Response of Native Vegetation of the Central Great Plains to Applications of Corral Manure and Commercial Fertilizer

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Production of palatable herbage by native vegetation on the central Great Plains is low. For example, average production by palatable grasses from 1940 to 1956 on the Central Plains Experimental Range[2], Nunn, Colorado, was less than 600 pounds air dry per acre. Preliminary trials conducted on the Northern Great Plains have indicated that yields could be increased by the application of corral manure and commercial fertilizer to the native range vegetation. The response of the vegetation on the Central Great Plains to such treatments is reported herein.

In southern Saskatchewan, Canada, yields of short-grass vegetation were more than doubled for a 6-year period by a single application of corral manure at the rate of 12 tons per acre (Clark *et al.*, 1943). Annual rainfall on the study area averaged 12 inches, an amount comparable with that at the Central Plains Experimental Range. Repeated applications of corral manure at 2-, 3-, and 4-year intervals increased yields of blue grama *(Bouteloua gracilis)* by 250 to 300 percent, while western wheatgrass *(Agropyron smithii)* yields averaged 150 percent of the yields from untreated vegetation.

Applications of nitrate and phosphate to native vegetation on the Great Plains region of southern Canada were discussed by Clark and Tisdale (1945). Nitrates increased yields 32 to 36 percent but did not increase the protein content significantly. Phosphates did not increase yields but did increase the phosphorus content of the herbage.

Significant increases in yields of dry herbage, chiefly western wheatgrass, were obtained from annual topdressings of nitrogen on native range at 2 rates during a 6-year study in central North Dakota (Rogler and Lorenz, 1957). Average annual precipitation at this location was near 18 inches for the period of study.

Materials and Methods

Fertility studies were established in northeastern Colorado in 1951, 1952, and 1953 on the Central Plains Experimental Range operated by the Agricultural Research Service in cooperation with the U. S. Forest Service. The study area of approximately 40 acres had a uniform stand of native vegetation. It was located in a 600-acre pasture that had been used for several years as a holding pasture for cattle. This pasture had been grazed for about a week each spring and fall. Stocking rates were relatively high, and the utilization had averaged nearly 40 percent by weight of the annual production of blue grama and buffalograss *(Buchloe dactyloides)* each year.

The density and composition of the native vegetation on August 1, 1952, are given in Table 1. Blue grama made up more than 88 percent of the total vegetation cover. Buffalograss, second among the grasses, furnished only 1.74 percent of the total cover. Two browse species, fourwing saltbush *(Atriplex canescens)* and plains pricklypear *(Opuntia polyacantha)* each provided more of the ground cover than did buffalograss. Scarlet globemallow *(Sphaeralcea coccinea)*, a palatable perennial forb, was the only other species that furnished 1 percent more of the total cover.

The soils on this experimental area belong to the Ascalon series, although they are not fully typical of that series. They differ by having too dark a color in the surface soils and by having too much clay in the subsoil. The gross characteristics of the soils on the experimental area are as follows: The surface soils are about 12 inches thick, with a dark grayish-brown color, sandy-loam texture, and a weak fine-granular structure. They have a very firm consistence when dry and a pH of about 7.5. The upper subsoil is 15 inches thick, with a dark grayish-brown color, light clay texture, and a coarse to moderate blocky structure. The dry subsoil is hard, and the pH is about 7.8. The lower subsoil is a light-gray, fine sandy loam with little structure and a firm consistence. It is a zone of high lime accumulation. The substratum is a loose, pale-brown

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Table 1. Average density and percentage composition of vegetation on range fertility study area, August 1, 1952.

