Perennial Grass and Soil Responses to Four Phosphorus Rates At Point MacKenzie

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INTRODUCTION

Three perennial grasses were established on Kashwitna silt loam at Pt. MacKenzie in 1985 to test their responses to different rates of phosphorus (P) fertilization. Laboratory studies with a number of Alaskan soils have indicated strong P-fixation properties for the Pt. MacKenzie soils (Ping and Michaelson 1986, Michaelson and Ping 1986). Earlier work with cereal forages showed responses for barley up to 90 lbs/acre and for oats up to 60 lbs P_20_5/acre (Michaelson et al. 1984).

All three perennial grasses ['Engmo' timothy *(Phleum pratense)*, 'Manchar' bromegrass *(Bromus inermis)*, and reed canarygrass *(Phalaris arundinacea)*] responsed to P_2O_5 up to 120 lbs/acre in their establishment year in 1985 (Mitchell and Mitchell 1986). Reed canarygrass significantly outproduced in 1985, yielding over two tons dry matter/acre at the higher fertilizer levels. Bromegrass was the least productive in the establishment year.

This report concerns the results obtained in 1986, which constituted the first full harvest year.

MATERIALS AND METHODS

Engmo timothy, Manchar bromegrass, and common reed canarygrass were broadcast seeded in 1985 in four replications in a randomized complete design. Each grass was broadcast fertilized at four rates of P with 0-45-0 (treble superphosphate) applied to supply 40, 80, 120, or 160 lbs P_20_5/acre. Each plot also received 90 lb nitrogen (N)/acre as 45-0-0 (urea) and 80 lbs K_20/acre as 0-0-60 (muriate of potash). Seed and fertilizer were worked into the soil with rakes followed by tamping. The plots were fertilized by top dressing at the same rates in the spring of 1986, the second year of growth. After the first harvest in 1986, the plots were refertilized with urea to supply 90 lbs N/acre.

Yield samples were taken from a 2 × 12-ft area from the center of each 4 × 15-ft plot with a sickle-bar mower, leaving about 3 inches of stubble. Subsamples were dried at 140°F for dry matter determination; yields are reported on an oven-dry basis. Laboratory analyses for quality measurements were conducted on plant material ground to pass a 1-mm screen. Analyses were conducted for N, P, potassium (K), calcium (Ca), magnesium (Mg), and digestible dry matter (DDM) by the in vitro method. Crude Protein (CP) was determined by multiplying N content by 6.25. Soil samples were taken at depths of 0-2 and 0-6 inches after the second harvest. Samples were air dried, sieved to pass a 2-mm screen, and P extracted using Bray P-1 and Mehlich 3 extracting solution.

FORAGE YIELD AND QUALITY RESULTS

Reed canarygrass, the highest yielding grass in 1985 (the year of establishment), experienced serious winter injury and was the lowest producer in the first harvest of 1986 (table 1). Phosphorus levels positively affected recovery, however, with higher yields obtained at each higher increment of P. Manchar bromegrass showed a large response to the first P increment (from 40 to 80 lbs P_2O_5/acre) but showed smaller increases in response to the next two increments at the first harvest. Engmo timothy showed no response to increasing levels of P, yielding as much at the lowest level as at the higher levels of treatment. Timothy produced about 40 percent more dry matter than bromegrass and well over twice as much as reed canarygrass in the first harvest, yielding almost 2.5 tons/acre.

Reed canarygrass had recovered sufficiently to produce about 2 tons/acre in the second harvest, outyielding the other two grasses by large amounts (table 1). Phosphorus treatments did not significantly affect second harvest yields of reed canarygrass. Bromegrass showed a large response to the first increment of P, while timothy showed the largest increase (not significant, however) at the 120-lb level of P_2O_5/acre.

Timothy sustained good values for CP and DDM along with its high first-harvest yield (table 2). Reed canarygrass, in conjunction with its low yield, had the highest CP and DDM contents. Bromegrass was notably low in P content. Reed canarygrass was exceptionally high in Mg content. Except for an increase in P content, there was no discernible effect of P rate on quality measurements. The interaction of yield and quality, with higher yields tending to have a diluting effect on quality concentrations, confounds the interpretation of P effect on these measures.

In the second harvest the low-yielding timothy had lower protein content than the high-yielding reed canarygrass (table 2). Bromegrass also exceeded timothy in CP with about the same yield. Timothy was high in energy (DDM). Reed canarygrass maintained good digestibility with its high yield, was exceptionally high in Mg content, and was the highest in P content. Phosphorus rates had no discernible effect on quality measures apart from those of yield.

