Effects of Nitrogen Fertilization on Native Rangeland[1]

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Highlight

Nitrogen fertilizer was applied to native rangeland at the Archer and Gillette Substations in Wyoming to determine the effect on yield, crude protein and composition. Yields of the warm season grasses were not significantly increased by fertilization. The increase of cool season grasses was a function of time rather than fertilization with one exception. Nitrogen fertilization increased the percentage crude protein of the grasses studied. The decline of blue grama at both locations was attributed to the subnormal precipitation during the study period. Nitrogen fertilization was not an economical practice during the years of the study at the two locations because moisture was the greatest limiting factor.

Efecto de Fertilizacion Nitrogenado en Pastizales Resumen

Se hizo un estudio en las Subestaciones Archer y Gillette, Wyoming, para determinar el efecto de ciertas dosis y fechas de la aplicación de fertilizantes nitrogenados en la producción, por centaje de proteína cruda y cambios en composición. La precipitatción estuvo por abajo del promedio de muchos años por espacio de 3 de los 4 años de estudio en la subestación de Archer y durante los 4 años en la subestación de Gillette. Los resultados reflejan las condiciones de sequía que prevalecieron.

Los resultados de estos estudios indican que la fertilización de pastizales nativos representados por estas localidades y para los años de estudio no fue una práctica económica debido a la humedad que fue el factor limitante mas grande. Los zacates de épocas frías aumentaron en ambas localidades, pero el aumento no fue resultado directo de la fertilización. Un aumento significativo de los zacates de época fría en la loca lidad de Gillette, se obtuvo con 66 kg/ha (66 lb/acre) en 1959. Debido a la sequía el pasto *Bouteloua gracilis* redujo su cobertura relativa en las parcelas de la subestación de Gillette. La cobertura de *Poa secunda* aumentó por la utilización de la humedad de principios de primavera.

En ambas subestaciones el porcentaje de proteína cruda fue aumentando en las especies colectadas en los lotes fertilizados. El promedio de tres y cuatro años para las los localidades mostró algo de variación en el porcentaje de proteína cruda por tratamientos y época de siembra.

Response of native rangeland to fertilizer appears to vary with location in the Great Plains. Rogler and Lorenz (1957) reported increased yields and a change in botanical composition on overgrazed rangeland in North Dakota from application of nitrogen fertilizer. Retzer (1954) found that native plants responded to nitrogen application on soils derived from granitic rocks in Colorado. In the Central Cross Timbers Section of Oklahoma, Huffine and Elder (1960) found that weed production was 2 to 5 times greater on nitrogen-fertilized native pastures than on nonfertilized native pastures, indicating that the weeds responded much better than the native grasses. Other workers (Klipple and Retzer, 1959; Huffine and Elder, 1960; Cosper and Thomas, 1960) also reported that fertilization of native rangeland resulted in increased production of forbs.

The effect of fertilization on native rangeland depends upon climate, soils, and management. Some of the more important factors influencing the success of range fertilization include soil type, soil fertility level, soil and air temperatures, and amount and distribution of precipitation during the growing season. Hoagland et al. (1962) reported that low fertility limited forage production more than rainfall, or at least total rainfall did not vary enough among years to offset the beneficial effect of fertilizer on annual range in California. Kilcher (1958) reported that favorable precipitation in May was an important requirement for the successful and economical use of fertilizer on pure stands of cultivated grass in Canada.

Studies were conducted at the Gillette and Archer Substations in Wyoming to obtain additional data on the effect of commercial fertilizers on native rangeland. The studies were designed to

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determine the effect of dates and rates of nitrogen application on yield, protein level, and botanical composition of shortgrass rangeland.

Study Areas and Methods

The Gillette Substation is located in northeast Wyoming at an altitude of approximately 4,500 ft. The dominant native vegetation is blue grama (*Boutelous gracilis*), Sandberg bluegrass (*Poa secunda*), and needleandthread (*Stipa comata*). The study area, a portion of a native pasture grazed by cattle, was fenced in the spring of 1958, and livestock excluded thereafter. The soil is classified as Maysdorf fine sandy loam.

The Archer Substation is located approximately 10 miles east of Cheyenne, Wyoming at an altitude of about 6,000 ft. The dominant native vegetation is blue grama, buffalograss (*Buchloe dactyloides*), and western wheatgrass (*Agropyron smithii*). The area used for the study was fall grazed by sheep until fenced in the spring of 1958. The soil on the study area is classified as Altvan fine sandy loam.

