12-1971

Effect of Fertilization and Management on the Production of Bromegrass in Northeast Nebraska

G. W. Rehm

W. J. Moline

E. J. Schwartz

R. S. Moomaw

Research Bulletin

247

December 1971

Effect of Fertilization and Management on the Production of Bromegrass In Northeast Nebraska

by

G. W. Rehm

W. J. Moline

E. J. Schwartz

R. S. Moomaw

University of Nebraska College of Agriculture
The Agricultural Experiment Station
E. F. Frolik, Dean; R. W. Kleis, Acting Director

CONTENTS

Issued December 1971, 1,500

CONCLUSIONS

Several experiments were conducted in northeast Nebraska to determine the effect of fertility and management practices on the production of smooth bromegrass (*Bromus inermis* Leyss). The effectiveness of the various fertilizer treatments was measured in units of dry matter produced per acre as well as beef produced per acre. Conclusions from the several experiments are:

1. Dry matter production increased with increasing rates of N up to 160 lb./A. There was no difference in bromegrass production when comparing the 160 and 240 lb./A. rates of N.
2. Use of P with N resulted in increased yields in some cases. A response to P could be expected where soils test low or very low in available P.
3. The use of K, S and Zn gave no increase in forage yield. These nutrients do not need to be supplied to most bromegrass pastures in northeast Nebraska.
4. Neither light nor heavy disking increased the production of old stands of bromegrass. In contrast, the heavy disking treatment caused a reduction in yield.
5. Beef production trials showed that a pound of beef could be produced from a pound of N. Beef production as well as average daily gains were increased by fertilization.

Results of these studies showed that the production of bromegrass pastures in Nebraska could be markedly improved through proper fertilization.

The Effect of Fertilization and Management on the Production of Bromegrass In Northeast Nebraska

G. W. Rehm, W. J. Moline, E. J. Schwartz, R. S. Moomaw[1]

INTRODUCTION

Northeast Nebraska is well suited for the production of smooth bromegrass (*Bromus inermis* Leyss). Many acres are seeded to bromegrass, with most of this acreage used for pasture. But production is quite low.

Information was needed to demonstrate ways to increase pasture production. Therefore, experiments were begun in 1965 to study the effects of fertilization and other management practices on the production of bromegrass pastures. Some experiments ended in 1967, others continued through 1970.

Results of these studies are divided into the following phases:

Multinutrient fertilization trials.

Rates of nitrogen fertilization.

Cultural practices on bromegrass production.

Beef production from bromegrass pastures.

MULTINUTRIENT FERTILIZATION TRIALS

Effects of adding N, P, K, S and Zn to northeast Nebraska soils on the forage production of bromegrass pastures were evaluated on some of the major soil types.

These northeast Nebraska soils have high pH values and high or very high exchangeable K contents. However, they are low in available P and have low NO_3-N contents as well as low nitrification rates.

Many studies have demonstrated that bromegrass will respond to fertilization (1, 6, 8, 9, 12). The objective of this phase of the study was to collect information regarding the response of bromegrass to applications of these essential nutrients in northeast Nebraska.

---

[1] Asst. Prof. of Agronomy; Assoc. Prof. of Agronomy; former Asst. Prof. of Agronomy, and Asst. Prof. of Agronomy University of Nebraska. This work was supported in part by a grant from Terra Chemical.

Experimental Procedure

Seven sites were selected for the first fertilizer trials in 1965. All treatments were applied on four replications of a randomized complete block design. Following fertilizer applications in the spring of 1965, the N rates were re-applied in April, 1966 and November, 1966. No N application was made in April, 1967. All fertilizers were broadcast on the surface of established stands.

The age of bromegrass stands varied from 4 to 20 years (Table 1). Soil types were Crofton silt loam, Nora silty clay loam and Thurman loamy fine sand. Crofton silt loam (a Typic Ustorthent) occurs on moderate to steep slopes of 5 to 40%. This soil was formed under grass vegetation and is well drained. Rapid to moderate surface runoff occurs with most rainfall intensities.

The thickness of the solum ranges from 6 to 15 in., with the depth to lime ranging from 0 to 8 in. This soil is highly calcareous (pH 7.0 to 8.0+), has a high exchangeable K content and is low in available P. This is a highly eroded soil with a low organic matter content.

Nora soil (a Typic Haplustoll) has developed on rolling slopes and rounded ridgetops. This soil differs from Crofton in that calcium carbonate has been leached below 20 in. and the subsoil contains more clay than Crofton subsoil. This soil is also calcareous, with high exchangeable K content and a low amount of available P.

Thurman loamy fine sand (a Udorthentic Haplustoll) occurs on nearly level to strongly sloping uplands. Slopes range from 1 to 15%. This soil series is well drained and highly permeable, slightly to moderately acid, has a medium to high exchangeable K content and is low or very low in available P.

Rainfall recorded at five of the seven locations in 1966 and 1967 is recorded in Table 2. Except for the sandy area (Craft location), rainfall totals for 1966 and 1967 were about the same. The 1966 rainfall was considerably below that recorded in 1965. The 1967 rainfall was near normal but a cold May and an abundance of rain

Table 1. Location, age of stand and soils for experimental sites used in fertilization trials.

Cooperator	Age of stand	Soil type	Soluble nutrients				
			pH	N	P	K	Zn
				---- ppm ----			
Binger	10	Thurman	6.5	11	29	150	2.2
Craft	20	Thurman	6.6	1	5	110	2.5
Furness	8	Crofton	7.5	11	2.5	170	6.3
Koester	6	Crofton	7.9	11	1	185	4.8
Novak	20+	Crofton	....	....	....	......	....
NE Station	4	Nora	6.3	10	3	188	5.1
Roberts	8	Crofton	7.9	8	1	225	5.4

Table 2. Average rainfall recorded during growing season at five locations in Northeast Nebraska in 1966 and 1967.

Location	Rainfall (inches)	
	1966	1967
Binger	....	17.40
Craft	10.32	16.94
Furness	16.97	20.80
Koester	14.67	19.20
NE Station	14.90	22.04

in June masked the total impact of growth because plots were harvested in early June. Normal rainfall for the area is generally considered to be from 22 to 24 in. per year.

Data were collected from six of the original seven locations in 1966 and 1967. Work at the Novak location was discontinued after 1965 and except for the Northeast Station location in 1965, only one cutting was taken from all experimental sites in 1965 and 1966. Two cuttings were taken from all but the Craft location in 1967. Yields listed in following tables are the total production for each year.

Yield measurements were taken from all experimental sites in early June when bromegrass was in the immature inflorescence stage. Second cuttings were taken in mid-September whenever regrowth was adequate. At each harvest, samples were collected for chemical analysis. They were dried at 65° C and ground to pass a 2 mm. screen. These samples were analyzed for protein-N, P, K and Zn by the University of Nebraska Soil and Plant Testing Laboratory (3, 7). All yields were calculated on an oven-dry basis.

Two statistical methods were used to compare treatment means in this report. Therefore, the treatment means can be compared by Duncan's Multiple Range test (treatment means in any column followed by the same letter are not significantly different at the 5% level) and the HSD test at the 5% level (10).

Results

Forage Yields—Bromegrass yields for 1965, 1966 and 1967 are listed in Tables 3, 4 and 5, respectively.

The 1965 forage yields ranged from .32 T/A at the Binger location to a 2-cutting total of 4.53 T/A at the Northeast Station. The response to fertilizer was similar for the two locations on the Thurman soil (Binger and Craft). Applications of both 40 and 80 lb. of N/A produced yield increases each year (Table 3). There were no yield increases from the use of P, K, S or Zn at either of these locations in 1965.

The lack of a response to P at the Binger location can probably be explained by the high available P level shown from the soil test

Table 3. Effect of application of N, P, K, S and Zn on yield of bromegrass in 1965.

