Fertilization Influences Cattle Diets on Blue Grama Range During Drought

CHRISTOPHER D. ALLISON, REX D. PIEPER, GARY B. DONART, AND JOE D. WALLACE

Highlight: Botanical composition of cattle diets on fertilized and unfertilized blue grama rangeland was evaluated during drought by microhistological examination. Seventy-two percent of all species available were found in the diets. Grass comprised 62% of the yearly diets on the fertilized pasture compared with 73% on the unfertilized pasture. Annual forbs made up 18% of the diets on the fertilized pasture and 8% on the unfertilized pasture. There were no differences in perennial forb composition of the diets among the two pastures. Total grass consumption did not vary among seasons, but composition of individual species did. Blue grama provided the bulk of grass in summer and fall diets with mat muhly furnishing the majority of grass in diets during winter and spring. Perennial forbs were important in winter and spring diets. Annual forbs were major components of diets during summer and fall. Cattle consistently exhibited a greater preference for fertilized blue grama than for unfertilized blue grama. Preference trends for other plants were inconsistent and were influenced mostly by availability.

Nitrogen fertilization increases forage production in certain areas, including New Mexico (Banner 1969; Schickedanz 1970). Little is known, however, about the effect of nitrogen fertilization on diet composition or preference of grazing cattle.

Knowledge of plants preferred by livestock is necessary for the development and implementation of grazing schemes and range supplementation programs (Harris et al. 1952; Bohman and Lesperance 1967). This is a report on the botanical composition of cattle diets on nitrogen-fertilized and unfertilized blue grama (*Bouteloua gracilis*) range at various seasons and on cattle preferences for different forage species. Although

Authors are former research assistant in range science, professor and associate professor of range science, and associate professor of animal science, New Mexico State University, Las Cruces. Allison's present address is Range Science Department, Texas A&M University, College Station.

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data were collected for only one year, they do show the influence of drought on cattle diets.

Experimental Procedures

The study was conducted on the Fort Stanton Experimental Ranch, in the foothills between Sierra Blanca and the Capitan Mountains in southern Lincoln County, New Mexico. The climate of the area is generally mild with some extreme weather occurring during the winter. The mean annual temperature is 29°C with a mean maximum temperature of 36°C and a mean minimum temperature of 20°C. Average annual precipitation for a 79-year period is 35 cm. The average precipitation for the growing season of June, July, August, and September is 23 cm or 65% of the total (Table 1). Rainfall during June, July, and August, 1974, was 41% below average.

The study area was divided into two comparable pastures of bottomland, upland, and hillside sites. One pasture (56 ha) had received nitrogen fertilization at a rate of 44 kg/ha in the form of urea (45% nitrogen) for 7 years (1968 through 1974). The other pasture (61 ha) was not fertilized. This study was confined to bottomland sites in both pastures.

The major forage species is blue grama, which is dominant or co-dominant on both sites. Sand dropseed (*Sporobolus cryptandrus*) and mat muhly (*Muhlenbergia richardsonis*) are other important grass

Table 1. Monthly and seasonal precipitation (cm) for Fort Stanton, 1974, and for 79 years of continuous record between 1895 and 1973.

Month	1974	Average for 79 years	Departure from normal
January	2.52	1.45	+1.07
February	1.57	1.24	+0.33
March	0.84	1.50	-0.66
April	—	1.40	-1.40
May	—	2.26	-2.26
June	0.91	3.21	-2.30
July	4.57	7.87	-3.30
August	5.21	6.86	-1.65
September	8.31	4.70	+3.61
October	5.13	1.93	+3.20
November	—	0.66	-0.66
December	2.74	1.75	+0.99
Total	31.80	34.83	-3.03

species. The major perennial forbs are Carruth sagewort (*Artemisia carruthii*), tall globemallow (*Sphaeralcea angustifolia*), and scarlet globemallow (*S. coccinea*). The principal annual forb during 1974 was portulaca (*Portulaca pilosa*).

Botanical composition and herbage availability (kg/ha) of the pastures during each season were estimated by clipping twelve 76.2 × 13.3-cm quadrats at each sampling period. All material was separated by species and dried at 60°C before being weighed.

Forage was collected from eight esophageal-fistulated steers equipped with screen-bottomed canvas collection bags during 4-day periods in late July, late August, October, and November, 1974, and in March, 1975. In January, 1975, only a 2-day collection was made due to inclement weather. Steers grazed both pastures approximately 2 weeks before the first collection period and were left on the pastures for the remainder of the study. Collections were made once daily at daybreak and lasted about 30 to 40 minutes. Both pastures were sampled each day of each 4-day collection period. Steers were allocated to pastures based on collection ability, fistula size, weight, temperament, and ease of removing and replacing cannulae to have similar sampling conditions among steers between pastures. They were allowed to graze the pastures freely during the day, but were penned and fasted overnight to minimize regurgitation and to ensure grazing and adequate forage collection the following morning. The steers received no supplementation until November, and then supplements were withdrawn 15 days before the remaining collection periods.

Collected forage was dried for 48 hours at 50°C in a forced-air oven at Fort Stanton. Upon termination of the collection period, samples were transported to New Mexico State University, re-dried in a forced-air oven at 50°C for an additional 24 hours to ensure uniform dryness among samples, and then ground through a 1-mm screen in a Wiley mill. Forage was composited for each day by pasture treatment.

Species composition of steer diets was determined by a modified microscopic technique adopted from Sparks and Malechek (1968). Microscope reference slides of plant species occurring on the site were prepared by covering ground plant material with synthetic resin mounting media and cover slips. Slides of fistulae-collected forage were prepared to be like the reference slides. Plant particles in forage slides were identified by comparing with species reference slides. Histological characteristics were used to identify plant species as reported by Free et al. (1971) and Rosiere et al. (1975).