In the spring of 1958, plots 7 × 50 ft were established on native rangeland at the Gillette and Archer Substations. Ammonium nitrate was applied to three replications at rates of 0, 33, and 66 lb/acre of nitrogen on April 15, May 15, and June 15, 1958, and the same design was repeated in 1959. The ammonium nitrate was hand broadcast at the Gillette Substation and was applied to the soil surface with a grain drill at the Archer Substation.

The vegetation was inventoried with a modified point quadrat in the spring of 1958, and again in the fall of 1961. Only basal hits were recorded.

All old plant growth was clipped and removed from a 2-ft square plot early in April before plant growth started. The current year's vegetation on the same plot was harvested in mid-September. Different subplots were clipped each year from 1958 through 1961. Clipped herbage was separated as midgrass, shortgrass, annual grass, and forbs. Annual forbs and Sandberg bluegrass generally had matured and much of their production was lost prior to harvest. Blue grama at both locations and buffalograss and western wheatgrass at the Archer Substation were harvested separately in the first week of July and in mid-September to determine crude protein percentage.

Climatic conditions for the two Substations are similar; the long-time averages of annual precipitation are nearly the same, but growing season (April 1 to September 30) precipitation is higher at the Archer Substation (Table 1).

Table 1. Annual and growing season precipitation (inches) for the 1958–1961 period and the 31- and 43-year averages at the Gillette and Archer Substations in Wyoming.

Year	Annual		April–September	
	Gillette	Archer	Gillette	Archer
1958	11.00	14.31	8.08	10.79
1959	11.97	12.31	8.06	7.78
1960	12.52	10.60	9.28	6.96
1961	11.99	18.70	6.96	14.48
4-year average	11.87	13.98	8.09	10.00
31-year average	13.88		9.60	
43-year average		14.86		11.67

Results and Discussion

Yields

Fertilization did not significantly affect the yields of the warm season grasses at the two locations (Table 2). Yield of cool season grasses on the plots fertilized in the spring of 1959 varied among treatments. At Archer, the May application of 33 lb N/acre produced more cool season grasses than the check or June applications of 33 or 66 lb N/acre. There were no significant differences among yields from the other dates and rates of nitrogen application.

Plots fertilized in 1959 with 66 lb N/acre produced an average of 142 lb/acre more cool season grasses than the check plots at the Gillette location (Table 2). There were no significant differences in the yield of cool season grasses between the plots fertilized with 33 lb N/acre in 1959 and the check plots during the 3-year period, although average yields on the fertilized plots were almost twice as high as the check plot yields.

Yields of the cool and warm season grasses varied

Table 2. Average yields[1] (lb/acre air-dry) of warm and cool season grasses from plots fertilized in 1958 and plots fertilized in 1959 at the Archer and Gillette Substations, Wyoming.

Treatments	Archer				Gillette			
	Warm Season		Cool Season		Warm Season		Cool Season	
	1958[2]	1959[2]	1958[2]	1959[2]	1958[3]	1959[2]	1958[3]	1959[2]
Check—no nitrogen	185[a]	185[a]	131[a]	131[b]	220[a]	199[a]	77[a]	89[b]
33 lb nitrogen—April	215[a]	197[a]	175[a]	148[ab]	265[a]	204[a]	142[a]	155[ab]
33 lb nitrogen—May	235[a]	176[a]	119[a]	262[a]	259[a]	283[a]	103[a]	154[ab]
33 lb nitrogen—June	190[a]	229[a]	138[a]	100[b]	295[a]	270[a]	102[a]	160[ab]
66 lb nitrogen—April	223[a]	199[a]	73[a]	148[ab]	244[a]	228[a]	152[a]	249[a]
66 lb nitrogen—May	250[a]	234[a]	91[a]	193[ab]	254[a]	263[a]	173[a]	227[a]
66 lb nitrogen—June	216[a]	187[a]	114[a]	136[b]	276[a]	221[a]	136[a]	217[a]

[1] Means in each column with the same letter or letters superscript are not statistically different from each other at the 0.05 level of significance.
[2] 3-year average (1959, 1960, 1961).
[3] 4-year average (1958, 1959, 1960, 1961).

