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Phosphorus Rate Effects on Establishment of Perennial Grasses And on Soil Values at Point MacKenzie

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INTRODUCTION

Considerable soil fertility data are available for production of annual forages at Pt. MacKenzie (Michaelson et al. 1984; Mitchell 1983, 1985). As producers at Pt. MacKenzie progress from annual to perennial forages, fertilizer requirements for establishment and maintenance of perennial grasses must be determined. Phosphorus fixation in the Kashwitna and Homestead soil series, which predominate in the Pt. MacKenzie agricultural project area, is much higher than on the loess soils of the Matanuska and Tanana valley agricultural areas (Ping and Michaelson, in press). Consequently, application rates of phosphate (P_2O_5) must be adjusted accordingly.

The present study was established in 1985 to determine the response of three perennial grasses to P applications and to develop P soil-test criteria for measuring residual P. This report presents information on the first year's results.

MATERIALS AND METHODS

The trial was established on a tract at Pt. MacKenzie in an area where Homestead silt loam verges on Kashwitna silt loam, Kashwitna being the deeper soil. 'Manchar' bromegrass *(Bromus inermis)*, 'Engmo' timothy *(Phleum pratense)*, and common reed canarygrass *(Phalaris arundinacea)* were seeded at four fertilizer rates in four replications, the entries being randomly arranged in each replication (a randomized, complete-block design). Phosphorus fertilizer was applied as 0-45-0 (treble superphosphate) at 40, 80, 120, or 160 lbs/acre of P_2O_5. Each plot also received 90 lb N/acre as 45-0-0 (urea) and 80 lbs K_2O/acre as 0-0-60 (muriate of potash). Seed and fertilizer were broadcast on the surface of the soil and raked in and tamped with hand rakes. The seeding was conducted on 17 June 1985, and the plots were harvested on 12 September with a sickle-bar mower, leaving almost 3 inches of stubble. The plots measured 5 × 15 ft., and a 2 × 12 ft. area was harvested from the center of each plot. Forage samples were dried at 140 °F for dry matter determination; yields are reported on an oven-dry basis.

Soil samples were taken to about the 6-inch depth from each plot in three replications in September after the harvest was completed. Analyses were conducted of the soil samples for nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg). Plant tissue samples also were analyzed for N, P, K, Ca, Mg, and in vitro dry matter digestibility (IVDMD).

FORAGE YIELD AND QUALITY RESULTS

All three grasses showed a significant response in yield to increasing phosphorus treatments up to 120 lb P_2O_5/acre (table 1). The highest treatment of 160 lb P_2O_5/acre did not increase yields over that obtained with 120 lb P_2O_5/acre (tables 1 and 2). The high P treatments increased yields of bromegrass almost seven-fold over that of the low P treatment. Reed canarygrass significantly outyielded the other grasses at each level of P treatment and for the combined treatments (table 2).

Manchar bromegrass had the highest crude protein contents (table 1). This was at least partially related to its low yields. Reed canarygrass, with the highest yields, had the lowest protein concentrations. As is frequently the case, the higher yields appear to have had a diluting effect on crude protein and energy contents. Reed canarygrass, therefore, also had the lowest digestible dry matter (IVDMD) content. Except for a notably low P content for bromegrass at the 40 lb P_2O_5/acre rate, the grasses did not differ greatly in the concentration of phosphorus in their herbage, with timothy having some of the highest levels. Timothy and brome had particularly high levels of dry matter digestibility. Reed canarygrass remained above 60 per cent IVDMD for most treatments.

Interpretation of phosphorus effects on nutrient contents is confounded by the effects of phosphorus on yield. What appears to be a negative effect of P level on crude protein and digestible dry matter content may only be true indirectly. Increased phosphorus treatments produced higher yields, thus resulting in a dilution effect on nutrient contents. Although the evidence for dilution as a result of increased growth rate is circumstantial, it nevertheless is quite convincing.

SOIL TEST RESULTS

The use of soil tests to measure availability of residual nutrients has a long history and enjoys general acceptance by producers. However, phosphorus chemistry in soils is such that several years of fertilization are required before residual levels stabilize to the point of giving reliable soil-test data.

