Influence of Nitrogen Rate, Nitrogen Source, And Phosphorus Rate on Native Bluejoint Grass Yield and Composition On the Lower Kenai Peninsula

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Introduction

Properly managed native bluejoint grass [*Calamagrostis canadensis* (Michx.) Beauv.], the dominant grass on the Kenai Peninsula (Laughlin et al. 1984), is important for supplying supplemental forage for winter feeding of livestock. This 11-year study was undertaken to determine responses of native bluejoint to two rates of nitrogen (N) supplied by ammonium nitrate (AN), urea, and two rates of phosphorus (P) on Kachemak silt loam at two locations on the lower Kenai Peninsula.

Experimental Procedure

The first location (Anderson's) was selected in September of 1973 on the Elton Anderson Ranch from a uniform area of bluejoint which, in the past, had not produced sufficient growth to justify machine harvest. The

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soil pH at this site was 5.2. This area had been leveled with a bulldozer several years previously. The second location (Lookout) was selected in June of 1979 on the University of Alaska research tract on Lookout Mountain where the pH was 4.7. The area had been leveled with a rotary plow in both 1972 and 1973. In 1973 treblesuperphosphate was applied heavily over the entire area. An excellent stand of bluejoint had again established itself by 1979. At both locations the field experiment involved two N sources (AN and urea), two N rates (120 and 240 lb per acre), and two P rates (26 and 53 lb per acre). In addition to these treatments, N was not applied in one other treatment and P was not applied in two others. All treatments received 166 lb potassium (K) per acre as sulfate of potash and were replicated six times. The fertilizer treatments were broadcast annually by hand during the first half of June each year.

Two clippings were made each season with a small sickle-equipped power mower in early July and in September. The harvested area consisted of a strip 30 inches wide and 12 feet long cut from the center of each 6- by 15-foot plot. Green and dry weights were recorded for each harvest. Representative samples from each plot were ground to pass a 20-mesh stainless steel laboratory mill screen. Chemical determinations were made as follows: total N and P colorimetrically with the Technicon autoanalyzer (TIS 1976); K, calcium (Ca), and magnesium (Mg) with an atomic absorption spectrophotometer following a sulfuric-selenous acid digestion and using lanthanum to control interferences (Perkin-Elmer 1973); and total sulfur (S) using an automatic S analyzer (Smith 1980).

The data from each location were subjected to a split-plot type of analysis for repeated measures experiment. The main plots of the experiments were a 2^3 randomized complete block with six blocks. Each experimental plot was measured over 5 years for yield and N and S concentration and uptake and 4 years for P, Ca, and Mg at the Anderson location and over 6 years for all factors at Lookout. In the analysis of variance, the whole plot effects were N, P, and N source and all interactions among these factors. The subplot on repeated measures effects were year and all interactions involving years. In the significance tests for the year and year interaction effects, conservative tests using minimum degrees of freedom for the required F values for significance allowing for auto correlations among years were utilized.

The data are presented eliminating interaction with years and in some cases combining locations for simplification.

Results

Yield

Nitrogen response at both Anderson's and Lookout was similar (table 1). First-cutting yields responded to N application, but no significant differences resulted from doubling the N rate from 120 to 240 lb N per acre. However, second-cutting and total annual yields increased with each increasing N rate. The lack of response of the first cutting to 240 lb N per acre indicates that 120 lb per acre was adequate but not sufficient for a second cutting.

At Anderson's there was no significant difference between the response of the two N sources, but at the Lookout Mountain site the yields of both cuttings were greater with AN than with urea (table 2). We cannot explain this response difference at the two locations unless it was more moist at Anderson's than at Lookout.

Each increasing P rate increased the yield of both cuttings at Anderson's and of the first-cutting and annual yield at Lookout (table 3). The application of P increased second-cutting yields at Lookout, but increasing the P rate from 26 to 53 lb per acre did not increase the yield significantly.

Nutrient Concentration

Nutrient concentrations for all years at both locations are presented as averages in Tables 4-7. The N concentration in each cutting and the K and Mg concentrations in the second cutting were increased by each increasing N rate (table 4). First-cutting P, K, S, and Mg concentrations were increased, and second-cutting S and the Ca concentration in both cuttings were decreased by N application. This decrease probably results from nutrient dilution resulting from the increased growth with the application of N. Increasing the N rate from 120 to 240 lb per acre had no significant effect on the Ca concentration in either cutting; in first-cutting P, K, and Mg concentrations; or in second-cutting S concentration. Second-cutting P concentration and first-cutting S concentration varied with N rate as follows: $240 > 0 > 120$ and $120 > 240 > 0$, respectively.