SOIL TEST RESULTS

Phosphorus soil tests have generally been unresponsive to fertilizer application rates at Pt. MacKenzie. On samples taken to a depth of 6 inches at the end of the establishment year, there was no significant difference between P soil tests at different application rates of P_2O_5 (Mitchell and Mitchell 1986). In 1986, replicated samples were taken to a depth of 2 inches in addition to the 6-inch samples. All samples were extracted with the standard Bray P-1 extracting solution and the relatively new Mehlich 3 solution. The latter has been shown to be superior to Bray on high P-fixation soils (Michaelson and Ping 1986).

Uptake of P_2O_5 increased with each increment of P fertilization while percent recovery of that applied decreased (table 3). Neither the Bray P-1 nor Mehlich 3 extracting solutions measured the residual P when taken to a depth of 6 inches. Since top dressing fertilizer on perennial grass allows no incorporation into the soil, residual P will be found in the uppermost portion of the profile. Shallower sampling (2 inches) resulted in higher concentrations and better measurement of apparent residual P; however, these differences were significant only in the case of Mehlich 3.

DISCUSSION

According to observations made over a number of years, the three perennial grasses included in this trial can be compared as follows regarding winterhardiness and acid tolerance. Timothy and reed canarygrass, are more acid tolerant than bromegrass. Engmo timothy is more winterhardy than reed canarygrass and bromegrass generally is more winterhardy than timothy.

The poor first-harvest yield for bromegrass is related to its marginal adaptability to the soil conditions; however, increasing P applications, at least to the 80 to 120 lbs P_2O_5/acre level, improved performance. Total 1986 yield of bromegrass at the high P level (160 lb P_2O_5/acre) was about double that at the low P level (40 lbs P_2O_5/acre). In other trials bromegrass sometimes has produced only half the first-harvest yield of timothy on Pt. MacKenzie soils, but has generally equalled or exceeded timothy in second-harvest yields (Mitchell, W.W., unpublished data). High P treatments appear necessary to maintain bromegrass stands on the Homestead, Kashwitna, and Flathorn series of silt loams at Pt. MacKenzie.

Table 1. Yield (T/A) of grasses fertilized at four phosphorous rates on Kashwitna silt loam, Pt. MacKenzie.

P_2O_5 Rate (lb/A)[1]	Reed canarygrass	Manchar brome	Engmo timothy	Av. yield
		First Harvest (25 June 1986)		
40	0.59 b[2]	1.06 c	2.42	1.36 c
80	0.76 b	1.78 b	2.48	1.67 b
120	1.02 a	1.97 ab	2.36	1.78 ab
160	1.17 a	2.10 a	2.41	1.89 a
Av.	0.89	1.73	2.42	
		Second Harvest (20 Aug. 1986)		
40	1.87	0.78 b	1.01 b	1.22 b
80	2.13	1.27 a	1.05 ab	1.48 a
120	2.05	1.26 a	1.21 a	1.51 a
160	2.08	1.40 a	1.22 a	1.57 a
Av.	2.03	1.18	1.12	
Av. total	2.92	2.91	3.53	

[1]Also fertilized with 90 N and 80 K_2O per acre in the spring and 90 N after the first harvest.
[2]Means within a column followed by the same letter do not differ significantly at the 5 percent level of probability using duncan's mean separation.

Table 2. Forage quality of grasses fertilized at four phosphorus rates.

	C.P. (%)	P (%)	K (%)	Ca (%)	Mg (%)	DDM (%)	T/A yield
			First Harvest (25 June 1986)				
Grass[1]							
Engmo Timothy	13.4 b[2]	0.28 a	2.85	0.52 b	0.16 b	64.7 b	2.42 a
Manchar br.	13.9 b	0.18 c	2.84	0.51 b	0.14 b	68.8 c	1.73 b
Reed can.	17.0 a	0.26 b	2.93	0.58 a	0.24 a	70.7 a	0.89 c
lb/A P_2O_5[3]							
40	15.5 a	0.19 c	2.75	0.54	0.17 b	70.7 a	1.36 c
80	15.0 ab	0.23 b	2.90	0.55	0.18 ab	68.1 b	1.68 c
120	14.6 ab	0.25 b	3.00	0.55	0.19 ab	67.5 b	1.78 ab
160	14.0 b	0.28 a	2.84	0.50	0.20 a	65.8 c	1.89 a
			Second Harvest (20 Aug. 1986)				
Grass							
Engmo timothy	10.6 c	0.17 b	1.71 c	0.67	0.19 b	70.1 a	1.12 b
Manchar br.	15.1 a	0.19 b	2.66 a	0.65	0.19 b	67.6 b	1.18 b
Reed can.	12.4 b	0.22 a	2.25 b	0.63	0.39 a	62.5 c	2.03 a
lb/A P_2O_5							
40	14.8 a	0.18 b	2.66 a	0.61	0.25 ab	69.4 a	1.22 b
80	12.3 b	0.18 b	2.16 b	0.70	0.25 ab	66.8 b	1.48 a
120	12.1 b	0.21 a	2.15 b	0.65	0.25 b	66.0 bc	1.51 a
160	11.8 b	0.20 ab	1.84 b	0.62	0.29 a	64.7 c	1.57 a