Treatment	Location						
N P K S Zn	Binger	Craft	Furness	Koester	NE Station	Novak	Roberts
Soil type	Thurman	Thurman	Crofton	Crofton	Nora	Crofton	Crofton
- - - lb./A - - -	- - - - - T/A - - - - -						
....	.32 a[1]	.74 a	1.76 a	1.67 a	4.13 a[2]	.56 a	.77 a
40	.84 b	1.06 b	1.82 a	1.80 ab	3.87 a	1.26 b	.98 a
80	1.35 c	1.24 c	2.22 a	2.38 bc	4.13 a	1.21 b	1.43 a
80 20	1.33 c	1.40 c	2.38 a	2.52 c	4.06 a	1.31 b	1.22 a
80 40	1.35 c	1.50 c	2.31 a	2.61 c	4.39 a	1.66 b	1.51 a
80 20 20	1.32 c	1.19 bc	2.52 a	2.55 c	4.53 a	1.18 b	1.30 a
80 20 20 40	1.37 c	1.22 c	2.24 a	2.54 c	4.14 a	1.58 b	1.32 a
80 20 20 40 10	1.34 c	1.30 c	2.36 a	2.60 c	4.28 a	1.62 b	1.26 a
HSD .05	.40	.45	ns	1.04	ns	.77	ns

[1] Treatment means in each column followed by the same letter are not significantly different at the 5% level.

[2] Total of 2 cuttings.

(Table 1). However, because of the low available P content of the soil, we have no explanation for the lack of a response to P at the Craft location.

On Crofton soils, 40 lb. N/A resulted in a yield increase at the Novak location while an application of 80 lb. N/A was required for a yield increase when compared to the check, at the Koester location. As with Thurman sites, there were no responses to the use of P, K, S or Zn. Because of low levels of available P in these soils, a response

Table 4. Effect of application of N, P, K, S and Zn on yield of bromegrass in 1966.

Treatment	Location					
N P K S Zn	Binger	Craft	Furness	Koester	NE Station	Roberts
Soil type	Thurman	Thurman	Crofton	Crofton	Nora	Crofton
- - - lb./A - - -	- - - - - T/A - - - - -					
....	.31 a[1]	.27 a	.57 a	.55 a	1.50 a	.27 a
40	.51 b	.43 abc	.99 ab	.77 ab	2.08 b	.66 b
80	.63 bc	.48 bc	1.22 c	.94 bc	2.63 d	1.11 c
80 20	.58 bc	.51 bc	1.36 cd	1.01 bc	2.66 d	1.14 c
80 40	.72 cd	.61 c	1.44 d	1.06 bc	2.52 cd	1.04 c
80 20 20	.68 cd	.44 abc	1.44 d	1.11 c	2.46 cd	.97 c
80 20 20 40	.72 cd	.38 ab	1.26 cd	1.09 c	2.20 bc	1.20 c
80 20 20 40 10	.83 d	.57 bc	1.29 cd	1.16 c	2.38 bcd	1.12 c
HSD .05	.23	.31	.29	.44	.57	.41

[1] Treatment means in each column followed by the same letter are not significantly different at the 5% level.

Table 5. Effect of application of N, P, K, S and Zn on yield of bromegrass in 1967.

Treatment	Location					
N P K S Zn	Binger	Craft	Furness	Koester	NE Station	Roberts
Soil type	Thurman	Thurman	Crofton	Crofton	Nora	Crofton
- - - lb./A - - -	- - - - - T/A - - - - -					
....	.30 a[1]	.16 a[2]	.62 a	.49 a	.90 a	.34 a
40	.44 abc	.47 b	.70 a	.69 a	1.26 b	.78 b
80	.40 ab	.42 ab	.83 ab	1.02 b	1.82 c	.97 bc
80 20	.40 ab	.56 bc	.96 b	1.10 b	2.04 c	.93 bc
80 40	.56 cd	.93 d	.98 b	1.13 b	1.99 c	.98 bc
80 20 20	.52 bc	.61 bcd	1.06 b	1.21 b	1.93 c	1.10 c
80 20 20 40	.69 de	.68 bcd	1.08 b	1.20 b	1.81 c	1.00 bc
80 20 20 40 10	.75 e	.86 cd	.99 b	1.16 b	1.90 c	1.06 c
$HSD_{.05}$	.22	.47	.42	.42	.42	.35

[1] Treatment means in each column followed by the same letter are not significantly different at the 5% level.

[2] One cutting; all other yields are totals of 2 cuttings.

to the use of P was expected but not observed. Fertilizer treatment did not influence yields at the Northeast Station and Roberts locations in 1965.

In 1966 yields were lower than those reported in 1965 (Table 4). Lower yields can be largely attributed to the rainfall distribution pattern. For example, only .88 in. rain was recorded at the Northeast Station in May while normal rainfall for this month is 3.44 in.

Treatment effects were different each year. In 1965, bromegrass on Thurman soil responded to the application of N but not to the addition of P, K or S. The use of Zn with N and P, however, produced a yield increase when compared to the use of N and P alone at levels of 80 and 20 lb./acre at the Binger but not at the Craft location in 1966. It is difficult to attach a large amount of importance to this observation at this time.

At two of the four locations on silt loam soils (NE Station and Roberts), the application of both 40 and 80 lb. N/A produced yield increases when compared to the check (Table 4).

Although not evident at other locations, there was also a response to the application of P at the Furness location in 1966. There were no yield responses from the use of K, S or Zn at any of the sites on Crofton or Nora soils in either 1965 or 1966.

In 1967, treatment effects were variable. The use of 40 lb. N/A increased yields at the Craft, Northeast Station and Roberts locations. The use of 80 lb. N/A produced an additional yield increase at the Northeast Station site. When compared to the check and 40 lb. N/A treatments, the addition of P to 80 lb. N/A increased forage yields at the Furness, Koester and Northeast Station sites.

At one site (Craft), yields were increased when 40 rather than 20 lb. P were combined with 80 lb. N/A. This observation, however, was not consistent throughout all sites. As in 1965 and 1966, the use of K, S and Zn on silt loam soils had no effect on dry matter yields in 1967.

Yield increases from the use of 40 and 80 lb. N/A varied over the 3-year period. The use of 40 lb. N/A produced average yield increases of .33, .34 and .26 ton/A in 1965, 1966 and 1967 respectively. When compared to the application of 40 lb. N/A, the addition of 80 lb. N/A created increases of .34, .26 and .19 ton/A in 1965, 1966 and 1967 respectively.

At some sites, P produced significant yield increases when combined with N; yield responses from N and P combinations, however, were not as large as those from the use of N alone.

This experiment was continued at the Northeast Station and the Furness location in 1968 (Table 6). Yields were severely curtailed by dry weather but treatment effects were similar to those recorded in 1965, 1966 and 1967. Applications of 40 and 80 lb. N/A produced significant yield increases and again there were no significant yield increases from the use of P, K, S or Zn at either location.

The cumulative forage production for 1965, 1966 and 1967 is shown in Table 7. Data show that, when compared to check treatments, there were yield increases from the use of 40 and 80 lb./acre rates of N. In some instances (Koester and Furness locations), interpretation of data is rather difficult if Duncan's Multiple Range Test is used to compare treatment means. To better evaluate the

Table 6. Effect of application of N, P, K, S and Zn on yield of bromegrass in 1968.

Treatment	Location	
N P K S Zn	NE Station	Furness
	Soil type Nora	Crofton
- - - lb./A - - -	- - - - - T/A - - - - -	
....	.27 a[1]	.29 a
40	.62 b	.37 ab
80	.81 c	.53 bc
80 20	.82 c	.64 c
80 40	.80 c	.59 c
80 20 20	.83 c	.64 c
80 20 20 40	.88 c	.54 bc
80 20 20 40 10	.85 c	.66 c
HSD .05	.22	.30

[1] Treatment means in each column followed by the same letter are not significantly different at the 5% level.

Table 7. Cumulative yields of bromegrass forage for 1965, 1966 and 1967 as influenced by application of N, P, K, S and Zn.

