Blue Grama Response to Nitrogen and Clipping Under Two Soil Moisture Levels¹

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Highlight

Effects of N-fertilization and clipping on production and water use of blue grama were evaluated under two soil moisture levels, field capacity and $\frac{1}{2}$ available water. Nitrogen increased shoot production 77% on unclipped plants. Clipping decreased shoot production 287% below the control averaged across N levels. Soil moisture levels produced no differences in yields. Root weights were decreased an average of 253% below the control by clipping. No differences were observed in total water used between fertilized and unfertilized plants but clipping reduced water used by 95%. Unclipped plants fertilized with 80# N/acre used more water than unfertilized unclipped plants. The amount of water required to produce a unit of a shoot was reduced 37% when fertilized. Clipping lowered this water requirement an average of 98%. Nitrogen greatly increased seed stalk numbers and the increase in shoot production due to fertilization came primarily from increased numbers of seed stalks.

Demands on agricultural land for increased production and non-agricultural purposes have necessitated research into methods of improving production on rangelands. The use of fertilizers offers a possibility for increasing rangeland productivity. Blue grama (*Bouteloua gracilis* [H.B.K.] Lag.) is dominant or co-dominant throughout much of the Great Plains and

at elevations of 4000 to 6000 feet in the West.

This study was a greenhouse evaluation of blue grama response to nitrogen fertilization under clipping and two soil moisture levels. Investigations were also made during a recovery period to determine possible carry-over effects of the treatments.

Nitrogen fertilization has increased yields on native ranges (Gay and Dwyer, 1965; Smika et al., 1963) and particularly blue grama ranges (Klippel and Retzer, 1959; Lehman et al., 1968; Rogler and

Lorenz, 1957). Reproductive capabilities may be enhanced by nitrogen fertilization as shown by increased seed production (Kneebone, 1957) and increased seed stalk numbers. Desirable carry-over effects from nitrogen for as long as three to six years following application have been reported (Kay et al., 1957).

Blue grama responds quickly to both favorable and unfavorable stimuli. Yields may be seriously damaged by frequent clipping (Branson, 1956), although judicious harvesting may stimulate yields of blue grama and prove valuable in the planning of sound management systems (Jameson, 1963). Morphologically, blue grama is resistant to a relatively high level of defoliation because of the inaccessibility of its meristematic growing points (Branson, 1953).

Several studies have shown an increase in water requirement when soil moisture content approaches either extreme (Bennett and Doss, 1963; Briggs and Shantz, 1913). Regardless of the environment, water requirement was reduced when watering was postponed until high soil moisture tensions were reached (Letey and Blank, 1961). Shantz (1927) reported that 312 ± 12 grams of water were required to produce one gram of blue grama under greenhouse conditions. Clipping

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Table 1. Blue grama shoot and root weights (g) under nitrogen fertilization (lb./acre) and clipping.

Clipping treatments	Nitrogen			Mean
	0	40	80	
Shoot weights				
Clipped ²	2.89a ¹	3.14a	3.17a	3.07a
Unclipped	7.63b	12.55c	15.46c	11.88b
Mean	5.26a	7.85ab	9.32b	7.48
Root weights				
Clipped ²	3.94a	3.92a	3.59a	3.82a
Unclipped	9.50b	14.22b	16.79b	13.50b
Mean	6.72a	9.07a	10.19a	8.66

¹Means with the same small letter are not significantly different within clipping level ($P < .05$).

²All differences between clipped and unclipped are significantly different for all fertilizer levels ($P < .05$).

increased water requirement and made moisture stress effects more severe (Briggs and Shantz, 1913). Water requirement of range grasses was decreased by the addition of nitrogen (Lehman et al., 1968; Viets, 1962).

Methods and Procedures

Following a procedure similar to that used by Keller (1954), two-gallon ceramic pots seven inches in diameter and ten inches deep were filled with equal amounts of a thoroughly mixed, air-dry sandy soil. A three-inch by three-inch core of blue grama sod obtained at the Ft. Stanton Cooperative Range Research Station, Ft. Stanton, New Mexico, was inserted into the soil of each pot and allowed to become established at a field capacity water level.

