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Lime or Phosphorus: Which is Best to Limit Broomsedge in Tall Fescue Pastures?

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Abstract

Most Missouri tall fescue (*Schedonorus arundinaceus* (Schreb.) Dumort.) pastures grow on acidic, low-phosphorus (P) soils. These conditions favor increases in broomsedge (*Andropogon virginicus* L.), a grass that is unpalatable for livestock. Three management strategies, 1) liming, 2) P fertilization, and 3) liming plus P fertilization, were evaluated for limiting broomsedge in tall fescue pastures. An established tall fescue pasture containing broomsedge was selected in southwest Missouri (soil pH 4.6, 6 lb/acre Bray I P). Lime was applied at 0x, 0.5x, 1x, and 2x the soil test recommendation (x = 3.67 ton/acre). Plots were treated with 0 or 50 lb P/acre. Plant counts for tall fescue and broomsedge were estimated over the next 3 years. Without P fertilization, broomsedge doubled over a 3-year period. Phosphorus fertilization effectively maintained broomsedge at the initial level. The P treatment doubled the tall fescue count in 3 years following treatment, but without P, tall fescue counts remained at the initial level. Broomsedge increased nearly threefold without lime. Tall fescue more than doubled with the two highest lime treatments in 3 years. The 0x lime treatment resulted in no increase in tall fescue. Lime and P combined limited broomsedge increase to the greatest degree and produced the greatest increase in tall fescue. Increased vigor of tall fescue resulting from improved soil fertility likely influenced the increase in tall fescue and limited further encroachment of broomsedge. Applying lime and P could improve pastures by encouraging growth of desirable grasses and discouraging increases in common weeds like broomsedge.

Broomsedge (*Andropogon virginicus* L.), a native, perennial, warm season, C4 grass, can be found in the eastern, midwestern, and southern US (see map on USDA Plants Database website). Although it is a native species, it has been called an important "invasive weed" in pastures (Griffin et al., 1988). When it takes over pasture land, it provides little grazing, except in the early spring, and has long been considered very low-quality forage (Dustman and van Landingham, 1930).

Early research found that in several pastures in the Ozarks, mid-summer forage sample P concentration of broomsedge was 40% lower than that of switchgrass (*Panicum virgatum* L.), 49% lower than that of big bluestem (*Andropogon gerardii* Vitman), and 69% lower than that of orchardgrass (*Dactylis glomerata* L.) (Ehrenreich et al., 1960). One reason for the success of broomsedge in Ozark soils may be its ability to grow in low plant-available P conditions

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Core Ideas

- Broomsedge increases in low-fertility tall fescue pastures.
- Phosphorus fertilization limits broomsedge increase in tall fescue pastures.
- Lime application limits broomsedge increase in tall fescue pastures.
- Applying recommended rates of lime and phosphorus increases tall fescue and limits broomsedge.

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Conversions: For unit conversions relevant to this article, see Table A.

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Table A. Useful conversions.

To convert Column 1 to Column 2, multiply by	Column 1 Suggested Unit	Column 2 SI Unit
1.12	pound per acre, lb/acre	kilogram per hectare, kg/ha

(Peters and Lowance, 1974). This suggestion is supported by Ning and Cumming (2001), who reported that broomsedge roots are colonized by arbuscular mycorrhizal fungi which increase their P-use efficiency under low P conditions. Work done by Peters and Lowance (1974) showed that the numbers of broomsedge and broadleaf weeds were decreased with the application of nitrogen (N), P, potassium (K), and lime.

In Missouri and many other states, broomsedge flourishes on acidic, low-pH soils. Dr. Monroe Rasnake, long time Extension Agronomist at the University of Kentucky, has stated that "Some will swear it (the problem with broomsedge encroachment into pastures) is a soil pH (liming) problem, others have blamed the problem on low soil test P levels" (Rasnake, 2004). Even now, there is considerable debate in the grazingland community about broomsedge encroachment and growth in tall fescue pastures: Is it a problem of low soil P or low soil pH?