Botanical group and species	Density *Percent*	Composition *Percent*
Grasses and grasslike plants:		
Blue grama	8.10	88.23
Buffalograss	0.16	1.74
Needle-and-thread	0.04	0.44
Red three-awn	0.08	0.87
Sand dropseed	0.02	0.22
Threadleaf sedge	0.01	0.11
Western wheatgrass	0.03	0.33
Total	8.44	91.94
Forbs:		
Goosefoots	0.02	0.22
Pale evening-primrose	0.06	0.65
Russian thistle	0.03	0.33
Scarlet globemallow	0.10	1.09
Slenderbush eriogonum	0.03	0.33
Tansyleaf aster	0.05	0.54
Total	0.29	3.16
Browse:		
Broom snakeweed	0.04	0.43
Fourwing saltbush	0.20	2.18
Plains pricklypear	0.21	2.29
Total	0.45	4.90
All vegetation	9.18	100.00

fine sandy loam or loamy fine sand that is highly calcareous. These Ascalon soils are sandy and absorb water readily. They also release a large percentage of water to growing plants. They are well suited to growing grass in this dry climate, where much of the rain falls in high-intensity small storms of less than 0.75 inch.

Climatic conditions during these fertility trials were normal except for the acute drought of 1954. The 6-year (1951-56) average annual precipitation was 11.13 inches (Table 2). The 18-year (1939-56) average for the same area was 11.67 inches.

Well-rotted cattle manure was topdressed on a 6-acre area at the rate of 10 tons to the acre in the summer of 1951. As determined by standard laboratory analyses the manure contained 85 pounds of total nitrogen, 92 pounds of available phosphoric acid, and 84 pounds of water-soluble potash per acre.

On April 27, 1952, seven commercial fertilizers were topdressed without replication on plots 8 by 50 feet. They were nitrogen (N), potassium (K), phosphorus (P), and the combinations NPK, NK, NP, and PK. A 12-foot border strip separated the plots. The rates per acre were 67 pounds of nitrogen in ammonium nitrate (NH_4NO_3), 100 pounds of phosphorus in phosphoric oxide (P_2O_5), and 150 pounds of potassium in potassium chloride (KCl). These plots were not grazed until 1957.

On April 15, 1953, five fertilizer treatments (N, NP, NPK, P, and K), and two check treatments were established in two replications each on plots 10 feet wide by 300 feet long. The fertilizers were drilled into the native soil to a depth of 3 inches. The empty drill was run through the sod on one set of check plots, while the other set was untreated. The application rates in pounds per acre were N, 80; P, 100; and K, 200. These plots were protected from grazing through 1956.

Yield measurements were obtained from the manured and the untreated native range areas in 1952, 1953, and 1956. The drilled fertilizer and check plots were sampled for yields in 1953 and again in 1956. The vegetation on each of the treated and check plots was examined by the square-foot-density method in early September 1956; 20 sample plots of 25-square feet area were used for each of the 10 fertility and grazing management treatments.

Observations and Results

Vegetation Growth

Growth of vegetation varied widely from year to year during these trials. The manure was applied too late in 1951 to influence vegetation growth that year, but in 1952 the growth of the short grasses was more luxuriant on the manured area than on the untreated native range. The midgrass species did not respond to the manure treatment.

The plots topdressed with commercial fertilizer in 1952 showed no observable differences in volume of growth that year. The vegetation on plots receiving nitrogen retained a green color about 10 days longer than

Table 2. Annual and growing-season precipitation, 1951-56, Central Plains Experimental Range.

Year	Total annual precipitation	Growing-season (May 1-Sept. 30) precipitation
	Inches	*Inches*
1951	13.10	9.10
1952	14.01	11.57
1953	11.96	8.72
1954	4.89	3.48
1955	13.08	9.68
1956	9.72	7.21
6-Year average	11.13	8.29

