Bray-1 P in the soil. However, although most of the soil samples exceeded the optimum level for Bray-1 P, forage P concentrations were related to soil Bray-1 P concentrations within each month (Figure 1).

The P concentration of 91.6% of the forage samples exceeded the P requirements of a mature, March-calving cow weighing 1170 lb with peak milk production of 18 lb at each month of the grazing season. Thus, the probability of cows grazing the pastures utilized in this project was very low throughout the summer and increased to 17% in October (Figure 2).

Conclusions

Data presented in this study suggests that supplementing P is not necessary for lactating beef cows grazing pastures with soils that contain adequate soil test P during the growing season. Because leaves have higher concentrations of P than stems of forage plants, the P concentration of forage consumed by grazing cattle will exceed those of hand-clipped forage samples if forage availability is adequate. Thus, basing P supplementation of beef cows on forage P concentration and/or soil available P is likely a cost-effective management strategy. Because of the variability in soil test P between farms, it is important that cattle producers test soils in their pastures for soil test P at least every 3 years. If soil test P values are less than optimal, pastures should be fertilized with P and, possibly, lime and/or cattle should be supplemented with P. In addition, as forage P concentration is low in mature grasses, crop residues or stockpiled grass forages after a killing frost, P supplementation is likely necessary when cattle are grazing in the fall and winter.

Table 1. Mean concentrations of soil Bray-1 P and forage P at increasing distances from congregation sites in cool-season grass pastures in May, July, and September.

	Month			
Distance from Congregation Area, ft	**May**	**July**	**September**	***Mean***
	Mean Bray-1 Soil P Concentration, ppm			
100	42	49.3	61.5	*50.9*^{x}
400	29.3	27	19.3	*25.2*^{y}
700	41.5	34.8	40.3	*38.9*^{z}
Mean	*37.6*^{a}	*37*^{a}	*40.4*^{a}	
	Mean Forage P Concentration, % of DM			
100	0.395	0.315	0.215	*0.308*^{x}
400	0.353	0.323	0.22	*0.299*^{x}
700	0.39	0.245	0.25	*0.295*^{x}
Mean	*0.379*^{a}	*0.294*^{b}	*0.228*^{c}	

^{abc}Differences between means in a row with different superscripts are significant, ($P<0.05$)
^{xyz}Differences between means in a column with different superscripts are significant ($P<0.05$).

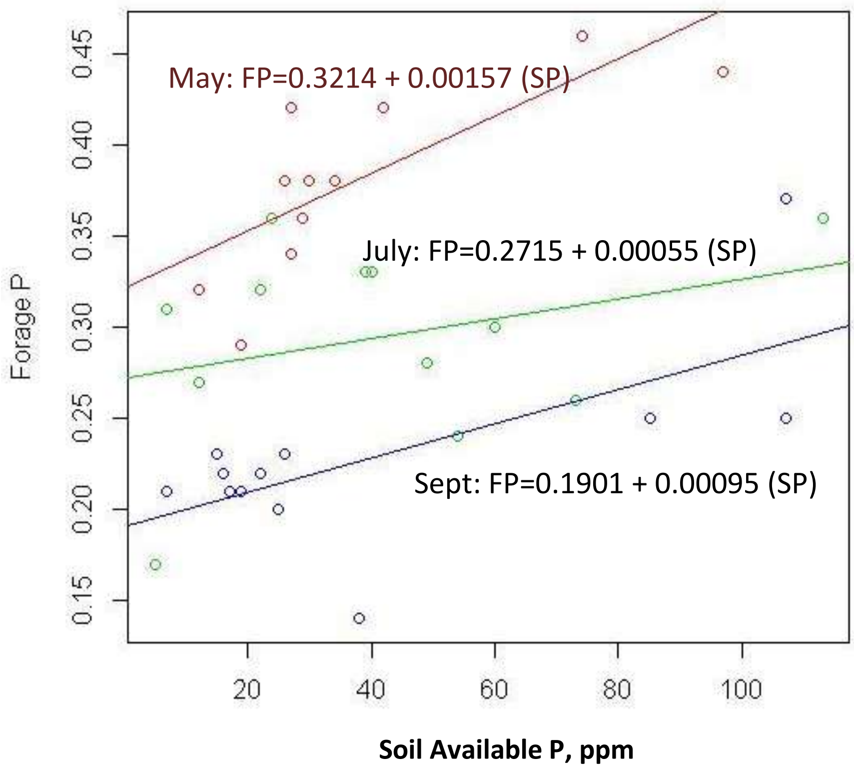

Figure 1. Multiple regression analysis to predict Forage P (FP) from soil available P (SP) in different months of the grazing season.

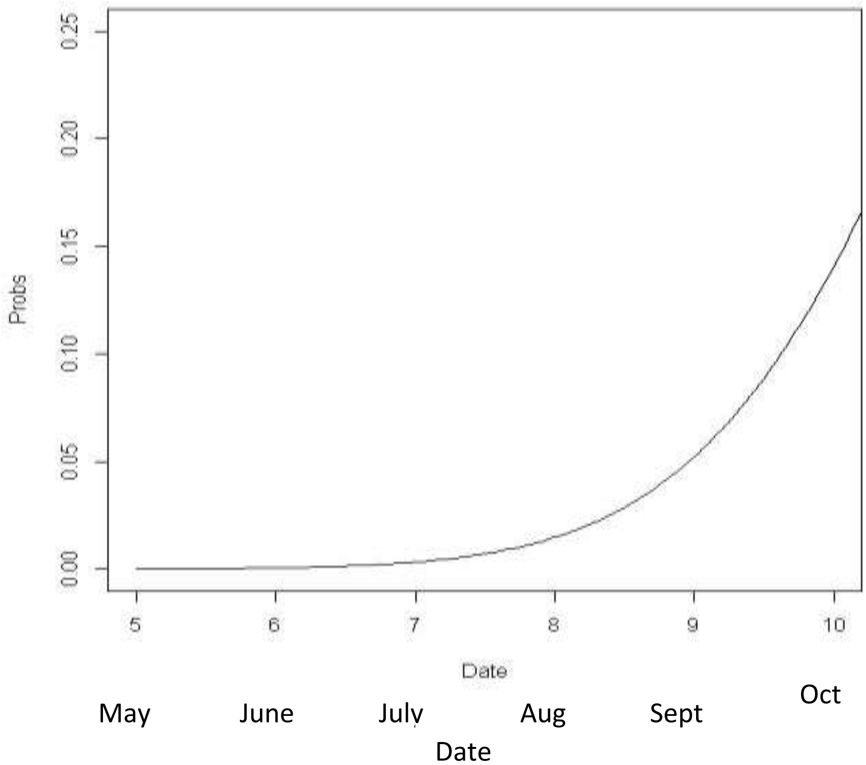

Figure 2. Probability of forage P not meeting the requirement of lactating beef cows throughout the grazing season.