Forage Potential of Irrigated Blue Grama with Nitrogen Fertilization[1]

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Highlight

In 1959, ammonium nitrate was surface applied to blue grama at rates of 0, 200, 400, and 800 lb N/acre. Initial plant response to fertilizer N was measured in 1959, and residual response in 1960 and 1961. High moisture levels were maintained by irrigation. Each increment of applied N increased forage yields and yield trends indicate that with adequate water and N blue grama will produce at least 7,500 lb/acre/year of oven-dry forage. Recovery of added N was very low, ranging from 28 to 34% for the 200- and 800-lb rates, respectively. Total water use was similar for all treatments, but pounds of forage produced per inch of water used increased with each increment of N. The results indicate blue grama is a relatively inefficient user of moisture and N when compared with sudan grass, bermuda grass, and some other introduced grasses. However, further studies are needed to determine if blue grama can be managed to use fertilizer and water more efficiently.

Nonfertilized blue grama [*Bouteloua gracilis* (H.B.K.) Lag. ex Steud.] exhibits limited response to irrigation and distribution of precipitation. Experiments at Bushland, Texas, showed that irrigation before and during the growing season increased forage yields by ⅓ ton/acre or less.[3] Average forage production during a 6-year period of near-average precipitation was ⅓ ton/acre/year, with little difference between years (Whitfield et al., 1949). However, Cosper et al. (1961) showed that native grasses in the Northern Great Plains produce more forage on less water when soil fertility is not limiting.

The following experiment was designed to evaluate the production of blue grama supplied with high levels of nitrogen and water.

Experimental Procedure

This study was initiated in 1959 at the Southwestern Great Plains Research Center on an almost pure stand of blue grama originally seeded in 1940. Only a few broadleafed weeds and grasses, such as little barley (*Hordeum pusillum* Nutt.), 6-weeks fescue (*Festuca octoflora* Walt.), and tumblegrass [*Schedonnardus paniculatus* (Nutt.) Trel.], were present.

The deep, slowly permeable soil of the experimental area is a Pullman silty clay loam and is representative of about 12 million acres of medium- to fine-textured soils commonly referred to as the "hardlands" of the Southern High Plains (Coover et al., 1953). Average total soil N by depths on the check plots in 1959 was: 0 to 6 inches, 0.115%; 6 to 12 inches, 0.093%; 12 to 24 inches, 0.063%; 24 to 36 inches, 0.046%; and 36 to 48 inches, 0.041%.

Ammonium nitrate was surface applied to obtain the following N applications: 0 (check), 200, 400, and 800 lb/acre. The 200- and 400-lb rates were applied on May 22, 1959. To prevent burning, half the 800-lb rate was applied on each of the two dates—May 22 and July 31, 1959. All N applications were watered in. No additional fertilizer was applied after 1959. Treatments were replicated three times in a randomized block design.

Individual plots 20 × 30 ft were isolated by borders for flood irrigation and to prevent interplot water movement. Water was applied through a meter and gated pipe. Periodic, replicated soil moisture measurements to a depth of 4 ft were made in each plot. Gravimetric measurements were made in the first foot, and neutron soil moisture readings were used in the second, third, and fourth feet. The plots were irrigated when one-half to two-thirds of the available soil moisture was depleted from the upper 2 ft of soil. Seasonal precipitation plus irrigation averaged about 40 inches of water for each of the 3 years of study. The seasons, from first irrigation to final clipping, were May 11 to October 21, April 1 to November 14, and May 4 to October 3 in 1959, 1960, and 1961, respectively. Seasonal rainfall totaled 10.3, 24.7, and 10.5 inches respectively.

Forage yields were determined by clipping entire plots with a reel-type lawn mower set to leave a stubble height of approximately 0.5 inch. All plots, including the check plot, were clipped at each harvest date. Clipping dates were arbitrarily set to favor fullest development of the fertilized herbage without allowing advanced maturity. At most clipping dates the grass had begun to head and bloom. Initial N response in 1959 produced five clippings, whereas the smaller residual responses in 1960 and 1961 produced only three and one clippings, respectively. Forage production was determined by weighing the entire plot yield and oven-drying a representative subsample at 70 C.

Forage N was determined by a modified Kjeldahl technique (Jackson, 1958). The factor 6.25 was used to convert plant nitrogen to protein. Recovery of applied nitrogen was calculated as:

$$\frac{\text{N in fertilized crop} - \text{N from check}}{\text{N applied}} \times 100$$

Soil samples were collected to a 4-ft depth and analyzed for total N (Kjeldahl procedure modified to include NO_3-N) at the end of the experiment in October 1961.

Differences between treatment means were tested by analysis of variance. The probability (P) that differences are due to chance alone is shown in the appropriate tables.

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Table 1. Forage yields of irrigated blue grama as affected by applied nitrogen.

1959 treatment (lb N/acre)	Forage yields 1959	1960	1961	Total 3 yr	Total increase
	(lb/acre)				(lb/lb N)
0	1,260	1,350	1,610	4,220	—
200	3,940	1,820	1,850	7,610	16.9
400	6,060	2,950	2,000	11,010	17.0
400 + 400	7,060	7,640	3,940	18,640	18.0
P	.01	.01	.01		NS

Table 2. Recovery of applied nitrogen (percent) by irrigated blue grama.[1]

1959 treatment (lb N/acre)	1959	1960	1961	Total
0	—	—	—	—
200	24	3	1	28
400	27	5	1	33
400 + 400	18	13	3	34
P	—	—	—	—

[1] N uptake from check plots was 16, 14, and 12 lb/acre in 1959, 1960, and 1961, respectively.