Table 5 shows the first cutting N, K, and Mg concentrations were greater with ammonium nitrate than with urea while S and Ca concentrations in both cuttings and second-cutting K and Mg concentrations were essentially the same with both N sources.

The N rate × N source interaction with the N and P concentrations is shown in Table 6. At the lower 120 lb N per acre rate the second-cutting N concentration and the P concentration in both cuttings were essentially the same for both N sources. However, with the higher 240 lb N rate the concentrations of both N and P were greater with AN than with urea.

Each increasing P rate increased the P concentration in both cuttings and the Ca concentration in the second cutting (table 7). Application of P increased the N, S, Ca, and Mg concentrations in the first cutting and the K concentration in both cuttings while depressing the N concentration in the second cutting. This depression probably resulted from dilution by increased forage production with the addition of P. Increasing the P rate from 26 to 53 lb per acre had no significant effect on the N, K, S, or Mg concentrations in either cutting or on first-cutting Ca concentration.

Nutrient Uptake

Each increasing N rate resulted in an increase in the annual N, Ca, and Mg uptake by native bluejoint (table 8).

Table 9 presents the significant N rate × N source interaction with nutrient uptake. Increasing the nitrogen rate from 120 to 240 lb per acre increased the P, K, and S uptake significantly only when AN was used. The increase when urea was applied was not large enough to be significant.

The uptake of N, Ca, and Mg by native bluejoint during this 11-year period was greater with AN than with urea (table 10). Each increasing P rate increased the N, P, K, S, and Ca uptake by native bluejoint during this 11-year period (table 11). Uptake of Mg was increased by P application, but further increasing the P rate from 26 to 53 lb per acre did not increase the Mg uptake significantly.

Table 1. Effect of nitrogen rate on native bluejoint yield at Anderson's (1974-1978) and at Lookout (1979-1984).

	Anderson's[1]			Lookout[2]		
Lb N/A	1st Cut	2nd Cut	Total	1st Cut	2nd Cut	Total
	(T/A)					
0[3]	0.93b[4]	0.37c	1.30c	0.73b	0.26c	0.99c
120	1.64a	0.77b	2.41b	1.54a	0.82b	2.36b
240	1.63a	1.02a	2.65a	1.47a	1.12a	2.59a

[1]Means of 120 measurements.
[2]Means of 144 measurements.
[3]Means of 30 (Anderson's) and 72 (Lookout) measurements.
[4]Letters in tables are used in accordance with Duncan's multiple range test. Any two values within a column not followed by the same letter are significantly different at the 5% level of probability.

Table 2. Effect of nitrogen source on native bluejoint yield at Anderson's (1974-1978) and at Lookout (1979-1984).

	Anderson's[1]			Lookout[2]		
N Source	1st Cut	2nd Cut	Total	1st Cut	2nd Cut	Total
	(T/A)					
AN	1.66a[3]	0.90a	2.56a	1.55a	1.03a	2.58a
Urea	1.61a	0.89a	2.50a	1.46b	0.91b	2.37b

[1]Means of 120 measurements.
[2]Means Of 144 measurements.
[3]Letters in tables are used in accordance with Duncan's multiple range test. Any two values within a column not followed by the same letter are significantly different at the 5% level of probability.

Table 3. Effect of phosphorus rate on native bluejoint yield at Anderson's (1974-1978) and at Lookout (1979-1984).

	Anderson's[1]			Lookout[2]		
Lb P/A	1st Cut	2nd Cut	Total	1st Cut	2nd Cut	Total
	(T/A)					
0[3]	0.70c[4]	0.52c	1.22c	1.06c	0.69b	1.75c
26	1.59b	0.85b	2.44b	1.47b	0.95a	2.42b
53	1.68a	0.93a	2.61a	1.54a	0.99a	2.53a

[1]Means of 120 measurements.
[2]Means of 144 measurements.
[3]Means of 60 (Anderson's) and 108 (Lookout) measurements.
[4]Letters in tables are used in accordance with Duncan's multiple range test. Any two values within a column not followed by the same letter are significantly different at the 5% level of probability.

Table 4. Effect of nitrogen rate on N and S and P, K, Ca, and Mg concentrations in native bluejoint averaging data from Anderson's and Lookout (1974-1984).