Treatments were applied after a two month establishment period on forty-eight pots selected for their uniformity of stand of blue grama. These treatments were applied in a $3 \times 2 \times 2$ arrangement of three nitrogen levels (0, 40, and 80 lb. N/acre equivalents), two soil moisture levels (field capacity and one-fifth available water), and two clippings levels (no-clip and clipped to a $1\frac{1}{2}$ inch stubble height every ten days), with four replications in a randomized block design. One-fifth

available water was determined as 20% of the difference in weight of a given unit of soil at field capacity and at permanent wilting point measured in grams of water. Ammonium sulfate (21% N) was used as the source of nitrogen. Water levels were held constant for the entire 96 day sampling period, after which all treatments were clipped. All pots were then raised to field capacity and allowed to recover for 48 days, after which they were all clipped to determine final production.

Production, water usage, and water requirement were measured

throughout the study. Water requirement in this study was based on Viets (1962) definition as the ratio of water absorbed by the plant during the growing season to the weight of dry matter produced by the plant during that time. Upon termination, root weights, leaf lengths, seed stalk length, leaves per seed stalk, seed stalk numbers, and number of inflorescence spikes were measured.

Data were statistically analyzed by the analysis of variance procedures outlined by Steel and Torrie (1960) and significant sources of variation containing more than two means were tested by Duncan's new Multiple Range Test.

Results and Discussion

Shoot Production

Fertilization and clipping both produced differences² in above ground dry matter yield of blue grama during the initial portion of this study. Increases in shoot production due to the addition of N on unclipped plants was 64% above the control at the 40 lb. N/acre rate and 103% at the 80 lb. N/acre rate (Table 1). Efficiency of N on unclipped plants, based on grams

²All given deviations are significantly different from the control at the .05 probability level unless stated otherwise.

Table 2. Blue grama water use (g) and water requirement (g) under conditions of nitrogen fertilization (lb. N/acre) and clipping.

Clipping treatment	Nitrogen level			Mean
	0	40	80	
Total water used				
Clipped	6,317a ¹	5,936a	6,153a	6,134a
Unclipped	10,078b	12,058bc	13,647c	11,955b
Mean	8,089a	8,729a	9,532a	8,804
Water requirement ²				
Clipped	2,222a	1,923a	1,961a	2,041a
Unclipped	1,333b	962c	877d	1,031b
Mean	1,667a	1,282ab	1,219b	1,370

¹Means with same letter are not significantly different in clipping treatments and nitrogen levels ($P < .05$).

²Grams of water required per gram of shoot produced.

Table 3. Blue grama shoot yields (g) following 48 day recovery under prior conditions of nitrogen fertilization (lb./acre) and soil moisture levels.

Moisture	Nitrogen level			Mean
	0	40	80	
Field capacity	4.31a ¹	5.71ab	6.19b	5.40a
1/5 available water ²	4.81ab	5.05ab	4.75ab	4.87a
Average	4.56a	5.38b	5.47b	5.14

¹ Means with the same letter are not significantly different within moisture level ($P < .05$).

² Maintained at field capacity during recovery period.

of additional grass produced over the control per g of N applied, was 44.3 g at the 40 lb. N/acre rate and 35.3 g at the 80 lb. rate.

Clipping reduced above ground yields by 287% compared to the unclipped treatment averaged across N levels (Table 1). Increased production due to fertilization was not apparent when clipping treatments were applied. It appears that the addition of nitrogen to blue grama which is maintained at a clipping height below two inches will not give increased yields. This is supported by other work (Dwyer, 1969).

There was no difference in yields between the field capacity and one-fifth available water levels, an indication of the ability of blue grama to produce forage under conditions of limited moisture supply.