Table 3. Average yields[1] (lb/acre air-dry) of cool season and warm season perennial grass and annual grass and forbs at the Archer and Gillette Substations, Wyoming. 1958, 1959, 1960, and 1961 (data were averaged over all fertilizer treatments).

	Archer				Gillette			
Item	1958	1959	1960	1961	1958	1959	1960	1961
Fertilized 1958								
Cool season grasses	*	43[b]	104[a]	214[b]	66[c]	96[bc]	207[a]	137[b]
Warm season grasses	*	163[b]	186[b]	300[a]	457[a]	333[b]	152[c]	93[d]
Annual grass	*	1[b]	13[b]	111[a]	24[a]	1[b]	13[b]	8[b]
Forbs	*	30[b]	110[a]	290[a]	26[b]	9[b]	165[a]	14[b]
Total		237	413	915	573	439	537	252
Fertilized 1959								
Cool season grasses		55[b]	144[a]	281[a]		96[a]	251[a]	190[a]
Warm season grasses		136[b]	184[a]	284[a]		400[a]	214[a]	101[b]
Annual grass		2[b]	15[b]	131[a]		1[b]	8[a]	6[a]
Forbs		44[b]	172[a]	281[a]		1[b]	55[a]	9[b]
Total		237	515	977		498	528	306

[1] Means in each column with the same letter or letters superscript are not statistically different from each other at the 0.05 level of significance.
* No yields shown because of harvesting error.

among years at both locations (Table 3). Yields of cool season grasses increased during the study period at both locations except for 1961 at the Gillette Substation. The increase was a function of time rather than of fertilization. The increase of the cool season grasses may be partially explained in that no grazing was permitted on the experimental areas and plant vigor was increased. Also, the cool season grasses utilized the early spring moisture and available nitrogen.

Warm season grasses, blue grama and buffalograss, increased in yield at the Archer location. As with cool season grasses, the increase was not a direct result of fertilization but rather due to the experimental area not being grazed. At the Gillette Substation, yield of blue grama grass declined each year of the study. This decline was a result of drought and use of early spring moisture by the cool season grasses, especially Sandberg bluegrass.

As a result of over 2 inches of rain in early August 1960, forbs, mostly Russian thistle (*Salsola pestifer*), were present on all plots. The plots fertilized with 33 lb N in April 1959 had an abnormal amount of Russian thistle.

Total herbage production at the Archer Substation increased 386% between 1959 and 1961 on the plots fertilized in the spring of 1958, and 413% on plots fertilized in 1959 (Table 3). The increase was partially a result of more forbs and annual grasses and the above-average precipitation in 1961. Forbs and annual grasses accounted for 44 and 42% of the total herbage produced in 1961 from the fertilizer treatments applied in the spring of 1958 and 1959, respectively.

Crude Protein

Percentage crude protein of the three grass species harvested at Archer in September was significantly increased by the nitrogen fertilizer (Table 4). All fertilizer treatments except the May 1958,

Table 4. Percentage crude protein[1] in blue grama, buffalograss, and western wheatgrass harvested in September. Nitrogen was applied to separate plots in 1958 and 1959; Archer Substation, Wyoming.

		Blue grama Nitrogen applied		Buffalograss Nitrogen applied		Western wheatgrass Nitrogen applied	
Treatment		1958[2]	1959[3]	1958[2]	1959[3]	1958[2]	1959[3]
Check		6.92[d]	7.67[c]	6.45[d]	7.11[c]	7.28[bc]	7.18[c]
33 lb N/A	April	7.46[bc]	9.07[b]	6.80[cd]	8.30[ab]	7.12[c]	7.09[c]
	May	7.22[cd]	9.65[ab]	7.55[ab]	8.13[b]	7.58[abc]	7.44[bc]
	June	8.19[ab]	9.65[ab]	7.74[ab]	8.32[ab]	7.75[ab]	8.18[ab]
66 lb N/A	April	7.64[bc]	9.78[ab]	7.36[bc]	8.97[ab]	7.80[ab]	7.86[abc]
	May	8.60[a]	10.31[a]	8.12[a]	9.21[ab]	8.04[a]	8.33[a]
	June	8.59[a]	9.90[ab]	7.46[b]	9.33[a]	7.54[abc]	8.33[a]

[1] Means in each column with the same letter or letters superscript are not statistically different from each other at the 0.05 level of significance.
[2] 4-year average.
[3] 3-year average.