Our interest in developing this research project on broomsedge resulted from observation of pastures used in a previous cow-calf grass tetany study (Lock et al., 2002) in pastures adjacent to the present study. Some of the pastures on low-P soil in the previous study had been treated with P fertilization annually from February 1999 to February 2001, which increased the soil Bray I P from 6 to 30 lb/acre. Other pastures received no P treatments, and their soil test Bray I P levels remained at 6 lb/acre (Lock et al., 2002). These pastures, with and without added P, received the same rates of N and K. The tall fescue pasture on the left side of Fig. 1 clearly demfonstrated an invasion of broomsedge by late summer 2003 following termination of the previous experiment in 2001. On the right side of Fig. 1 is the tall fescue pasture that had P fertilization treatments with minimal broomsedge invasion in contrast to the low-P pasture. Therefore, it is evident that on the low-P, low-pH soil, P fertilization prevented broomsedge invasion of the tall fescue pasture in that previous study. The invasion of a pasture may be different from limiting broomsedge already established in a tall fescue pasture. Therefore, the current study was designed to determine which management practice was best for limiting the increase of an established population of broomsedge in a tall fescue pasture growing in a soil with low plant available P and low pH: 1) P fertilization, 2) liming, or 3) both P fertilization and liming.

Setting Up the Study to Limit Broomsedge in a Tall Fescue Pasture

An established tall fescue pasture with a diverse plant community was selected at the University of Missouri Southwest Research Center at Mt. Vernon for this study in summer 2005. The soil resource in the plot area was primarily a Gerald silt loam (fine, mixed, active, mesic Aeric Fragiaqualf) with some inclusions of the Creldon silt loam (fine, mixed, mesic, Oxyaquic Fragiudalf). Soil tests for 0- to 6-inch depth from the plot area had the following initial values: CEC 10.1 meq/100g, neutralizable acidity 5.2 meq/100g, pH 4.6, Bray I P 6 lb/acre, potassium 258 lb/acre, calcium 1515 lb/acre, and magnesium 203 lb/acre.

In a 20-acre pasture, 48 plots with 10- by 25-ft dimensions were delineated with 5-ft borders. Liming treatments were calcitic ag lime with 0x, 0.5x, 1x, and 2x the amount recommended by the University of Missouri Soil Testing Laboratory Woodruff Buffer method. The limestone used possessed an ENM (effective neutralizing material) value of 396. The limestone recommendation (1x) was 3.67 ton/acre. A single limestone application was made on 28 June 2005. Additionally, P treatments were 0 or 50 lb P/acre. A single P application was made on 28 June 2005. Maintenance K was applied at a rate of 110 lb K_2O/acre based on soil test values on 30 June 2005, and 100 lb N/acre was applied to each plot annually in September. Each treatment was replicated six times.

Initial vegetative composition assessments were made in the summer of 2005. Vegetative composition assessments and forage yields of the plots were determined in May and August 2006, 2007, and 2008. Only data from August 2005 and August 2008 analyses are reported here. Final soil samples from each plot were taken at 0- to 6-inch depth in September 2008 for soil test analyses (Table 1).

The Line Intercept Method, as described by Cook and Stubbendieck (1986), was used for species counts. Four ropes with 30 equally spaced knots were stretched across the length of the plots in the center and each species touching a knot was identified and recorded.

Data were analyzed using PROC GLIMMIX of SAS (v. 9.3; SAS Inst. Inc., Cary, NC). The general linear model for the response variables, broomsedge and tall fescue count, was a randomized complete block design with eight treatments arranged as a split plot (main plots = 0x, 0.5x, 1x, and 2x lime and sub-plots = 0 and 50 P). Data for plant response to P were pooled across all lime treatments. Data for plant response to lime were pooled across all P treatments. Least square means were estimated and were compared using Fisher's least significant difference ($P \leq 0.05$).

Limiting Broomsedge in a Tall Fescue Pasture

In plots that were not treated with P fertilization, the broomsedge count doubled over the 3-year period (Fig. 2 a),

Fig. 1. Two tall fescue pastures at the University of Missouri SW Center that had been in a P fertilization cow-calf grass tetany experiment a few years prior to this photograph. The pasture on the left had received no P fertilizer while the pasture on the right had received P fertilization (Lock et al., 2002).