Treatment	Location					
N P K S Zn	Binger	Craft	Furness	Koester	NE Station	Roberts
Soil type	Thurman	Thurman	Crofton	Crofton	Nora	Crofton
- - - lb./A - - -	- - - - - T/A - - - - -					
....	.93 a[1]	1.18 a	2.94 a	2.74 a	6.35 a	1.38 a
40	1.78 b	1.95 b	3.50 ab	3.26 ab	7.19 b	2.42 b
80	2.38 c	2.14 bc	4.26 bc	4.35 bc	8.48 c	3.51 c
80 20	2.31 c	2.48 bcd	4.70 c	4.63 c	8.75 c	3.30 c
80 40	2.63 cd	3.04 d	4.66 c	4.80 c	8.73 c	3.50 c
80 20 20	2.53 cd	2.24 bc	5.01 c	4.72 c	8.92 c	3.37 c
80 20 20 40	2.79 d	2.28 bc	4.57 c	4.80 c	8.15 c	3.32 c
80 20 20 40 10	2.93 d	2.73 cd	4.64 c	4.92 c	8.56 c	3.33 c
HSD .05	.44	.66	1.10	1.53	.85	.97

[1] Treatment means in each column followed by the same letter are not significantly different at the 5% level.

effects of N rates, data representing the total 3-year yield from the first three treatments from all locations were analyzed separately. Results of this analysis are shown in Table 8.

Considering these treatments, both rate of N and location affected yield. There was no significant N - location interaction. The linear effect of N rates was highly significant. There was no quadratic effect.

Chemical composition—Protein content of the bromegrass was calculated in 1965, 1967 and 1968. To arrive at protein content, total N was measured and % N was multiplied by 6.25 to get % protein. In 1966, samples from treatments 1, 5, 6 and 8 were analyzed for P, K and Zn (7). Protein data for 1965, 1967 and 1968 are given in Tables 9, 10 and 11. Levels of P, K and Zn in 1966 plant samples are given in Table 12.

Table 8. Statistical analysis of cumulative bromegrass yields resulting from application of 0, 40 and 80 lb. of N per acre.

Source of Variation	SS	df	MS	F
Total	316.67	71		
Replication	1.12	3	.373	
Treatment	298.41	17	17.544	52.24[1]
N Rate	30.8	2	15.400	45.83[1]
Linear	30.7	1	30.700	91.37[1]
Quadratic	.1	1	.100	.30 ns
Location	264.9	5	52.980	157.68[1]
N X Location	2.7	10	.270	.80 ns
Error	17.14	51	.336	

[1] Statistically significant at the .01 level.

Table 9. Effect of fertility treatment on protein content of bromegrass in 1965.

Treatment N P K S Zn	Binger	Craft	Furness	Koester	NE Station	Novak	Roberts
Soil type	Thurman	Thurman	Crofton	Crofton	Nora	Crofton	Crofton
- - - lb./A - - -	- - - - - % protein - - - - -						
....	9.11 a[1]	9.03 a	7.61 a	7.98 a	11.30 a	10.04 a	12.16 a
40	9.48 ab	9.72 ab	8.25 a	8.56 a	12.68 a	11.51 a	11.16 a
80	11.70 e	10.98 c	9.01 a	9.45 a	11.97 a	12.50 a	11.67 a
80 20	10.58 cd	11.02 c	9.11 a	9.31 a	13.31 a	11.53 a	12.84 a
80 40	10.61 cd	11.62 c	9.09 a	9.37 a	12.11 a	11.36 a	12.54 a
80 20 20	10.22 bc	11.16 c	8.66 a	9.78 a	13.22 a	11.84 a	12.50 a
80 20 20 40	11.25 cd	10.69 bc	8.78 a	9.28 a	12.95 a	11.48 a	11.89 a
80 20 20 40 10	10.66 cd	11.20 c	8.61 a	9.12 a	13.67 a	11.50 a	12.08 a
HSD .05	1.39	1.81	ns	ns	ns	ns	ns

[1] Treatment means in each column followed by the same letter are not significantly different at the 5% level.

In 1965, fertilizer treatments had no effect on the protein content of bromegrass grown on Crofton or Nora soils (Table 9). Protein content of bromegrass grown on Thurman soil was not affected by the application of 40 lb. N/A but protein content increased with the addition of 80 lb. N/A. However, the trend toward increased protein content was evident with all increments of added N at 5 of the 7 sites.

Results from the first cutting at the Northeast Station in 1967 (Table 10) showed that there was an increase in the protein content of the tissue with the application of N and the first increment of P. At the Roberts location, all treatments were equally effective in

Table 10. Effect of fertility treatment on protein content of 1st cutting of bromegrass in 1967.

Treatment N P K S Zn	Binger	Craft	Furness	Koester	NE Station	Roberts
Soil type	Thurman	Thurman	Crofton	Crofton	Nora	Crofton
- - - lb./A - - -	- - - - - % protein - - - - -					
....	17.03 a[1]	15.91 a	17.83 a	16.47 a	12.60 a	15.86 a
40	18.92 a	16.40 a	19.69 a	17.96 ab	15.89 b	18.58 b
80	19.44 a	15.60 a	19.97 a	19.33 b	17.06 bc	18.88 b
80 20	21.83 a	17.33 a	19.39 a	19.53 b	18.91 d	19.00 b
80 40	21.33 a	16.00 a	19.25 a	18.72 b	18.55 cd	19.19 b
80 20 20	20.94 a	17.27 a	19.03 a	19.78 b	18.56 cd	19.88 b
80 20 20 40	20.85 a	15.80 a	20.25 a	18.69 b	19.16 d	19.78 b
80 20 20 40 10	20.20 a	19.47 a	19.95 a	19.04 b	18.18 cd	18.95 b
HSD .05	ns	ns	ns	3.10	2.42	3.61

[1] Treatment means in each column followed by the same letter are not significantly different at the 5% level.

Table 11. Effect of fertility treatment on protein content of bromegrass in 1968.

Treatment	Location	
N P K S Zn	NE Station	Furness
Soil type	Nora	Crofton
- - - lb./A - - -	- - - - - % protein - - - - -	
....	10.82 a[1]	10.69 a
40	13.19 b	13.53 b
80	14.63 cd	13.94 bc
80 20	15.37 de	16.55 d
80 40	15.18 cde	15.47 bcd
80 20 20	15.97 e	16.19 d
80 20 20 40	16.07 e	16.45 d
80 20 20 40 10	14.36 c	16.02 cd
$HSD_{.05}$	1.30	3.54

[1] Treatment means in each column followed by the same letter are not significantly different at the 5% level.

increasing protein content of the tissue. At all other locations, treatments had little effect on protein content of the tissue from the first cutting.

Data from 1968 (Table 11) show more distinct differences. At the Northeast Station, protein content increased with applications of both 40 and 80 lbs. N/A. Similarly at the Furness location, 40 and 80 lb. N/A when compared to the check increased protein content of the forage. Of further interest was the fact that the use of P produced additional increases in protein content of bromegrass at the Furness location. In general, the addition of P had no effect on protein content of samples collected in 1965. Data collected over the 3-year period also show that K,S and Zn had no effect on protein content of plant tissue.

The average content of P, K and Zn in tissue from five locations was not greatly affected by the use of P, K and Zn in the fertility treatments in 1966 (Table 12). Since composite samples were analyzed for P, K and Zn, statistical analysis was not possible. Without statistical analysis, definite conclusions cannot be made.

Table 12. Effect of selected treatments on average P, K and Zn content of bromegrass from five locations.

Treatment	Tissue Content		
N P K S Zn	P	K	Zn
- - - lb./A - - -	- - - - - % - - - - -		ppm
....	.17	2.0	23.7
80 40	.19	2.5	23.0
80 20 20	.17	2.4	22.7
80 20 20 40 10	.16	2.5	25.7

NITROGEN RATE STUDIES

Results of multinutrient fertilization studies demonstrated that, on the average, the application of 40 lb. N/A resulted in significant yield increases when compared to the check treatment, and in some instances the 80 lb. rate of N produced additional yield increases. In these earlier studies the 80 lb./A rate was the highest N application used and data did not show what effect higher N rates would have on bromegrass production. To measure the effects of higher N rates on bromegrass production, additional experiments were initiated in spring of 1966.