Results and Discussion

Forage Yields.—Annual forage production on the irrigated check plots was one-half to two-thirds ton/acre (Table 1). Added N markedly increased irrigated blue grama yields. For the 3-year period, blue grama receiving 200, 400, and 800 lb N produced approximately 2, 3, and 4 times as much forage, respectively, as the check. Greatest yield responses from the 200- and 400-lb N rates were measured during the first year when those treatments produced nearly one-half the total 3-year forage production. The 200-lb rate had little effect after the first season. The application of 800 lb N apparently resulted in large quantities of residual N, and yields were higher during the second season than during the first.

Direct comparisons between the blue grama and other perennial forage crops were not made in this study; however, annual sudan grass [*Sorghum sudanense* (Piper) Stapf] was grown in an irrigated fertilizer trial at Bushland in 1959 (Ellis et al., 1961). Sudan grass produced about 9,500 and 10,200 lb/acre oven-dry forage with 200 and 400 lb N/acre, respectively. Elder and Murphy (1961) studied N rates on Midland bermuda grass [*Cynodon dactylon* (L.) Pers.] at Stillwater, Oklahoma, in 1955 and 1956. Average annual yields were about 7,000 and 8,500 lb/acre for 200 and 400 lb N/acre/year, respectively.

Available results indicate that blue grama probably does not have as high a yield potential as some other species.

Forage Protein.—Added N increased the protein content of the forage in proportion to the amount of N applied (data not shown). The greatest increase in protein was from 6.8 to 17.2% in June of the first year of study, but response occurred in the two succeeding years. Differences in protein content gradually diminished with clipping. In 1961, only forage from the 800-lb rate contained more protein than the check.

Nitrogen Recovery.—Recovery of N was low for all treatments, with only about one-third of the applied N being recovered in the forage during the 3-year period (Table 2). Fate of the remaining two-thirds of applied N is not known. More than 80% of the total N recovery from the 200- and 400-lb N rates occurred during the first year. On the 800-lb rate, 53% of the total recovery occurred during the first year and 39% occurred during the second year. In the previously cited studies (Ellis et al., 1961; Elder and Murphy, 1961), sudan grass and bermuda grass recovered similar amounts of applied N. First year N recovery was 57 and 45% for the 200- and 400-lb N rates, respectively.

At the termination of this experiment, there was no statistically significant difference in total soil N between treatments in the 0 to 6, 6 to 12, 12 to 24, 24 to 36, or 36 to 48-inch depths (data not shown).

The low N recovery and absence of differential residual N in the soil indicate rather large losses of N from the soil.

Appreciable losses of applied N can occur from the soil by several mechanisms. For example, under some conditions leaching losses can be significant. However, in this experiment soils were rather dry below 4 ft, indicating that no appreciable amount of leaching occurred. Gaseous losses to the atmosphere of applied N can also be large. Soulides and Clark (1958) found N deficits as great as 60% on some grassland soils.

It is also possible that a significant amount of the applied N remained in the soil and in plant roots at the termination of the experiment and was not detected by the analysis for total soil N. By analyzing the soil for NO_3- and NH_4-N and by determining total N in grass tops and washed roots, Power (1966) accounted for about 80% of the fertilizer N applied to bromegrass (*Bromus inermis* Leyss.). At the end of two years under irrigation and with a total application of 500 kg/ha of fertilizer N, about 40% of the fertilizer N was contained in grass tops, 25 to 35% in roots, 5 to 10% in the soil in mineral form, and about 20% was not accounted for. Power (1966) suggested that

Table 3. Water-use efficiency (lb/inch) of irrigated blue grama as affected by applied nitrogen.

1959 treatment (lb N/acre)	Water-use efficiency		
	1959	1960	1961
0	31	33	39
200	92	44	45
400	140	72	49
400 + 400	163	182	97
P	.01	.01	.01

the appreciable quantity of fertilizer N in the root material would eventually mineralize and become available for top growth of subsequent crops.

The results of this experiment, in which two-thirds of the applied N was unaccounted for, point to the need for detailed research on the fate of fertilizer N applied to perennial grasses on this soil.

Total Water Use and Water-Use Efficiency.—Applied N had little effect on water use (data not shown). The seasonal water use by blue grama ranged from 40 to 43 inches. This is much higher than the 22 and 28 inches thought to be normal seasonal water use for optimum yields of irrigated grain sorghum and wheat, respectively, on the hardlands (Jensen and Sletten, 1965).

Where N was added, water-use efficiencies were greatly increased, leaving no doubt that N must be supplied for maximum efficiency (Table 3). Compared with the check, 800 lb of N increased water use efficiency more than five times in both 1959 and 1960. Apparently, water was lost from the soil at about the same rate regardless of the amount of dry matter produced. This was true in numerous experiments summarized by Viets (1962).

Without added N, water-use efficiencies were about the same as on native range on the hardlands. [Whitfield et al. (1949) reported that native range produced an average of 48 lb forage/inch of precipitation from May 1 through October 31.] Probably, lower water use and higher water-use efficiencies could have been obtained by adjusting dates and amounts of irrigation to periods of rapid or slow vegetative growth. It appears, however, that even with optimum irrigation and fertilizer treatments, water-use efficiency of blue grama would remain lower than that of some other forages. For example, Ellis et al. (1961) reported that irrigated annual sudan grass, growing on Pullman soil fertilized with 200 lb N, produced more than 300 lb forage/inch of water used.

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