Root Production

Neither fertilization rates when averaged across clipping levels nor soil moisture levels produced differences in root weights (Table 1). Clipping reduced root weights 253% below those of the unclipped plants, almost the same reduction shown by the shoot production data. Roots, like the shoots, did not respond favorably to additions of N under relatively severe clipping.

Root : Shoot Ratios

Root weights exceeded shoot weights an average of 16% for each treatment, but no differences were shown in root : shoot ratios for any treatment. The response of roots and shoots to the treatments was about equal.

Water Usage

There were no significant differences in total water used between fertilizer rates on clipped plants, but there were differences on unclipped plants (Table 2). Clipping reduced the total water used by 95% compared to unclipped plants averaged across N levels.

Water Requirement

Fertilization rates and clipping levels both produced differences in the water requirement of blue grama (Table 2), but there was no difference between the field capacity and one-fifth available water levels.

Nitrogen applied at 40 and 80 lb. N/acre rates reduced the water requirements below the control when averaged across clipping treatments by 30% and 37%, respectively. It appears that blue grama is more efficient in water use under N fertilization. The absence of response from moisture levels indicates that this increase in water use efficiency due to fertilization may exist within a wide range of available moisture.

Clipping also decreased water re-

quirement to about half of the water required for unclipped grass.

Recovery Study

Shoot production.—Nitrogen fertilization continued to influence shoot production of blue grama during the 48 day recovery period. Results at the end of this period showed that the 40 and 80 lb. N/acre rates increased yields 18 and 20%, respectively, over the control when averaged across moisture levels, however, fertilizer had no influence at the one-fifth available water level (Table 3). This increase amounted to a N efficiency of 7.4 g of grass produced over the control per g of N added at the 40 lb. N/acre rate, and 4.1 gm of grass/g of N at the 80 lb. rate.

Soil moisture levels alone had no influence on yields when carry-over effects were tested.

Blue grama apparently recovered quickly from defoliation since following the 48 day recovery period, there was no carry-over effect from clipping on yields (Table 4).

Water usage.—The carry-over effects of treatments showed that water used at field capacity under 80 lb. N/acre is greater than that used at 0 and 40 lb. of N. Also, water used was less for 80 lb. N than for 0 under one-fifth available water (Table 5).

Those grasses previously maintained at one-fifth available moisture used 17% less water during recovery than those grasses previously maintained at field capacity when averaged across fertilizer levels.

The carry-over effects of clipping continued to reduce water use.

Table 4. Blue grama shoot yields (g) following 48 day recovery under prior conditions of nitrogen fertilization (lb./acre) and clipping.

Treatment	Nitrogen level			Mean
	0	40	80	
Previously clipped	4.99a ¹	5.35a	4.78a	5.04a
Unclipped	4.14a	5.41ab	6.16b	5.24a
Average	4.56a	5.38ab	5.47b	5.14

¹ Means with the same letter are not significantly different within clipping treatment ($P < .05$).

Table 5. Total water used (g) and water requirement (g) for blue grama during a 48 day recovery period under prior conditions of nitrogen fertilization (lb./acre) and soil moisture levels.

Water measurement	Nitrogen level			Mean
	0	40	80	
Total water used ¹				
Field capacity	4180Ba	4328Ba	4661Bb	4390Ba
1/5 available water ²	3861Ab	3878Ab	3550Aa	3763Ab
Average	4020Ba	4103Ba	4106Aa	4076
Water requirement ³				
Field capacity	962Bb	746Aa	741Aa	806Ba
1/5 available water ²	800Aa	769Aa	763Aa	775Aa
Average	881Bb	757Aa	752Aa	791

¹Means with same small letter are not significantly different for soil moisture. Those with capital letter are not significantly different for N level ($P < .05$).

²Maintained at field capacity during recovery period.

³Grams of water required per g shoot produced.

Table 6. Total water used (g) during 48 day recovery period under prior conditions of nitrogen fertilization (lb./acre) and clipping.