Experimental Procedure

Three locations were selected for this phase of the study. Plots at two sites were located on upland soils while the third location was on a complex of bottomland soils. The upland sites were on Crofton and Nora soils described earlier. Bottomland complex soils were alluvial and formed from deposition of material during frequent flooding of small streams in the immediate area. Because of alluvial characteristics, bottomland complex soils are normally more fertile than upland soils in the area.

All rates of N, P and K were applied in spring of 1966. Materials were broadcast to the surface of established stands. N rates were repeated at all locations in 1967 and 1968. In 1969, the plots at two locations were discontinued (NE Station and Hankins) while N rates were applied at the third location (Spence). Residual effects of N added in 1966, 67, 68 and 69 were measured in 1970. The nine treatments were replicated four times in a randomized complete block design.

Yield measurements were taken in June at early inflorescence growth stages and second cuttings were taken in mid-September whenever regrowth was adequate. In instances where two cuttings were taken, the total yield from these cuttings is reported in the appropriate table.

At each harvest, plant samples were collected for chemical analysis. Chemical analyses were carried out by the procedures of the University of Nebraska Soil and Plant Testing Laboratory (7). These samples were dried at 65° C and ground to pass a 2 mm. screen. All yields were calculated on an oven-dry basis.

Results

Forage Yields—Yields recorded in 1966, 1967 and 1968 are given in Tables 13, 14 and 15 respectively. Data collected in this phase of the study show the influence of soil type on the response to fertilizers. Plots at the Hankins location were *on the bottomland*

Table 13. Response of bromegrass to varying rates of nitrogen in 1966.

Treatment	Location		
N P K	NE Station	Hankins	Spence
- - lb./A - -	- - - - - T/A - - - - -		
....	.53 a[1]	3.23 a	.44 a
.... 50	.52 a	2.80 a	.37 a
...... 80	.52 a	2.94 a	.43 a
..... 80 50	.56 a	3.45 a	.36 a
40 80 50	1.32 b	3.25 a	.70 ab
80 80 50	1.86 c	3.14 a	1.01 bc
120 80 50	2.18 d	3.60 a	1.12 c
160 80 50	2.31 de	3.79 a	1.13 c
240 80 50	2.45 e	3.36 a	1.20 c
$HSD_{.05}$	.37	ns	.58

[1] Treatment means in each column followed by the same letter are not significantly different at the 5% level.

complex described in the previous section. In 1966 and 1968, fertilizer treatments had no effect on yield at this location. There were differences among treatments in 1967 but the differences were variable and difficult to interpret.

In 1966, bromegrass yields at the Northeast Station and Spence sites increased with rates of N up to 120 lb./A. Soil series were the Nora and Crofton respectively. Because of the low inherent fertility of these two soils, the response to N was not unexpected.

Yield trends at the Northeast Station and Spence sites in 1967 were similar to those reported from these same locations in 1966. There were differences among treatments at the Hankins location in 1967. These differences, however, were inconsistent and difficult to interpret.

Table 14. Response of bromegrass to varying rates of nitrogen in 1967.

Treatment	Location		
N P K	NE Station	Hankins	Spence
- - lb./A - -	- - - - - % - - - - -		
....	.32 a[1]	2.19 a	.62 a
.... 50	.27 a	2.54 ab	.67 a
...... 80	.26 a	2.37 a	.64 a
...... 80 50	.29 a	2.26 a	.68 a
40 80 50	.72 b	2.51 ab	1.23 b
80 80 50	1.04 c	2.63 ab	1.47 c
120 80 50	1.62 d	2.94 bc	1.96 d
160 80 50	2.15 e	3.23 c	2.07 de
240 80 50	2.34 e	2.87 bc	2.14 e
$HSD_{.05}$	.34	.68	.24

[1] Treatment means in each column followed by the same letter are not significantly different at the 5% level.

Table 15. Response of bromegrass to varying rates on nitrogen in 1968.

Treatment	Location		
N P K	NE Station	Hankins	Spence
- - lb./A - -	- - - - - T/A - - - - -		
....	.05 a[1]	.64 a	.11 ab
.... 50	.06 a	.57 a	.18 bc
...... 80	.05 a	.70 a	.07 a
...... 80 50	.05 a	.74 a	.08 a
40 80 50	.33 b	.81 a	.13 ab
80 80 50	.36 bc	.68 a	.14 ab
120 80 50	.45 c	.80 a	.20 bc
160 80 50	.38 bc	.78 a	.19 bc
240 80 50	.35 b	.61 a	.26 c
$HSD_{.05}$	.13	ns	.13

[1] Treatment means in each column followed by the same letter are not significantly different at the 5% level.

Extremely dry weather limited yields in 1968. At the Northeast Station, 40 lb. N/A produced an increase in yield. There was, however, no difference between yields from the application of 40 and 240 lb. N/A, again demonstrating the effect of drought. Results from the Spence location were more variable and fertility treatment had no influence on yield at the Hankins location. There was no significant difference in yield between the 0 and the 160 lb. N/A rates at these two locations in 1968. These results illustrate the point that high rates of fertilization did not produce higher yields whenever moisture was limiting. In 1968, moisture rather than fertility was the limiting factor.

Applications of 160 lb. N/A produced a 4-fold increase in yield at the NE Station in 1966. In 1967, the same rate of N produced about a 7-fold increase in production. There was a yield response with each added increment of N up to 120 lb. N/A at both the NE Station and Spence locations in 1966. There was no significant difference between 160 and 240 lb. N rates at any of the locations in each of the three years of study. Across all sites, the use of K alone, P alone or P and K without added N produced no yield responses.

Cumulative forage yields for the three years of production are listed in Table 16. Rate of N had no influence on total yield at the Hankins location. Total yields increased with N rates up to 160 lb./A at the NE Station and 120 lb./A at the Spence location.

Results of the statistical analysis of the effect of N rate on total yield at the three locations are shown in Table 17. Effects of both N rate and location were significant and there was a significant N rate-location interaction. Linear and quadratic effects were significant. Total yields from all locations are presented graphically in Figure 1.

Table 16. Total bromegrass forage production for 1966, 1967 and 1968 as affected by rate of N.

Treatment N P K	NE Station	Hankins	Spence
		- - - - - T/A - - - - -	
....	.89 a[1]	6.07 a	1.15 a
.... 50	.85 a	5.91 a	1.21 a
...... 80	.84 a	6.01 a	1.13 a
...... 80 50	.91 a	6.45 a	1.16 a
40 80 50	2.38 b	6.65 a	2.06 b
80 80 50	3.26 c	6.44 a	2.64 c
120 80 50	4.24 d	7.33 a	3.28 d
160 80 50	4.84 e	7.79 a	3.38 d
240 80 50	5.14 e	6.85 a	3.59 d
$HSD_{.05}$	.38	ns	.56

[1] Treatment means in each column followed by the same letter are not significantly different at the 5% level.

Fertility plots were maintained at the Spence location from 1966 through 1970. Residual effects of yearly N applications from 1966 through 1969 were measured in 1970 (Table 18). Nitrogen applications of less than 120 lb./A from 1966 through 1969 did not produce a yield increase in 1970. When compared to the check treatment, previous yearly applications of 120, 160 and 240 lb. N/A caused yield increases in 1970.

Total yields for the 5-year period at the Spence location show that the use of N produced a 2- to 3-fold increase. The 5-year totals also show that yields increased with each added increment of N with the increase being dependent upon rate of N used. In three of the four years when N was applied at this site, 240 lb./A did not increase yields above those resulting from the use of 120 lb./A.