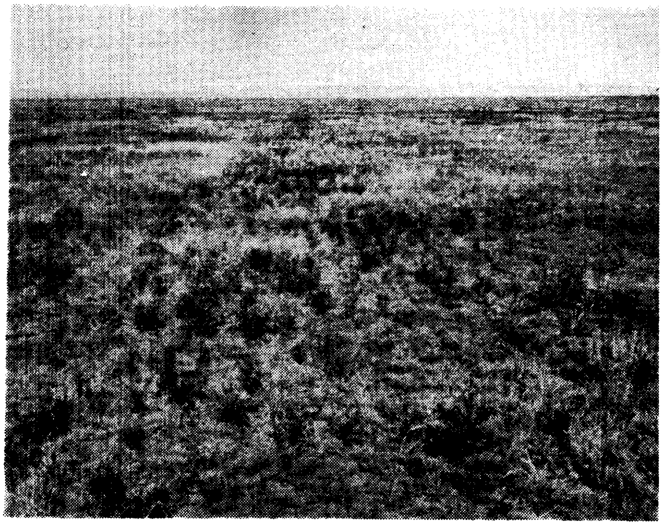

FIGURE 1. *Left:* Plot with nitrogen drilled into native sod in 1953. *Right:* Plot drilled only in 1953. Photographed in 1956.

that on other plots. The short grasses on the manured area stayed green approximately a week longer than they did on the nitrogen-treated plots.

The vegetation on the manured land began growth about 2 weeks earlier in 1953 than that on the untreated range. The cattle held in the pasture during the first week of May congregated on the manured area and made heavy use of the old and new growth of forage grasses; whereas, the adjoining untreated range was only lightly grazed during the same period. Part of both the manured and the untreated range were fenced during the summer of 1953 to exclude grazing.

Vegetation on the plots topdressed with nitrogen in 1952 and on those drilled with nitrogen in 1953 had a decided burned appearance by the last week of July 1953. One-half inch of rain fell on July 30, and 2½ inches were received in a high-intensity storm on August 21. Blue grama and buffalograss greened up promptly after the August storm and produced some new leaf growth on all plots. New growth was more luxuriant on the nitrogen plots than on other plots. A fair crop of blue grama seedstalks also developed on the nitrogen plots but not on other plots. Western wheatgrass and needle-and-thread *(Stipa comata)* had matured before the August storm and made no appreciable new growth that fall under any treatment.

The spring of 1954 was very dry. Cool-season species such as western wheatgrass and needle-and-thread did not produce new shoots. Old-growth vegetation was grazed from the unfenced study area. Blue grama and buffalograss root crowns produced a few new shoots on the manured range, but new growth was not found on any other part of the study area in 1954. Old vegetation remaining from the 1953 crop stood on the protected areas all summer and fall without apparent disintegration. Much of this old growth disappeared during the high-velocity windstorms early in 1955.

There was no grazing on the plots in the spring of 1955, and new growth was late. Live plants of western wheatgrass and needle-and-thread were found only occasionally. Many of the root crowns of blue grama and buffalograss appeared to be dead. The areas of apparently dead vegetation were more extensive on the manured than on the untreated area. The plots treated with commercial nitrogen in 1953 appeared to have less dead vegetation than the check plots. The nitrogen plots produced a crop of blue grama seedstalks in the fall of 1955, following heavy rains in late August and mid-September, but yield samples were not obtained.

Abundant growth of annual forbs, especially Russian thistle *(Salsola kali* var. *tenuifolia)* and summer-cypress *(Kochia scoparia)* developed in 1955 on all the plots. This forb growth was much heavier on the manured area than on the untreated native range. The growth of annuals was taller on the nitrogen plots but somewhat less dense than that on some of the other plots among the fertilizer treatments.

Observation in 1956 showed changes from 1955. The mortality of short grasses from 1955 to 1956 on all the nitrogen plots appeared to be more severe than it had been from 1953 to 1955. The grasses on the check plots and potassium plots had little if any new mortality, and those on the phosphorus plots appeared to have made some recovery.

The manured plot produced more annual forbs, chiefly Russian thistle, in 1956 than did the untreated range, but the density

Table 3. Densities of palatable grasses[1] and annual forbs in 1956 following manuring in 1951 and drilled-in fertilizer in 1953.