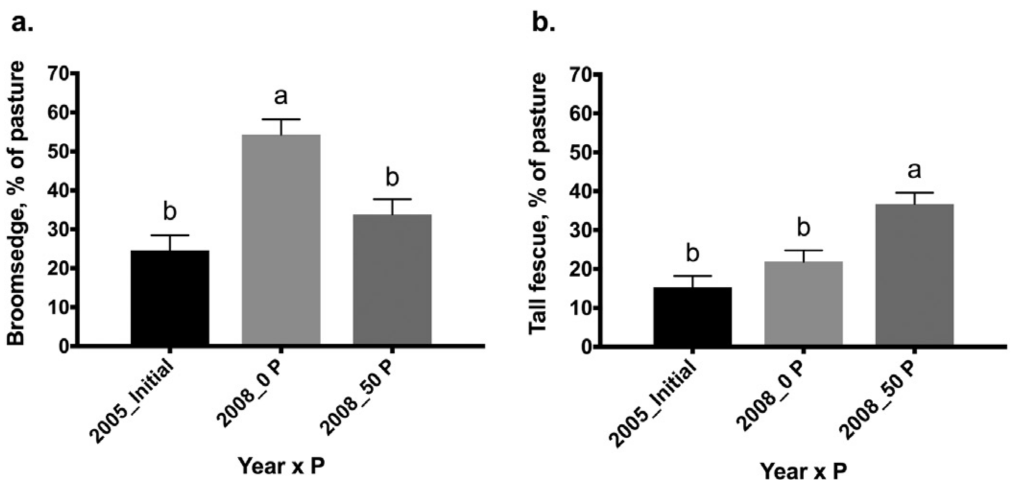

Fig. 2. (a) Broomsedge and (b) tall fescue response to a 2005 P application during a 3-year experiment in SW Missouri. Phosphorus was applied on 28 June 2005. Data for plant response to P were pooled across all lime treatments. Least square means with the same letter are not significantly different ($P \leq 0.05$). Broomsedge SEM = 3.9; Tall fescue SEM = 2.9.

whereas that of tall fescue remained unchanged (Fig. 2 b). This result indicates that low soil P conditions favored the growth of the broomsedge over the tall fescue in a pasture. On the other hand, the P fertilization treatment produced broomsedge counts that remained at the initial level after the 3-year experiment. Tall fescue count increased in plots that received P application (Fig. 2 b). The tall fescue count doubled with the 50 lb/acre P treatment; however, without P fertilization, tall fescue counts remained at the initial level after 3 years. A previous study showed significant yield increases with P applications in tall fescue plots with low soil test P near the area of the present study although plant counts were not conducted in the earlier study (Reinbott and Blevins, 1997).

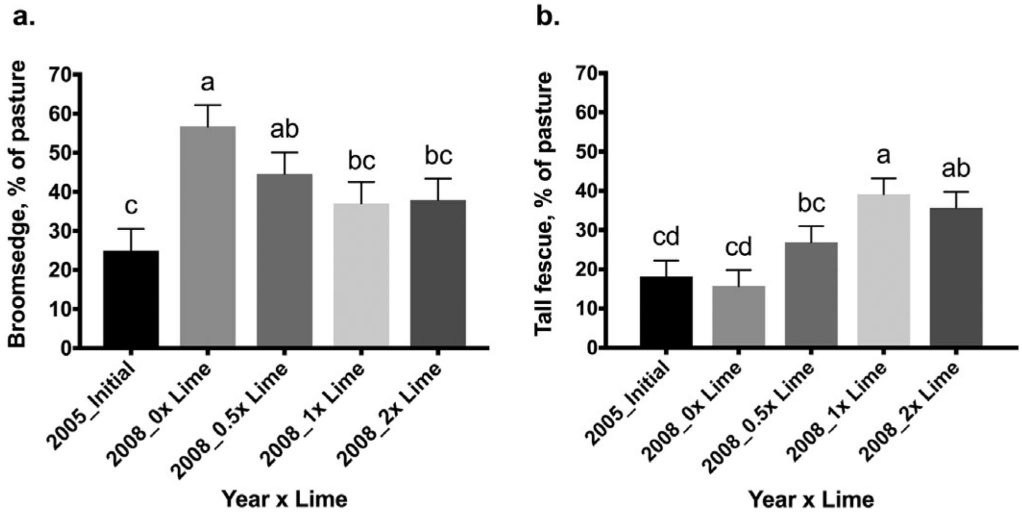

Fig. 3. (a) Broomsedge and (b) tall fescue response to a 2005 lime application during a 3-year experiment in SW Missouri. Lime was applied on 28 June 2005. Data for plant response to lime were pooled across all P treatments. Least square means with the same letter are not significantly different ($P \leq 0.05$). Broomsedge SEM = 5.5; Tall fescue SEM = 4.1.