Table 5. Average percentage crude protein[1] of blue grama harvested in July and September. Nitrogen was applied in 1958 and 1959; Gillette Substation.

Treatment	Harvested July Nitrogen applied		Harvested Sept. Nitrogen applied	
	1958[2]	1959[3]	1958[2]	1959[3]
Check	12.64[b]	12.64[c]	9.34[c]	10.35[c]
33 lb April	13.38[b]	14.72[b]	10.68[bc]	11.49[b]
May	13.53[b]	14.51[b]	10.95[b]	11.89[ab]
June	13.41[b]	15.28[ab]	10.87[bc]	12.20[ab]
66 lb April	15.24[a]	15.91[ab]	12.02[ab]	12.46[ab]
May	15.15[a]	15.04[ab]	12.75[a]	12.63[a]
June	15.05[a]	16.58[a]	11.69[ab]	12.29[ab]

[1] Means in each column with the same letter superscript are not statistically different from each other at the 0.05 level of significance.
[2] 4-year average.
[3] 3-year average.

33 lb N/acre produced blue grama yields that were significantly higher in percentage crude protein than the check. For western wheatgrass, only the May 1958, May 1959, and June 1959 fertilizer treatments of 66 lb N/acre significantly increased crude protein percentage. Generally, the 1959 fertilizer treatments tended to produce a higher percentage crude protein content than the 1958 treatments. Percentage crude protein of fertilized blue grama harvested in July was not significantly different from that of the check except for the 66 lb N/acre treatment applied in May.

Percentage crude protein of the blue grama grass at Gillette, harvested in July, was significantly higher on the fertilizer treatments of 66 lb N/acre than on the check or the 33 lb N/acre treatments (Table 5). Significant differences in percentage crude protein of the blue grama grass harvested in September were found between treatments. The plots fertilized in 1958 with 66 lb N/acre and the May fertilizer treatment of 33 lb N/acre produced blue grama grass having a significantly higher percentage crude protein content than the check. The 1959 fertilizer treatments produced blue grama having a higher percentage crude protein content than that produced on 1958 fertilizer treatments.

Composition

The botanical composition of vegetation on each plot was determined in the spring of 1958 and again in the fall of 1961. The percentage composition of the major species declined at both locations between 1958 and 1961 (Table 6).

At Archer, blue grama and buffalograss cover declined an average of 9 and 19%, respectively, during the study. Decline of these warm season species was attributed to subnormal precipitation received in three years of the four-year study period.

Western wheatgrass, a cool season species, made its growth in the spring when moisture was available. Thus, western wheatgrass utilized the early moisture and nitrogen. Competition for moisture and nutrients early in the growing season by other species was not as critical as it was for the warm season species later in the growing season.

At Gillette, the relative cover of blue grama declined on all but the check plots and the plots fertilized with 66 lb N/acre in May 1958. The overall average decline of blue grama cover was 13%. Sandberg bluegrass, a cool season species, increased on all treatments. Sandberg bluegrass cover varied from year to year in the native composition but increased during periods of drought. Sandberg bluegrass was more abundant on the fertilized plots than on the check plots, and it was assumed that it utilized the early spring moisture and nitrogen and became more vigorous. The overall average increase of Sandberg bluegrass cover was 20%. The increase of this species was a function of years rather than fertilizer.

Table 6. Percentage vegetational composition of the major species determined by a modified point quadrat on plots fertilized in 1958 at the Archer and Gillette Substations, 1958 and 1961.

Treatment[1]	Archer						Gillette			
	Blue grama		Buffalograss		Western Wheatgrass		Blue grama		Sandberg Bluegrass	
	1958	1961	1958	1961	1958	1961	1958	1961	1958	1961
Check	65	54	24	14	8	10	76	76	12	19
33 lb N/A April	52	56	43	17	3	5	77	60	11	37
May	53	58	43	9	3	12	77	51	10	45
June	58	51	32	16	4	5	80	70	4	30
66 lb N/A April	65	41	24	21	4	9	76	65	17	23
May	56	35	35	17	6	4	67	74	21	26
June	53	49	43	17	3	6	80	44	14	51
Average	57	49	35	16	4	7	76	63	13	33

[1] Average of three replications.

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