Chemical Analysis—The effect of N rate on the protein content of first cutting of bromegrass is given in Tables 19 and 20. Results from the Northeast Station and the Spence sites in 1967 demonstrated

Table 17. Statistical analysis of cumulative bromegrass yields resulting from application of 0, 40 and 80 lb. of N per acre.

Source of variation	SS	df	MS	F
Total	377.7	71		
Replication	20.2	3	6.733	
Treatment	319.5	17	18.794	25.23[1]
N Rate	57.9	7	8.271	11.10[1]
Linear	52.8	1	52.100	69.93[1]
Quadratic	3.8	1	3.800	5.10[2]
Location	243.7	2	121.900	163.62[1]
N X Location	17.9	8	2.238	3.00[1]
Error	38.0	51	.745	

[1] Statistically significant at the .01 level.
[2] Statistically significant at the .05 level.

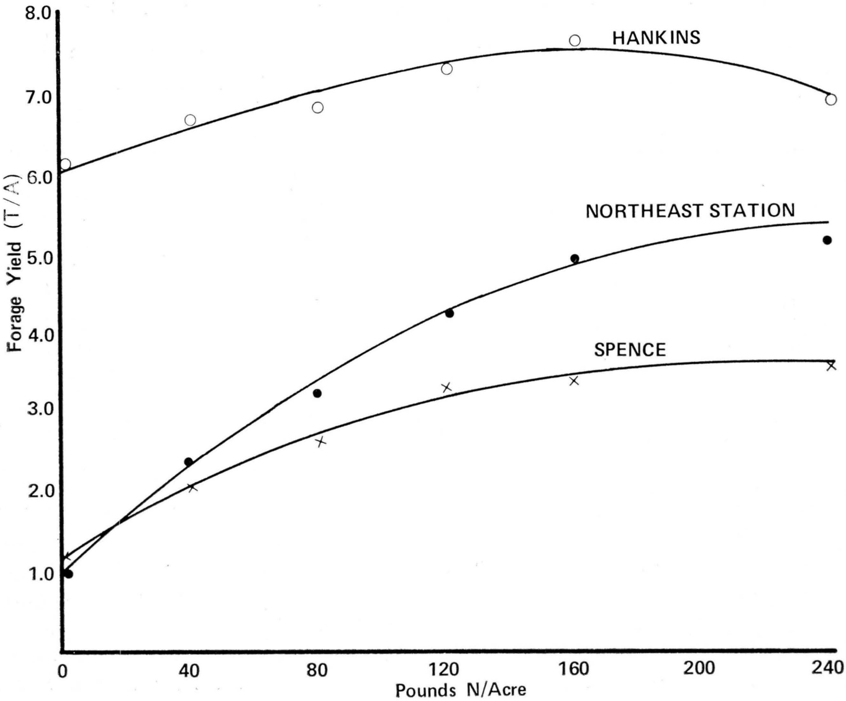

Figure 1. The effect of N rate on total bromegrass forage production at three locations for 1966, 1967 and 1968

Table 18. Response of bromegrass at Spence location to varying rates of nitrogen from 1966 through 1970.

Treatment N P K	1966	1967	1968	1969	1970	Total 5 yr.
- - lb./A - -	- - - - - T/A - - - - -					
....	.44 a[1]	.62 a	.11 ab	.72 a	.94 a	2.83 a
.... 50	.37 a	.67 a	.18 bc	.69 a	.84 a	2.75 a
...... 80	.43 a	.64 a	.07 a	.64 a	.93 a	2.71 a
...... 80 50	.36 a	.68 a	.08 a	.74 a	.90 a	2.76 a
40 80 50	.70 ab	1.23 b	.13 ab	1.42 b	.76 a	4.24 b
80 80 50	1.01 bc	1.47 c	.14 ab	1.64 c	.84 a	5.10 c
120 80 50	1.12 c	1.96 d	.20 bc	1.77 d	1.18 b	6.23 d
160 80 50	1.13 c	2.07 de	.19 bc	1.77 d	1.43 c	6.59 d
240 80 50	1.20 c	2.14 e	.26 c	1.94 d	1.95 d	7.49 e
$HSD_{.05}$	.58	.24	.13	.52	.34	.82

[1] Treatment means in each column followed by the same letter are not significantly different at the 5% level.

Table 19. Effect of nitrogen rates on protein content of first cutting of bromegrass in 1967.

Treatment	Location		
N P K	NE Station	Hankins	Spence
- - lb./A - -	- - - - - % protein - - - - -		
....	13.10 a[1]	19.89 ab	20.15 a
.... 50	13.22 a	21.83 abc	20.77 a
...... 80	13.17 a	19.99 ab	20.47 a
...... 80 50	12.99 a	18.82 a	20.75 a
40 80 50	16.17 b	23.10 bcd	23.95 a
80 80 50	18.27 c	25.05 cd	27.24 c
120 80 50	20.16 d	24.11 cd	27.48 c
160 80 50	21.74 de	26.08 cd	30.50 d
240 80 50	23.32 e	29.08 e	32.22 e
$HSD_{.05}$	2.73	5.58	2.23

[1] Treatment means in each column followed by the same letter are not significantly different at the 5% level.

a general increase in the protein content with increasing rates of N. Results from the Hankins location, however, were not as distinct and definite trends were not evident in 1967 and 1968. In 1969, the protein content of the bromegrass at the Spence location was quite varied. Again, no concise trend was evident.

Residual effects of yearly N applications had no effect on protein content of bromegrass in 1970 (Table 20). Bromegrass which had received either no N or only small amounts of N in previous years contained the largest amounts of protein. Yields from all treatments were low in 1970. Therefore, differences among treatments recorded in 1970 can be attributed in part to dilution of protein within the plant rather than N treatment.

Table 20. Effect of nitrogen rates on protein content of first cutting of bromegrass in 1968, 1969 and 1970.

Treatment	Location and Year				
N P K	NE Station (68)	Hankins (68)	Spence (68)	Spence (69)	Spence (70)
- - lb./A - -	- - - - - % protein - - - - -				
....	11.71 a[1]	12.92 a	14.01 a	11.38 ab	11.52 c
.... 50	11.41 a	14.30 abc	14.63 a	11.63 ab	10.60 bc
...... 80	11.73 a	13.02 a	15.11 a	11.77 ab	11.22 c
...... 80 50	11.76 a	12.05 a	14.82 a	11.51 ab	12.00 c
40 80 50	11.64 a	13.59 ab	17.87 b	10.62 a	10.63 bc
80 80 50	15.01 b	17.37 abc	21.99 c	13.36 bcd	8.71 a
120 80 50	16.20 b	16.25 abc	22.64 cd	12.86 abc	9.28 ab
160 80 50	18.55 c	19.09 bc	24.02 d	16.46 d	9.19 ab
240 80 50	19.88 d	19.28 c	21.82 c	14.67 cd	9.47 ab
$HSD_{.05}$	2.18	8.32	3.01	3.38	2.49

[1] Treatment means in each column followed by the same letter are not significantly different at the 5% level.

Table 21. Effect of N fertilization on amount of protein removed by bromegrass pastures in 1967 and 1968.

Treatment N P K	NE Station (67)	NE Station (68)	Hankins (67)	Hankins (68)	Spence (67)	Spence (68)
- - lb./A - -	- - - - - lb./A - - - - -					
....	61.5[1] a[2]	11.1 a	604.9[1] a	163.6 a	134.7[1] a	30.7 ab
.... 50	54.4 a	13.1 a	707.3 ab	164.5 a	129.9 a	53.4 bc
...... 80	50.5 a	11.7 a	694.3 a	180.8 ab	133.9 a	21.5 a
...... 80 50	56.2 a	11.7 a	639.7 a	178.5 ab	155.9 a	23.3 a
40 80 50	164.3 b	77.1 b	762.2 ab	219.2 ab	307.7 b	46.9 abc
80 80 50	289.0 c	108.3 c	787.6 abc	226.8 bc	397.8 c	61.1 cd
120 80 50	450.6 d	144.1 d	895.7 bcd	246.0 c	563.5 d	91.3 de
160 80 50	624.4 e	141.4 d	973.0 cd	286.6 c	651.4 e	87.8 dc
240 80 50	743.5 f	138.6 d	993.1 d	231.6 bc	746.5 f	107.9 e
$HSD_{.05}$	128.2	32.1	292.9	89.2	90.1	43.7

[1] Total of 2 cuttings.