Fertility treatment	Grazing management	Density of palatable grasses *Percent*	Density of annual forbs *Percent*
Manuring 1951	Grazing 1951-56	4.07	1.81
Manuring 1951	Protection 1954-56	4.83	1.08
No treatment	Grazing 1951-56	3.14	0.88
No treatment (check)	Protection 1953-56	4.55	0.34
Drilled-in N 1953	Protection 1953-56	3.90	1.43
Drilled-in P 1953	Protection 1953-56	5.29	0.35
Drilled-in NP 1953	Protection 1953-56	3.52	0.97
Drilling only 1953 (check)	Protection 1953-56	4.48	0.38
Drilled-in K 1953	Protection 1953-56	3.85	0.55
Drilled-in NPK	Protection 1953-56	3.45	1.14
Least significant difference—5% level		0.43	0.57

[1] Blue grama plus very small amounts of needle-and-thread and sand dropseed *(Sporobolus cryptandrus)*.

of the grasses was not materially greater than that on the untreated plots (Table 3). Density and growth of annual forbs on the nitrogen plots were greater than on the phosphorous, potassium, or check plots (Figure 1). Competition from grasses on the phosphorus and check plots may have reduced the growth of annual forbs. This does not hold, however, for comparison between the potassium and the nitrogen plots. The 1956 vegetation cover on the plots treated with nitrogen in 1953 was definitely poorer than it was on all other plots except the grazed untreated range. Protection from grazing 1953 to 1956 helped the grasses to maintain their stand on both the manured and the untreated native range.

Drought Effects

The acute drought of 1954 caused a heavy mortality of some grasses and perennial forbs, and increases in the density of annual forbs, (Tables 1 and 3). These drought reactions varied among the different fertility treatments. Application of nitrogen and potassium increased the mortality of grasses over that suffered from applications of manure and phosphorus unaccompanied by nitrogen. Nitrogen and manure stimulated the production of annual forbs several years after the applications were made.

Individual species also reacted differently to the fertility treatments during the drought period. Buffalograss and western wheatgrass practically disappeared from all the plots. Blue grama suffered an average loss of one-half its density 1952 to 1956, but the density losses varied significantly among the fertility and grazing treatments. Needle-and-thread lost density on the grazed, untreated range; on manured plots, both grazed and protected 1954-56; and on protected plots with drilled-in N and NP. It increased in density on untreated range protected 1953-56 and on plots that received drilled-in P,K and NPK in 1953. Scarlet globemallow lost density on all plots but it was much less severe on the protected plots treated with NP and NPK in 1953.

Herbage Yields

The 1952 yields from the short grasses were 1,235 pounds of air-dry herbage per acre on the manured range and 805 pounds on the untreated range. This 430-pound difference was highly significant. The midgrasses did not respond to the manure treatment. Their combined yield was only 28 pounds per acre on the manured range and 38 pounds on the untreated range.

Yield samples were clipped August 31 and September 1, 1953 and in mid-September 1956 from all of the fertility and check plots. Short-grass yields and midgrass yields were sampled separately in 1953, but they were not separated in 1956 owing to the very small yields from midgrasses. Significant increases in short-grass yields over those of the drilled check plots were obtained in 1953 from all drilled-in fertilizer applications containing nitrogen (Table 4). The short-grass yield from untreated plots also was significantly larger than the yield from the drilled check plots, indicating that the drilling was unfavorable. The fertilized plots did not outyield the untreated check plots, but the yield of short-grass herbage from the grazed manured plots was significantly larger than the yield from the grazed untreated plots. Midgrass yields were erratic and showed no specific effects from fertilization.

Yields from the palatable grasses were smaller in 1956 than in 1953. Differences among yields from the several treatments, however, were significant again in 1956. The yields per unit area of grass density were not widely dispersed and they indicate little carryover of fertility effects from 1953 to 1956. Differences in density of palatable grasses influenced the variation in yields.