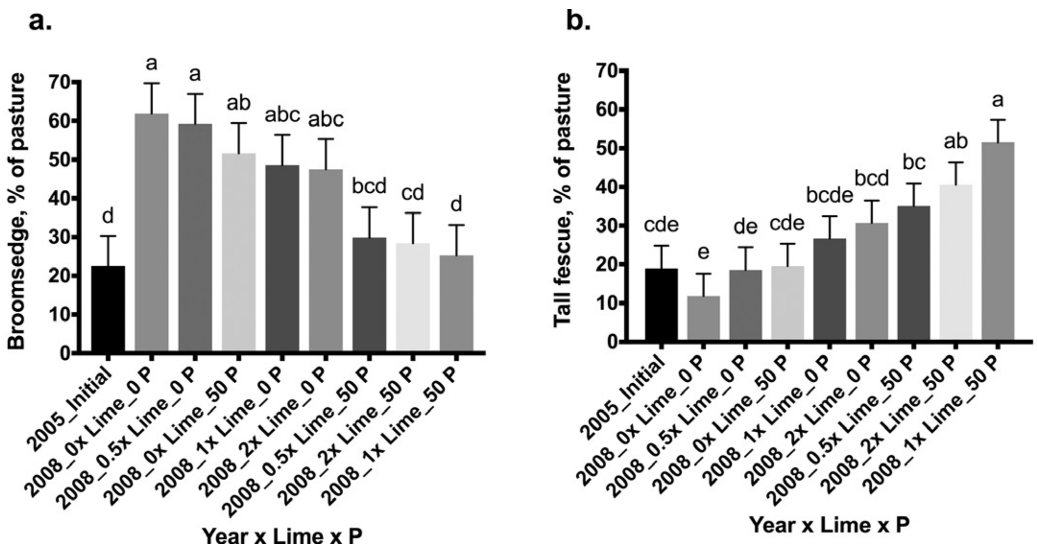

Fig. 4. Impact of a 2005 P and lime application on (a) broomsedge and (b) tall fescue count in a pasture infested with broomsedge during a 3-year experiment at the University of Missouri SW Center. Least square means with the same letter are not significantly different ($P \leq 0.05$). Broomsedge SEM = 7.8; Tall fescue SEM = 5.8.

Broomsedge counts increased from 25 to 57% in plots that did not receive lime over the 3-year period (Fig. 3a). Broomsedge count in the two highest lime treatments did not differ from the initial broomsedge count. The tall fescue count doubled with the two highest lime treatments, while the 0x lime treatment resulted in no increase in the tall fescue count after the 3-year study (Fig. 3b). It was not surprising that the tall fescue count increased in response to the lime treatments based on the low initial soil pH. It is well known that the optimum soil pH for growing tall fescue ranges from 5.5 to 7.0 (Belesky and West, 2009). Our previous study in an adjacent field showed that tall fescue yield responded to lime application; therefore, one might expect a population increase as well (Hamilton et al., 2012).

Broomsedge increased almost threefold in plots that did not receive any lime or P over the 3-year study (Fig. 4a). Combining lime and P limited broomsedge increase to the greatest degree after 3 years. The two highest lime treatments plus P fertilization produced the greatest increase in tall fescue counts after the 3 years (Fig. 4b). The initial soil test indicated low pH and low Bray I P values in these plots. Soil test results from 2008 (Table 1) indicated an increase in pH and a decrease in neutralizable acidity with increasing lime application, in addition to a slight increase in Bray I P in the 50 P treatment. As a result, an increase in tall fescue counts with liming and P fertilization would be expected. It was surprising that the combination of liming and P fertilization did not significantly decrease the broomsedge counts in the plots given that fertility treatments (P and K at rates based on soil test recommendations) in other studies have

Table 1. Soil test results (0- to 6-inch depth) obtained from 10 composited samples from each experimental plot in September 2008.

Treatment†	pH	NA‡	Bray I P	Ca	Mg	K	CEC§
		meq/100g	————	————	lb/acre	————	meq/100g
0 P-0x¶ Lime	5.0	4.7	4.2	1544.5	171.0	248.0	9.6
0 P-1/2x Lime	5.5	3.3	4.2	1880.2	152.0	190.3	8.8
0 P-1x Lime	5.8	2.3	5.2	2014.5	138.3	213.3	8.2
0 P-2x Lime	6.4	1.3	4.8	2628.5	147.3	196.2	8.8
50 P-0x Lime	5.0	4.9	10.7	1440.2	131.8	166.8	9.3
50 P-1/2x Lime	5.5	3.2	7.3	1926.3	141.0	200.0	8.8
50 P-1x Lime	5.7	2.5	8.0	2108.2	153.0	181.3	8.6
50 P-2x Lime	6.1	1.4	20.3	2525.7	133.5	170.3	8.5

†Treatment: *P* = phosphorus.