Clipping treatment	Nitrogen level			Mean
	0	40	80	
Previously clipped	3886b ¹	4006bc	3472a	3788a
Unclipped	4155a	4200b	4739c	4365b
Average	4020a	4103a	4106a	4076

¹Means with the same letter are not significantly different within clipping level ($P < .05$).

Those samples previously clipped used 15% less water than those samples not clipped (Table 6).

Water requirement.—Fertilization and clipping both showed differences in water requirement when carry-over effects of the treatments were measured (Tables 5 and 6).

Nitrogen at both the 40 and 80 lb. N/acre rates decreased the water required to produce a gram of shoot below those of the control (Table 6).

Carry-over clipping effects also decreased the water requirement of blue grama.

Source of Increased Production from Fertilized Plants

Significant increases in shoot production from fertilized plants have been shown in this and numerous other studies. This portion of the experiment was an attempt to determine from which plant parts this increased production comes.

Blade length.—Based on fertilization and water level treatments without clipping, blade length differences appeared only as a result of water level influence. Leaf lengths under the field capacity water level were 16% greater than those under the one-fifth available water level (Table 7).

No treatments were found to have any measurable effect on seed stalk height.

Leaves per seed stalk.—Fertilization produced no differences in number of leaves per seed stalk, but the field capacity water level averaged an 8% increase in number over the one-fifth available moisture group.

Seed stalk numbers.—Seed stalk numbers were increased considerably over the control as a result of fertilization. The 40 and 80 lb. N/acre rates produced 142% and 263% more seed stalks, respectively, than the control.

Soil moisture levels produced no differences in seed stalk numbers.

Spike numbers.—The number of inflorescence spikes per plant was not affected by water levels, how-

Table 7. Blue grama leaf blade lengths (mm), leaves per seed stalk, seed stalk numbers and spike numbers on unclipped plants under nitrogen fertilization (lb./acre) and soil moisture levels.

Measurement and moisture conditions	Nitrogen level			Mean
	0	40	80	
Leaf blade length				
Field capacity	177.5Aa ¹	184.6Aa	190.6Aa	184.2Ba
1/5 available water	143.7Aa	163.8Aa	169.0Aa	158.8Aa
Average	160.6A	174.2A	179.8A	171.5
No. leaves/seed stalk				
Field capacity	3.45Ba	3.50Ba	3.45Ba	3.47Ba
1/5 available water	3.15Aa	3.38Aa	3.15Aa	3.22Ab
Average	3.30Ba	3.44Aa	3.30Aa	3.34
No. seed stalks/pot				
Field capacity	22.00Aa	55.25Ab	85.50Ac	54.25Ab
1/5 available water	22.75Aa	53.00Ab	77.00Ac	50.92Ab
Average	22.38Aa	54.13Ab	81.25Ac	52.58
Spike numbers				
Field capacity	25.00Aa	68.75Ab	93.75Ac	62.50Ab
1/5 available water	24.50Aa	70.75Ab	93.00Ac	62.75Ab
Average	24.75Aa	69.70Ab	93.37Ac	62.63

¹Means with the same small letter are not significantly different for that moisture level. Those with capital letters are not significantly different for that N level ($P < .05$).

ever, the 40 and 80 lb. N/acre fertilization rates produced 181% and 277% more spikes, respectively, than the non-fertilized treatment.

These data imply that in addition to increased forage production, seed stalk and spike numbers due to N-fertilization, the reproductive capabilities of blue grama may be simultaneously improved. The increase in production due to N fertilization comes primarily from increased numbers of reproductive parts, namely flowering culms, or seed stalks and spikes. This, of course, implies more total leaf blades and sheaths since each seed stalk has an average of 3.34 leaves.

Overall the data from this study on blue grama infer that: 1) shoot and root production are both increased about the same order of magnitude with addition of N, 2) no increase in production of shoots and roots is found with N addition when blue grama is clipped to 1½ inch stubble height every 10 days, 3) clipping reduced the total water used nearly 100%, 4) clipping increased the water required per unit of shoot produced about 100% and 5) N fertilization reduced this requirement 37%.

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