Effects on Nutrient Content of Herbage

Protein and phosphorus deficiencies are critical nutritional factors in mature blue grama forage. Composite samples of mature blue grama herbage were clipped during mid-October 1956 from plots that had received four of the fertility treatments, and from untreated check plots, for fodder analyses and determina-

Table 4. 1953 and 1956 yields of air-dry herbage per acre from palatable grasses by fertility and grazing treatments, and yields per acre per 1 percent of density of palatable grasses in 1956.

Fertility treatment	Grazing management	1953 yields			1956 yields	
		Short grasses	Mid-grasses	Total palatable grasses	Total palatable grasses	Yields per acre per 1% of density
		Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Manuring 1951	Grazing 1951-56	757	6	763	427	105
Manuring 1951	Protection 1954-56	......	....	......	512	106
No treatment	Grazing 1951-56	628	7	635	368	117
No treatment (check)	Protection 1953-56	637	14	651	411	90
Drilled-in N 1953	Protection 1953-56	629	42	671	393	101
Drilled-in P 1953	Protection 1953-56	554	13	567	514	97
Drilled-in NP 1953	Protection 1953-56	646	14	660	356	101
Drilling only 1953 (check)	Protection 1953-56	464	14	478	425	95
Drilled-in K 1953	Protection 1953-56	499	32	531	375	97
Drilled-in NPK 1953	Protection 1953-56	699	4	703	333	97
Least significant difference—5% level		126	45	......	178	......

tions of phosphorus and calcium content. The protein content of herbage from the nitrogen plots (7.9 percent, dry basis) was only slightly higher than that of herbage from the untreated range (7.1 percent). This indicated no effect from nitrogen fertilization on the protein content of the mature herbage after 3 years from treatment. The protein content of herbage from the manured range (10.7 percent) and that from phosphorus-treated plots (10.9 percent), however, were definitely greater than that of the herbage from the untreated range. The protein content of herbage from the nitrogen-phosphorus plots (9.4 percent) was intermediate between that of herbage from the nitrogen plots and the phosphorus plots.

Herbage from the manured plots was lowest in phosphorus content (0.13 percent) and that from the nitrogen-treated plots (0.16 percent) was next to the lowest. Herbage from the phosphorus-treated plots had no higher phosphorus content (0.18 percent) than that from the untreated range (0.19 percent). The phosphorus-calcium ratios for these five samples were in the narrow range of 1:2.2 to 1:3.2.

Discussion and Conclusions

These fertility trials indicate that in the central Great Plains region ranch-produced manure can be applied to short-grass ranges with favorable results. Heavy applications of commercial fertilizer increased yields less than 100 pounds of air-dry herbage per acre under the conditions of this study. Fertilizer applications are not economically feasible with such small increases in herbage production. Applications of commercial fertilizers to native ranges, therefore, are not recommended for areas of the Central Plains that receive low precipitation such as that received by the study area.

Summary

Manure and several commercial fertilizer treatments were applied to a good stand of native short-grass vegetation on the Central Plains Experimental Range in northeastern Colorado during 1951, 1952, and 1953. The longtime average annual rainfall for the study area is about 12 inches. The rainfall during the study period was comparable to the longtime average, except for an acute drought in 1954. General observations were made each year from 1952 to 1956, and plot records of density and herbage production were taken in 1952, 1953, and 1956. Fodder analyses of the mature blue grama herbage from plots that had received four of the fertility treatments and from the untreated plots were made in 1956.

Manuring was the most effective treatment. It increased herbage yields 15 to 50 percent. Yields from plots treated with commercial fertilizers seldom exceeded those from the untreated native range. Commercial nitrogen applied in 1953 had little, if any, effect upon the protein content of blue grama herbage produced in 1956. Manure and phosphorus treatments improved the protein content of blue grama herbage. Manure and nitrogen reduced the phosphorus content, but phosphorus fertilization gave little increase in the phosphorus content of the herbage.

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