‡NA = neutralizable acidity.

§CEC = cation exchange capacity.

¶ x = 3.67 ton/acre.

been shown to negatively impact the broomsedge population (Butler et al., 2006; Peters and Lowance, 1974).

Invasive pasture weeds, like broomsedge, which cause a loss of about $2 billion in the United States (DiTomaso, 2000), not only result in a direct cost to producers when spraying and mowing are necessary control measures, but they also decrease the quality and quantity of forage. Increased vigor of tall fescue resulting from improved soil fertility likely influenced the increase in tall fescue and static growth of broomsedge observed in this study. Hence, enhancing the overall soil fertility by applying lime and P could provide an alternative for improving pastures by encouraging the growth of good quality grasses and legumes and discouraging encroachment or spread of common pasture weeds, like broomsedge.

References

Belesky, D.P., and C.P. West. 2009. Abiotic stresses and endophyte effects. In: Fribourg, H.A., D.B. Hannaway, and C.P. West, editor, 2009. Tall fescue for the twenty-first century. Agron. Monog. 53. ASA, CSSA, SSSA. Madison, WI. 540 pp. http://forages.oregonstate.edu/tallfescuemonograph. doi:10.2134/agronmonogr53.c4

Butler, T.J., L.A. Redmon, J.F. Stritzke, and C.L. Goad. 2006. Using prescribed fire, tillage and fertilizer to manage broomsedge-infested pastures. Online. Forage and Grazinglands doi:10.1094/FG-2006-0424-01-RS

Cook, C.W., and J. Stubbendieck. 1986. Range research: Basic problems and techniques. In: C.W. Cook, and J.L. Stubbendieck, editors. Society of Range Management. Denver, CO. 317 pp.

DiTomaso, J.M. 2000. Invasive weeds in rangelands: Species, impacts, and management. Weed Sci. 48:255–265. doi:10.1614/0043-1745(2000)048[0255:IWIRSI]2.0.CO;2

Dustman, R.B., and A.H. van Landingham. 1930. The chemical composition of consecutive cuttings of *Andropogon virginicus* L. and *Danthonia spicata*. Agron. J. 22:719–724. doi:10.2134/agronj1930.00021962002200080008x

Ehrenreich, J.H., R.F. Buttery, and C.W. Gehrke. 1960. How good is Ozark forage? MO. Agric. Exp. Bull. 759. 7 pp.

Griffin, J.L., V.H. Watson, and W.F. Strachan. 1988. Selective broomsedge control in permanent pastures. Crop Prot. 7:80–83. doi:10.1016/0261-2194(88)90016-6

Hamilton, E.J., R.J. Miles, K. Lukaszewska, M. Remley, M. Massie, and D.G. Blevins. 2012. Liming of two acidic soils improved grass tetany ratio of stockpiled tall fescue without increasing plant available phosphorus. J. Plant Nutr. 35:497–510. doi:10.1080/01904167.2012.631673

Lock, T.R., R.L. Kallenbach, D.G. Blevins, T.M. Reinbott, G.J. Bishop-Hurley, R.J. Crawford, and M.D. Massie. 2002. Adequate soil phosphorus decreases the grass tetany potential of tall fescue pasture. Crop Manag. 1. doi:10.1094/CM-2002-0809-01-RS

Ning, J., and J.R. Cumming. 2001. Arbuscular mycorrhizal fungi alter phosphorus relations of broomsedge (*Andropogon virginicus* L.) plants. J. Exp. Bot. 52:1883–1891. doi:10.1093/jexbot/52.362.1883

Peters, E.J., and S.A. Lowance. 1974. Fertility and management treatments to control broomsedge in pastures. Weed Sci. 22:201–205.

Rasnake, M. 2004. Managing broomsedge in pastures. p. 6-7. https://uknowledge.uky.edu/cgi/viewcontent.cgi?article=1059&context=forage_kca (accessed 9 Aug. 2014).

Reinbott, T.M., and D.G. Blevins. 1997. Phosphorus and magnesium fertilization interaction with soil phosphorus level: Tall fescue yield and mineral element content. J. Prod. Agric. 10:260–265. doi:10.2134/jpa1997.0260