[2] Treatment means in each column followed by the same letter are not significantly different at the 5% level.

As expected, N rates affected the amount of protein removed on a per acre basis (Table 21). The amount of protein removed increased with added increments of N and was not affected by P or K. Application of K alone, P alone or a combination of P and K without added N had no effect on the amount of protein removed by bromegrass. This trend is given in data from the Northeast Station in 1967 and 1968 and the Spence location in 1967. In general, the largest amount of protein was removed by the bromegrass crop receiving 160 or 240 lb. N/A.

In 1969, tissue samples from 1st and 2nd cuttings were analyzed for P, K, Ca, Mg, Zn, Cu, Fe and Mn (7) (Tables 22 and 23). The applied treatment did not affect the Cu or Fe content of tissue from the 1st cutting. The addition of P increased the P content of the tissue when no N was applied. The applied treatment had similar effects on the Ca and Mg content of the tissue.

Concentration of these nutrients was highest when no N was used and lowest when the N was applied. Rate of N had no consistent effect on the K, Zn and Mn content of the 1st cutting tissue.

As with the first cutting, applied treatment did not influence the Cu and Fe content of the 2nd cutting tissue. In addition, the K content was not affected by treatment. The P content of the 2nd cutting tissue was highest where P was applied without N. Differences in Ca, Mg, Zn and Mn content of the tissue were not consistent with treatment.

Although the applied treatment did influence the tissue content of the majority of the nutrients measured, differences among treatments were not consistent. In addition, data are not sufficient to

Table 22. **Effect of N rate on nutrient content of 1st cutting of bromegrass in 1969.**

Treatment N P K	P	K	Ca	Mg	Zn	Cu	Fe	Mn
-- lb./A --	----- % -----				----- ppm -----			
....	.20 a[1]	2.68 b	.49 ab	.18 ab	17.3 a	13.1 a	71.0 a	51.8 ab
.... 50	.20 a	2.48 a	.61 b	.21 b	18.9 ab	15.2 a	75.5 a	47.0 a
...... 80	.23 b	2.58 ab	.45 ab	.17 ab	17.5 a	10.2 a	69.3 a	46.0 a
...... 80 50	.23 b	2.70 b	.48 ab	.18 ab	16.5 a	11.6 a	72.3 a	45.0 a
40 80 50	.20 a	2.78 b	.34 a	.14 a	17.2 a	10.4 a	57.5 a	54.5 ab
80 80 50	.20 a	2.90 b	.33 a	.13 a	18.5 ab	10.5 a	60.0 a	53.5 ab
120 80 50	.20 a	2.80 b	.30 a	.12 a	19.2 ab	10.9 a	53.8 a	51.3 ab
160 80 50	.21 ab	2.90 b	.37 a	.14 a	22.5 b	10.7 a	76.0 a	61.6 b
240 80 50	.19 a	2.70 b	.36 a	.15 a	21.5 b	11.8 a	72.0 a	75.7 c
$HSD_{.05}$	.02	.40	.28	.08	4.4	ns	ns	19.9

[1] Treatment means in each column followed by the same letter are not significantly different at the 5% level.

Table 23. **Effect of N rate on nutrient content of 2nd cutting of bromegrass in 1969.**

Treatment N P K	P	K	Ca	Mg	Zn	Cu	Fe	Mn
-- lb./A --	----- % -----				----- ppm -----			
....	.24 bc[1]	2.1 a	.96 bc	.33 d	24.0 bcd	5.0 a	204 a	74.9 a
.... 50	.26 cd	2.2 a	.96 bc	.32 d	28.1 d	6.6 a	208 a	75.0 a
...... 80	.31 e	2.2 a	1.25 c	.33 d	24.9 cd	6.2 a	214 a	76.0 a
...... 80 50	.31 e	2.2 a	.99 bc	.30 d	24.1 bcd	6.3 a	203 a	75.2 a
40 80 50	.28 d	2.0 a	.82 ab	.29 cd	19.8 ab	4.9 a	175 a	80.2 a
80 80 50	.24 bc	2.1 a	.68 ab	.26 bc	17.9 a	4.2 a	174 a	90.8 a
120 80 50	.22 ab	2.1 a	.60 a	.23 ab	22.1 abc	4.9 a	192 a	108.4 b
160 80 50	.21 a	2.1 a	.55 a	.22 a	25.0 cd	4.9 a	209 a	110.4 b
240 80 50	.20 a	2.2 a	.57 a	.23 ab	25.0 cd	5.5 a	213 a	115.4 b
$HSD_{.05}$	.03	ns	.47	.05	6.7	ns	ns	24.1

[1] Treatment means in each column followed by the same letter are not significantly different at the 5% level.

Table 24. Effect of nitrogen applications on digestible dry matter content of and digestible dry matter produced by bromegrass grown at Northeast Station in 1968.

N P K	Digestible dry matter	Digestible dry matter produced
- - lb./A - -	- - - - - % - - - - -	- - - - - lb./A - - - - -
....	56.7 a[1]	57
.... 50	58.2 a	70
...... 80	60.7 a	61
...... 80 50	57.7 a	58
40 80 50	59.5 a	193
80 80 50	60.4 a	435
120 80 50	56.8 a	511
160 80 50	57.0 a	433
240 80 50	53.4 a	374
$HSD_{.05}$	ns	

[1] Treatment means in each column followed by the same letter are not significantly different at the 5% level.

provide explanations for these observations. Further work needs to be done in this area.

Protein contents have often been used as an index of forage quality (5, 8, 14, 15). Another index of quality widely used is the digestible dry matter percentage. The digestible dry matter was not determined for all samples from these studies (11) but selected samples were taken from the Northeast Station in 1968 (Table 24). There were no differences in percent digestible dry matter among the treatments. Other workers have shown that the percentage of digestible dry matter is affected more by stage of growth than by fertility treatment (2). Since these data are from only one location for one year (a very dry year), it is not possible to make broad interpretations from these results.

CULTURAL PRACTICES

When old, established stands of bromegrass become non-productive, they are commonly referred to as being "sod-bound." The "sod-bound" condition was a rather common complaint of northeast Nebraska farmers and ranchers. There was some question as to whether this condition could be improved with fertilization, tillage or a combination of fertilization and tillage. Studies were designed to measure the effects of tillage and fertilization practices on bromegrass production.

Experimental Procedure

This experiment was established in the spring of 1967 on a very old, established stand of bromegrass referred to as being "sod-bound." The soil type was Moody silt loam. Moody soil (a Udic Haplustoll) is similar to the Nora soil described earlier. Moody soil has a higher clay content and the depth to free lime is normally 40 inches or more. This soil also has a higher organic matter content than the Nora soil.

Treatments were begun in spring of 1967. Fertilizers were applied in 1967 and 1968. Disking was carried out in spring of 1967.

In 1969, the original plots were divided in half. On one half, N rates were reapplied and on the second half of each plot no fertilizer was applied so that the residual effects of the 1967 and 1968 fertilizer treatments could be evaluated. Treatments were replicated two times.

Plots were cut each year at the early flowering stage of growth. Samples from each harvest were dried at 65° C., ground to pass a 2 mm. screen and analyzed for protein N.