[1]Values were averaged for all rates P_2O_5 for each grass.
[2]Means within a column followed by the same letter do not differ significantly at the 5 percent level of probability.
[3]Values were averaged for all grasses at each fertilizer level.

Table 3. Effects of P application rate on P uptake and soil test values.[1]

P_2O_5 rate	P_2O_5 uptake	Soil Test P: Bray P-1 0-2"	Bray P-1 0-6"	Mehlich 3 0-2"	Mehlich 3 0-6"
lbA	lbA	ppm	ppm	ppm	ppm
40	19.6 c[2]	2.9	3.9	7.2 b	8.5
80	30.1 b	3.3	2.2	9.4 ab	6.6
120	35.3 ab	4.8	4.7	12.6 a	10.0
160	38.3 a	4.1	2.6	11.0 ab	6.8

[1]Values were averaged for all grasses at each fertilizer level.
[2]Means within a column followed by the same letter do not differ significantly at the 5 percent level of probability.

Reed canarygrass shows the potential for high yields at Pt. MacKenzie but is restricted by insufficient winterhardiness. The higher P treatments aided the grass in withstanding and recovering from winter injury, but the second-harvest performance suggested that a healthy stand would not require the higher levels of P for good performance. Though reed canarygrass can produce 2 tons or more of good-quality forage per acre in the year of establishment, first-harvest yields in subsequent years are highly variable depending on the health of the stand emerging from winter, as demonstrated in this and other studies (Mitchell, W.W., unpublished data). It often recovers, however, and produces a good second-harvest yield that may exceed 2 tons/acre, as it did in this study. Stands have deteriorated and become nonproductive after three or four years.

As indicated in this trial, timothy has been the most reliable for providing high first-harvest yields on Pt. MacKenzie soils (Mitchell, W.W., unpublished data). It generally has been the highest producer of all grasses tested in the June to early July harvest during its early years of production. Engmo timothy has produced up to 3.5 dry matter/acre in the first harvest at Pt. MacKenzie (Mitchell 1986). In this study, Engmo timothy was as productive at 40 lbs P_20_5/acre as at the higher rates. Despite the high yield, it had the highest P content in its first-harvest herbage, thus demonstrating an above-average ability to take up P in a high P-fixing soil. Timothy has shown relatively poor regrowth ability on Pt. MacKenzie soils, however, generally producing about 1 ton or less dry matter/acre. Phosphorus content also declines in the second harvest. Refertilization for the second harvest has been with N only; possibly some additional P is needed to promote better growth. In some other trials of longer duration, timothy has demonstrated a stagnating condition that has lowered production. The condition appears to be related more to loss of vigor than to stand reduction. More research needs to be done on how to revive productivity of these stands.

On the basis of this and other studies, timothy appears to be the preferred perennial grass to provide a good yield for a late June to early July harvest. However, it may be well to assign acreage so as to stagger plantings over a period of years. If stagnation is a problem after a certain period of years, staggered plantings would help maintain some acreage in a productive state. Timothy's ability to perform at relatively low levels of P lowers fertilizer costs.

Reed canarygrass offers the potential of high first-year yield if seeded prior to mid-June with good establishment. Though subsequent first-harvest yields may be relatively low because of winter injury, high second-harvest yields can result in total production about equaling or exceeding that of timothy. Winter and growing-season conditions can affect the production of all grasses.

The strong P-fixation properties of this allophanic soil coupled with the application of granular fertilizers on the surface of the soil results in an inordinate amount of P being retained in the surface layer. It appears that the combination of shallow sampling and the Mehlich extracting solution holds the best possibility for a usable soil test with perennials at Pt. MacKenzie.

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