Lb N/A	N[1]	P[2]	K[2]	S[1]	Ca[2]	Mg[2]
	First Cutting					
	(%)					
0[3]	2.02c[4]	.406b	2.60b	.222b	.186a	.092b
120	3.56b	.430a	3.42a	.246a	.164b	.116a
240	3.95a	.423a	3.33a	.232b	.157b	.115a
	Second Cutting					
	(%)					
0[3]	1.98c	.334b	1.78c	.266a	.250a	.078c
120	2.38b	.316c	2.16b	.212b	.222b	.092b
240	3.03a	.354a	2.50a	.211b	.210b	.112a

[1]Means of 264 measurements.
[2]Means of 240 measurements.
[3]Means of 102 (N and S) and 96 (P, K, Ca, and Mg) measurements.
[4]Letters in tables are used in accordance with Duncan's multiple range test. Any two values within a column not followed by the same letter are significantly different at the 5% level of probability.

Table 5. Effect of nitrogen source on N and S and P, K, Ca, and Mg concentrations in native bluejoint averaging data from Anderson's and Lookout (1974-1984).

N Source	N[1]	P[2]	K[2]	S[1]	Ca[2]	Mg[2]
	First Cutting					
	(%)					
AN	3.82a[3]	See	3.48a	.234a	.164a	.120a
Urea	3.68b	Table 6	3.27b	.244a	.158a	.111b
	Second Cutting					
	(%)					
AN	See	See	2.37a	.211a	.212a	.103a
Urea	Table 6	Table 6	2.30a	.212a	.220a	.100a

[1]Means of 264 measurements.
[2]Means of 240 measurements.
[3]Letters in tables are used in accordance with Duncan's multiple range test. Any two values within a column not followed by the same letter are significantly different at the 5% level of probability.

Table 6. Effect of nitrogen rate and source on second-cutting N and P and first-cutting P concentrations in native bluejoint averaging data from Anderson's and Lookout (1974-1984).

	(lb N/A)					
	120	240	120	240	120	240
N Source	N (2nd Cut)[1]		P (1st Cut)[2]		P (2nd Cut)[2]	
	(%)					
AN	2.38a[3]	3.16a	.447a	.414a	.318a	.366a
Urea	2.38a	2.90b	.452a	.394b	.316a	.342b

[1]Means of 132 measurements.
[2]Means of 120 measurements.
[3]Letters in tables are used in accordance with Duncan's multiple range test. Any two values within a column not followed by the same letter are significantly different at the 5% level of probability.

Table 7. Effect of phosphorus rate on N and S and P, K, Ca, and Mg concentrations in native bluejoint averaging data from Anderson's and Lookout (1974-1984).

Lb P/A	N[1]	P[2]	K[2]	S[1]	Ca[2]	Mg[2]
	First Cutting					
	(%)					
0[3]	3.44b[4]	.250c	2.78b	.212b	.130b	.092b
26	3.73a	.399b	3.38a	.238a	.155a	.115a
53	3.78a	.454a	3.36a	.239a	.167a	.116a
	Second Cutting					
	(%)					
0[1]	2.84a	.211c	2.06b	.211a	.176c	.092a
26	2.70b	.316b	2.34a	.212a	.209b	.100a
53	2.70b	.354a	2.34a	.210a	.224a	.102a

[1]Means of 264 measurements
[2]Means of 240 measurements.
[3]Means of 168 (N and S) and 156 (P, K, Ca, and Mg) measurements.
[2]Letters in tables are used in accordance with Duncan's multiple range test. Any two values within a column not followed by the same letter are significantly different at the 5% level of probability.

Table 8. Effect of nitrogen rate on N and S and P, K, Ca, and Mg uptake by native bluejoint averaging data from Anderson's and Lookout (1974-1984).

Lb N/A	N[1]	P[2]	K[2]	S[1]	Ca[2]	Mg[2]
	-----	-----	-----	(lb/A)	-----	-----
0[3]	45c[4]	8	52	5.0	4.63c	1.96c
120	150b	See	See	See	8.74b	5.20b
240	188a	Table 9	Table 9	Table 9	9.40a	6.00a

[1]Means of 264 measurements.
[2]Means of 240 measurements.
[3]Means of 102 (N and S) and 96 (P, K, Ca, and Mg) measurements.
[4]Letters in tables are used in accordance with Duncan's multiple range test. Any two values within a column not followed by the same letter are significantly different at the 5% level of probability.

Table 9. Effect of nitrogen rate and source on the P, K, and S uptake by native bluejoint averaging data from Anderson's and Lookout (1974-1984).