Results

Results from 1967 and 1968 (Table 25) show that tillage treatments without fertilizer had no effect on yield in either year. Use of fertilizer produced yield increases in both years. In 1967, disking of the fertilized bromegrass plots caused a reduction in yield. Lower yields can be attributed to the loss of stand as a result of disking. Some weeds invaded both the fertilized and non-fertilized plots that were disked. Tillage treatments imposed on the plots in 1967 had no effect on fertilized plots in 1968. The use of fertilizer did, however, produce an appreciable yield increase in the same year. Neither tillage nor fertilizer treatments had any effect on protein content of the bromegrass.

Residual effects of annual applications of fertilizer in 1967 and 1968 are given in Table 26. There was sufficient carryover from fertilizer applied in 1967 and 1968 to produce significant yield increases in 1969 at this site. The application of fertilizer in spring of 1969 produced 3 to 4-fold increases in yield. Also, heavy disking in

Table 25. Effect of tillage practices and fertilizer on yield and protein content of a well-established stand of bromegrass.

Tillage treatment	Fertilizer treatment	1967		1968	
		Yield	Protein	Yield	Protein
	- - - lb./A - - -	T/A	- - % - -	T/A	- - % - -
None	None	.98 a[1]	13.00 a	.28 a	9.95 a
Light disking	None	.88 a	14.56 a	.38 a	9.98 a
Heavy disking	None	.71 a	15.19 a	.44 a	12.21 a
None	60N + 13P	3.64 c	18.16 a	1.03 b	14.17 a
Light disking	60N + 13P	2.86 b	19.38 a	1.08 b	12.97 a
Heavy disking	60N + 13P	2.92 b	17.69 a	.84 b	13.10 a
HSD .05		.44	ns	.43	ns

[1] Treatment means in each column followed by the same letter are not significantly different at the 5% level.

Table 26. Effect of tillage practices and residual and annual fertilizer application on yield and protein and content of bromegrass.

Tillage treatment	Fertilizer treatment	Yield	Protein content
	- - - lb./A - - -	- - - T/A - - -	- - - % - - -
Annually Applied Treatments			
None	None	.45 a[1]	9.50 ab
Light disking	None	.73 bcd	9.47 ab
Heavy disking	None	.63 abc	10.66 ab
None	60N + 13P	2.02 f	8.94 a
Light disking	60N + 13P	1.88 f	12.59 abc
Heavy disking	60N + 13P	1.68 e	13.44 bcd
Residual From Previous Applications			
None	None	.60 ab	17.25 d
Light disking	None	.51 a	12.47 abc
Heavy disking	None	.54 ab	15.56 cd
None	60N + 13P	.82 cd	10.31 ab
Light disking	60N + 13P	.92 d	9.66 ab
Heavy disking	60N + 13P	.82 cd	9.78 ab
$HSD_{.05}$		.34	7.03

[1] Treatment means in each column followed by the same letter are not significantly different at the 5% level.

the spring of 1967 caused a significant reduction in the 1969 bromegrass yield. This was the case only when sufficient fertilizer and moisture were available for bromegrass production.

There were differences in protein content among treatments in 1969. These differences, however, were not expected. In residual plots, protein content of the tissue from the check plots was significantly higher than protein content of tissue from all but one of the treatments.

The difference in protein content between the check and fertilized plots in 1969 can be partly explained by N dilution in the plant. In 1969, fertilized plots produced more than non-fertilized plots. Because of the larger amount of plant growth, protein in the tissue is spread over a greater volume of plant tissue and is thus diluted.

Also, in 1969, the annual application of fertilizer in early spring produced higher yields. Likewise, the early spring use of fertilizer produced a slight increase in the protein content of the tissue.

BEEF PRODUCTION TRIALS

Results of studies showed that bromegrass will respond to the application of N and sometimes to the application of P. For data to be more meaningful, it was necessary to convert the production from yield in tons of dry matter/acre to estimated lb. of beef produced per acre.

Moldenhauer *et al.* (9) in Iowa used *various forage production:*

beef production ratios to convert tons of dry matter/acre to lb. beef/acre. To get a more realistic relationship between fertilization and beef production, we started a pasture grazing trial in 1968 and repeated it in 1969.

Experimental Procedure

For this study, 26 acres of bromegrass pasture were divided into four lots. This pasture was located on Crofton and Nora soils. Nitrogen was applied to two of these lots at a rate of 60 lb./acre in both 1968 and 1969. The two remaining lots received no fertilizer. In 1968, 24 yearling steers were randomly allocated to the four lots. In 1969, 21 yearling steers were randomly allocated to the same lots. The initial weight of the steers was approximately 500 lb. These steers had been overwintered on a ration to gain about 1 lb./day.

In 1968, the study was started on May 11 and terminated after 53 days because of a severe drought. In 1969, the study was started in early May and continued throughout the summer. Steers were weighed at intervals of about 30 days during both years.

Results

Beef production and average daily gains increased through the use of fertilizer (Table 27). Because of the severe drought in 1968, there was very little beef produced per acre. The use of fertilizer did, however, double the production during the very dry year. In 1969, a year with average rainfall, the use of fertilizer increased the amount of beef produced per acre by 2.5 times. The 2-year averages encompass both a good and a poor year. On the average, the gains show that a yearly application of 1 lb. N/A will produce more than 1 lb. beef/A.

Average daily gain figures also show the effect of fertilizing the bromegrass pastures. The average gain over the 2-year period was increased from 1.20 to 1.61 lb. by the use of fertilizer.

Considering the average beef production for the 2-year period, there was considerable return for the dollars invested in fertilizer. If the price of beef is set at $.25/lb. and N at $.10/lb., an additional

Table 27. Effect of fertilization on pounds of beef produced per acre and average daily gain over a two-year period.

Treatment	Beef production			Average daily gain		
	1968	1969	Average	1968	1969	Average
	- - - - - lb./A - - - - -			- - - - - lb. - - - - -		
No fertilizer	34	72	61	.77	1.63	1.20
Fertilizer @ 60 lb. N/A	72	205	139	1.15	2.07	1.61

$19.50 per acre was produced from the fertilized pasture. This is a return of $3.25 for every dollar invested in fertilizer. This return, of course, will vary with the amount of beef produced per acre, the price of beef and the cost of N fertilizer.

DISCUSSION

The response of smooth bromegrass to fertilizers has been extensively documented. Results of management and productivity studies in the Northeast have been summarized by Wright *et al.* (15). Duell (6), Carter *et al.* (4, 5), Anderson *et al.* (1), and Look Kin and Mac Kenzie (8) have reported increased production from the application of N. Moldenhauer *et al.* (9) recorded top production from a combination of N and P. The majority of the above studies also reported an increase in the protein content of the tissue from N fertilization.

Results of this study showed that bromegrass grown on most of the typical soils of northeast Nebraska will respond to the use of N and more rarely to P. In multinutrient fertilization trials, the use of N on sandy soils produced significant yield increases in the year of application (Table 3). During the first year, there was no response to fertilizers at three of the five sites located on silt loam soils. This lack of significance may be due, in part, to a large amount of soil and plant variability. Available data, however, provide for more complete understanding of the impact of fertilizer programs on bromegrass pastures in northeast Nebraska.

Data collected at the majority of the farm and ranch locations from 1965 through 1968 show the beneficial effects of the applications of N. In general, the 40 lb./A rate of N produced significant yield responses when compared to non-fertilized plots. Also, in several situations, the 80 lb./A rate produced significant increases when compared to the 40 lb. application.

Throughout this study, there was no response to the application of K, S or Zn. Since the soils were high to very high in exchangeable K, a response to this nutrient was not expected. Because of the low organic matter content of the soils, there was some question as to whether the use of S would produce yield responses. Data show, however, that S, at the rates used, had no effect on bromegrass yields.

In 1965 data from multinutrient fertilization trials emphasized the need for further study with N rates. As expected, yields increased with increasing increments of N up to 160 lb. N/A (Tables 13, 14, 15). The response to N, however, was related to soil type. On the soils of the steep side slopes (Crofton, Nora, Moody) there was a yield increase from each added increment of N. On the more fertile bottomland soils, the yield responses were not consistent.