While forage yield levels (table 1) and total plant uptake of phosphorus (table 3) responded to increasing application rates up to 120 lb/A of P_2O_5, soil-test P levels did not differ significantly for samples taken postharvest in the fall (table 3). Although P_2O_5 uptake accounted for only 10 to 15 per cent of that applied, the bulk of the residual P in the soil was not measured by either the Bray P-1 or the Mehlich 3 soil extractants. This is indicative of high P fixation soils and does not necessarily mean that no residual P is available for subsequent crops, but that P availability will be restricted until a greater portion of the P fixation capacity is satisfied. Preliminary P calibration data[1] would indicate that significantly more P_2O_5 than the high rate of 160 lb/A in the present study will be required to meet the P fixation capacity and show accumulation of residual P. A study by Michaelson and Ping (in press), which included soil from the Kashwitna series, demonstrated that the Mehlich 3 extractant was superior to Bray P-1 in measuring plant available P in high P fixing soils. Soil test calibration data using the Mehlich 3 extractant will continue to be collected as this study proceeds.

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[1] Michaelson, G.J., research associate, Ping, C.L., assistant professor, soils. 1985. Palmer Research Center, Agricultural and Forestry Experiment Station. Personal communication.

Table 1. Effects of fertilizer treatments (P levels) on yield and on crude protein (C.P.), phosphorus (P), and digestible dry matter (IVDMD) concentrations of bromegrass, timothy, and reed canarygrass.

Species and Treatment	Yield	C.P.	P	IVDMD
	(T/A)		%	
Manchar bromegrass				
90-160-80	1.04 cd[1]	17.9 bcd	.25 c	67.9 ef
90-120-80	1.03 cd	19.4 abc	.27 ac	74.2 bcd
90-80-80	0.51 f	22.7 a	.25 c	78.7 abc
90-40-80	0.15 g	21.6 ab	.18 d	79.9 a
Engmo timothy				
90-160-80	1.20 c	15.0 d-g	.31 ab	73.5 cd
90-120-80	1.08 c	15.9 d-g	.32 a	75.8 a-d
90-80-80	0.81 de	17.4 b-e	.27 bc	76.3 a-d
90-40-80	0.58 ef	19.4 abc	.27 bc	79.3 ab
Reed canarygrass				
90-160-80	2.18 a	12.7 fg	.27 bc	59.1 g
90-120-80	2.24 a	13.4 efg	.25 c	62.1 g
90-80-80	1.90 b	12.4 g	.24 c	63.1 fg
90-40-80	1.29 c	16.9 c-f	.27 bc	71.6 de

[1]Means within a column followed by the same letter do not differ significantly at the 5 per cent level of probability.

Table 2. Combined treatment and species results.

Treatment	Av. yield (all species)	Species	Av. yield (all treatments)
	(T/A)		(T/A)
90-160-80	1.47 a[1]	Reed canarygrass	1.90 a
90-120-80	1.45 a	Engmo timothy	0.92 b
90-80-80	1.07 b	Manchar bromegrass	0.68 c
90-40-80	0.68 c		

[1]Means within a column followed by the same letter do not differ significantly at the 5 per cent level of probability.

Table 3. Effects of P application rate on P uptake and soil test values.

P_2O_5 Rate	P_2O_5[1] Uptake	Soil Test P[1]	
		Bray P-1	Mehlich 3
(lb/A)		(ppm)	
40	6.8 c[2]	3.1 a	7.9 a
80	9.4 b	2.6 a	8.2 a
120	14.4 a	3.5 a	10.5 a
160	14.6 a	2.4 a	7.8 a

[1]Averaged over three cultivars; means of nine observations.
[2]Means within a column followed by the same letter do not differ significantly at the 5 per cent level of probability.

SUMMARY

This trial concentrates on the effects of varying rates of P with N and K supplied in amounts judged to be ample for establishment of perennial grasses. The results indicated that, by seeding sufficiently early and supplying 90-120 lb P_2O_5/acre, harvestable amounts of forage could be obtained in the year of seeding. Reed canarygrass would provide the most forage in the first year; however, in previous trials timothy has been more durable and higher yielding over a series of years (Mitchell, in press). Laboratory measurements of crude protein and digestible dry matter indicated the quality of the forage would be good to excellent. The high-yielding reed canarygrass was the lowest in quality but still afforded about 13 per cent crude protein and 60 per cent digestible dry matter.

The trial is to be continued to determine the cumulative effects of annual fertilizer applications at the same rates on yields and soil test values. A question of immediate concern is the possible effect of promoting high production in the year of establishment on the overwintering characteristics of the grasses.

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