	Nitrogen Source					
	AN	Urea	AN	Urea	AN	Urea
Lb N/A	P[1]		K[1]		S[2]	
	-----	-----	(lb/A)	-----	-----	-----
120	19b[3]	17a	148b	135a	10.9b	11.1a
240	22a	18a	165a	143a	11.9a	11.2a

[1]Means of 120 measurements.
[2]Means of 132 measurements.
[3]Letters in tables are used in accordance with Duncan's multiple range test. Any two values within a column not followed by the same letter are significantly different at the 5% level of probability.

Table 10. Effect of nitrogen source on the N, Ca, and Mg uptake by native bluejoint averaging data from Anderson's and Lookout (1974-1984).

N Source	N[1]	Ca[2]	Mg[2]
	-----	(lb/A)	-----
AN	178a[3]	9.40a	5.96a
Urea	160b	8.74b	5.28b

[1]Means of 264 measurements.
[2]Means of 240 measurements.
[3]Letters in tables are used in accordance with Duncan's multiple range test. Any two values within a column not followed by the same letter are significantly different at the 5% level of probability.

Table 11. Effect of phosphorus rate on the N and S and P, K, Ca, and Mg uptake by native bluejoint averaging data from Anderson's and Lookout (1974-1984).

Lb P/A	N[1]	P[2]	K[2]	S[1]	Ca[2]	Mg[2]
	(lb/A)					
0[3]	98c[4]	7c	78c	4.7c	4.58c	2.90b
26	164b	17b	144b	11.0b	8.52b	5.42a
53	174a	21a	151a	11.6a	9.62a	5.78a

[1]Means of 264 measurements.
[2]Means of 240 measurements.
[3]Means of 168 (N and S) and 156 (P, K, Ca, and Mg) measurements.
[4]Letters in tables are used in accordance with Duncan's multiple range test. Any two values within a column not followed by the same number are significantly different at the 5% level of probability.

Discussion

First-cutting yields were not increased by the higher 240 lb N per acre rate which indicates that if one were removing only one cutting per year and did not graze the area, 120 lb N per acre would be about the optimum amount to apply. However, if two cuttings were made, more N would be needed. We believe a spring N application of from 100 to 120 lb per acre, followed by a similar application immediately after the first harvest, would obtain the best yields when two cuttings a year are made. Of course adequate P and K should be applied with the spring N application. These conclusions agree with those of a previous study conducted from 1975 to 1979 (Laughlin et al. 1984).

Grass yield at Anderson's was essentially the same for both N sources, but were greater with AN than with urea at Lookout. This lack of consistent differences in yield between the two N sources in this area is in contrast to the results in the Matanuska Valley where AN invariably results in higher yields than does urea (Laughlin 1962). We attribute this more favorable response to a higher probability of rain shortly after fertilizer application together with lower temperatures so there is less chance of N loss through volatilization.

In the Matanuska Valley N concentrations and uptake are practically always less with urea than with AN at all N rates (Laughlin 1962). The present data indicate similar results with the two N sources at both N rates except that with the second cutting at the lower 120 lb N per acre rate. Here the N concentration is identical for both N sources.

Although native bluejoint, like other grasses, responds to N application to a greater extent than to P application, the latter is necessary to obtain high forage yields containing adequate P. Like most soils in Alaska, Kachemak silt loam is low in P. Thus high P applications will be needed for several years. More work will be necessary to determine when P applications can be decreased, but we feel it necessary to add some P each year.

We conclude an annual spring application of 500 pounds of a 20-10-10 or equivalent amount of nutrients of a similar fertilizer will produce high yields of excellent quality native bluejoint in this area for harvest during the first part of July. Another 100 pounds of N, either as AN or urea, will ensure another high-quality second crop in late August or early September.

References

Laughlin, W.M. 1962. Fertilizer practices for bromegrass. Alaska Agric. Expt. Stn., Bull. 32, 15 pp.

Laughlin, W.M., G.R. Smith, and M.A. Peters. 1984. Influences of N, P, K fertilization on yield and mineral composition of native bluejoint grass on the lower Kenai Peninsula, Alaska. *Agronomy Journal 76*:389-397.

Perkin-Elmer Corp. 1973. Analysis of plant tissue-acid digestion procedure. Analytical methods for atomic absorption spectrophotometry. Perkin-Elmer Corp., Norwalk, Conn.

Smith, G.R. 1980. Rapid determination of total sulfur in plants and soils by combustion sulfur analysis. *Analytical Letters 13*:465-471.

Technicon Industrial Systems. 1976. Technicon industrial methods 369-75 A/A and 334-74 A/A. Technicon Ind. Syst., Tarrytown, N.Y.