The reponse of bromegrass to N has been documented by many studies (1, 4, 6, 12, 14, 15). Canadian workers (8) have shown that

N rates as high as 300 lb./A will increase the productivity of established bromegrass. Data from our studies, however, demonstrated that at the majority of the sites there was no significant difference between 160 and 240 lb. N/A. P and K were supplied in ample quantities and should not have been limiting. Undoubtedly, moisture was a limiting factor and bromegrass production was dependent upon the moisture supply.

In evaluating bromegrass pastures, quality factors as well as total production were measured. The protein content of the pasturage has been used as a quality index. Data from these studies show that, in some cases, the protein content increased with increasing rates of N (Tables 19 and 20). In other cases, N rate had no effect on the protein content of the tissue. Variation in protein content among pasture sites was primarily due to differences in stages of maturity at the time of harvest and moisture supply.

Perhaps a better measurement of the effect of N fertilization on grass quality is the amount of protein produced on a per acre basis. Protein production for 1967 and 1968 (Table 21) demonstrated that 240 lb. N/A produced a 3- to 10-fold increase in the amount of protein produced per acre. A pound of protein produced in the bromegrass pasture represents a pound of protein that the farmer does not have to supply from another source.

The percentage of digestible dry matter, another index of forage quality, was not significantly altered by use of fertilizer. Generally, this index value will vary more with stage of maturity than fertilizer treatment.

Yields of old, established stands of bromegrass were not improved by either light or heavy disking without fertilization. In well fertilized stands, heavy disking actually decreased yields but had no effect on protein content in the treatment year. Data show that the use of tillage implements would be of little value in trying to improve well fertilized, older, established stands.

Since the large majority of the bromegrass acreage in northeast Nebraska is in pasture, it is important that dry matter yields be used to estimate beef production. Moldenhauer *et al.* (9) has given factors for converting dry matter yields to beef production. These factors vary with management practices. Using the average conversion of 25 lb. bromegrass to produce 1 lb. of beef, the amount of estimated beef production at the Northeast Station in 1967 varied with N rates (Figure 2). Beef production increased with increasing rates of N.

The effect of bromegrass pasture fertilization on measured beef production (Table 27) demonstrated during the extremely dry summer of 1968 and again in the summer of 1969, that fertilization increased net return from dollars invested in fertilizers. The averages represent the production that can be expected during an average season in northeast Nebraska. In these production trials, only two rates of N

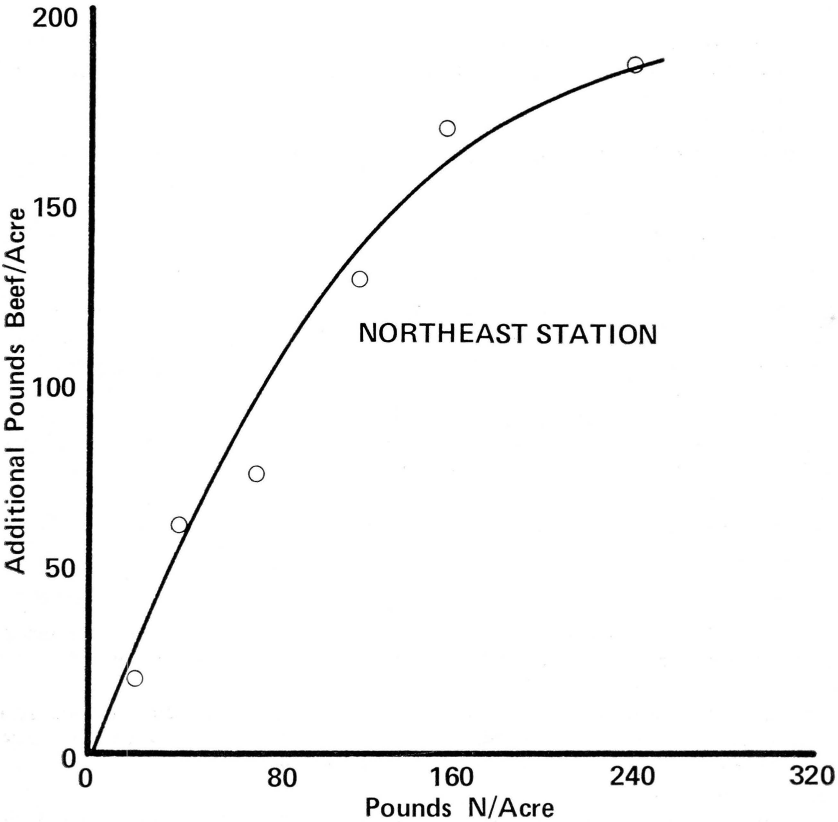

Figure 2. The effect of N rates on the calculated amount of additional beef produced per acre from fertilization.

were used. More information is needed with regard to the effects of higher rates of N with P fertilizers on beef production.

Data gathered in the four phases of this study provide a firm basis for fertilizer recommendations for bromegrass production in northeast Nebraska. Data show that good pasture production can be expected from yearly applications of 60 to 80 lb. N/A. Depending on organic matter content and level of N in the soil, higher rates can be used if moisture is available. The use of P should also prove to be beneficial with the most efficient use of P being 20 lb./A applied every two years when soil test levels for P are very low.

LITERATURE CITED

1. Anderson, K. L., R. E. Krenzin and J. C. Hide.
1946. The effect of nitrogen fertilizer on bromegrass in Kansas. J. Amer. Soc. Agron. 38: 1058-1067.

2. Blaser, R. E.
1964. Symposium on forage utilization: Effects of fertility levels and stage of maturity on forage nutritive values. J. An. Sci. 23: 246-253.

3. Bremner, J. M.
1965. Total nitrogen. *in* C. A. Black *et al* (ed.) Methods of Soil Analysis. Agronomy 9: 1149-1178.

4. Carter, L. P. and J. M. Scholl.
1962. Effectiveness of inorganic nitrogen as a replacement for legumes grown in association with forage grasses. I. Dry matter production and botanical composition. Agron. J. 54: 161-163.

5. Carter, L. P. and J. M. Scholl.
1964. Effectiveness of inorganic nitrogen as a replacement for legumes grown in association with forage grasses. II. Nitrogen content, yield of nitrogen and seasonal distribution. Agron. J. 56: 278-290.

6. Duell, R. W.
1960. Utilization of fertilizer by six pasture grasses. Agron. J. 52: 277-279.

7. Knudsen, D. and N. Hassan.
Soil, plant and water chemical procedures. (mimeo).

8. Look Kin, W. K. and A. F. Mac Kenzie.
1970. Effect of time and rate of N applications on yield, nutritive value index, crude protein and nitrate content of bromegrass. Agron. J. 62: 442-445.

9. Moldenhauer, W. C. *et al.*
1965. The influence of nitrogen and phosphorus fertilization on nutrient status and profitability of bromegrass on Ida soils. Research Bulletin 532. Agr. and Home Ec. Exp. Sta. Iowa State Univ., Ames, Iowa.

10. Steel, R. G. D. and J. H. Torrie.
1960. Principles and procedures of statistics. McGraw-Hill Inc., New York. 481 p.

11. Tilley, J. M. A. and R. A. Terry.
1963. A two-stage technique for the *in vitro* digestion of forage crops. J. British Grassland Soc. 18: 104-111.

12. Vanderlip, R. L. and J. Pesek.
1970. Nitrate accumulation in smooth bromegrass (*Bromus inermis* Leyss.): I. Effects of applied N, P and K. Agron. J. 62: 491-494.

13. Wagner, R. E.
1954. Influence of legume and fertilizer on forage production and botanical composition. Agron. J. 46: 167-171.

14. Wagner, R. E.
1954. Legume nitrogen versus fertilizer nitrogen in protein production of forage. Agron. J. 46: 233-237.

15. Wright, M. J., *et al.*
1967. Management and productivity of perennial grasses in the Northeast II. Smooth bromegrass. Bulletin 554 T. West Virginia Univ. Agr. Exp. Sta.