Data collected for the experiment were evaluated statistically by modified split plot analysis of variance. Tukey's *W* procedure was used to test differences among means (Steel and Torrie 1960). Preference "ranks," similar to those used by Rosiere et al. (1975), developed from preference indices (Van Dyne and Heady 1964) were used to evaluate species preference by cattle. The preference index was used to evaluate species preference by cattle. The preference index was

calculated by the following formula (Krueger 1972):

$$\text{Pref. Index} = \frac{\% \text{ dry wt of species in forage eaten}}{\% \text{ dry wt of species in herbage}}$$

Results and Discussion

Less total herbage as well as less blue grama was available in these pastures for this study than for an early one (Schickedanz 1970). This was attributed to low precipitation during the growing season.

Nitrogen fertilization did not increase blue grama, sand dropseed, or mat muhly availability, but did increase portulaca availability (Table 2). Total available herbage at the end of the growing season was higher on fertilized rangeland than on unfertilized range. This was attributed to greater amounts of annual forbs, particularly portulaca, and sand dropseed on the fertilized pasture.

Cattle selected 72% of the species available in the herbage, according to results from the microhistological technique; but they were observed to consume most of the available species to some degree. Microhistological evaluation of diets revealed consumption of fewer species than did grazing observation, since some species observed being grazed were not found in slides of selected forage. Although many species were grazed, most of the diet consisted of only a few species. Of the 29 species available in the standing herbage, 91% to 98% of the diet was comprised of only 8 of those species (Table 3). This agrees closely with results of Beck (1975) and Rosiere et al. (1975).

The only significant differences ($P < .05$) among seasons were for perennial and annual forb proportions in diets (Tables 3, 4). Perennial forb content of diets was higher ($P < .05$) in the winter and early spring than during the summer and fall (Table 4). This was attributed to high Carruth sagewort consumption. Annual forb content of diets was higher in the summer and fall than during the winter (Table 4), due to high portulaca consumption. Seasonal variation of grasses, perennial forbs and annual forbs in the standing crop was also significantly different ($P < .05$) (Table 2). Seasonal changes in botanical composition of diets and in standing herbage have also been reported on sandhills range (Free et al. 1971), shortgrass plains (Beck 1975), semidesert grassland (Rosiere et al. 1975), and pinyon-juniper grassland (Thetford et al. 1971).

Table 2. Available herbage (kg/ha) for the major species found in cattle diets for nitrogen-fertilized and unfertilized rangeland.

Species	July 1974		August 1974		October 1974		November 1974		January 1975		March 1975	
	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.
Grasses												
Blue grama	21.6	113.7	52.4	125.0	207.5	189.7	80.3	143.3	69.9	193.8	74.8	108.7
Sand dropseed	15.0	46.5	41.8	31.1	151.2	58.4	19.1	11.7	28.7	4.6	26.2	17.8
Mat muhly	6.0	20.0	0.8	31.1	46.1	36.6	132.4	108.4	88.5	100.7	59.2	35.5
Subtotal	42.6	180.2	95.0	187.2	404.8	284.7	231.8	263.4	187.1	299.1	160.2	162.0
Perennial forbs												
Tall globemallow	5.5	0.6	9.6	0.6	41.5	T ¹	19.1	2.7	N.A. ²	N.A.	N.A.	N.A.
Scarlet globemallow	0.8	6.0	0.3	0.6	12.3	3.6	2.5	1.1	6.6	3.3	3.0	0.8
Carruth sagewort	0.3	4.9	T	8.7	7.6	30.0	5.7	8.5	3.3	0.3	11.5	6.3
Verbena	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	43.7	0.3	8.5	3.0	16.4	0.3
Subtotal	6.6	11.5	9.9	9.9	61.4	33.6	71.0	12.6	18.4	6.6	30.9	7.4
Annual forbs												
Portulaca	3.8	24.6	31.9	38.0	206.9	62.8	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
All other species	10.4	9.7	74.8	43.4	368.1	128.6	58.7	33.3	18.6	25.7	12.5	22.5
Total	122.4	367.6	211.6	278.5	1041.2	509.7	361.5	309.3	224.1	331.4	203.6	191.9

¹ Occurred in herbage, but was not found on transects.

² Not available in herbage.

Table 3. Botanical composition (%) and preference rank¹ of plant species in steer diets on fertilized and unfertilized pastures.

Species	July 1974		August 1974		October 1974		November 1974		January 1975		March 1975	
	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.	Unfert.
Grasses												
Blue grama	40.1 ^b	49.9 ^c	43.4 ^a	67.2 ^b	43.4 ^a	68.6 ^a	16.3 ^d	27.3 ^d	17.7 ^d	19.9 ^d	17.7 ^d	20.6 ^d
Sand dropseed	13.4 ^c	14.4 ^d	10.7 ^d	12.1 ^c	11.6 ^c	11.3 ^c	8.3 ^b	7.1 ^a	9.1 ^d	5.7 ^a	7.8 ^d	4.9 ^d
Mat muhly	4.6 ^e	3.3 ^e	1.3 ^a	2.7 ^e	1.3 ^d	2.7 ^d	34.9 ^c	32.6 ^c	39.0 ^c	36.0 ^c	44.2 ^b	43.3 ^a
Others ²	6.3	4.1	1.3	0.3	0.7	0.5	0.9	1.2	—	0.3	—	1.3
Total grasses	64.4	71.7	56.7	82.3	57.0	83.1	60.4	68.2	65.8	61.9	69.7	70.1
Perennial forbs												
Carruth sagewort	0.6 ^a	1.0 ^c	0.5 ³	0.9 ^d	0.4 ^d	1.0 ^e	21.9 ^a	22.3 ^a	21.9 ^a	31.6 ^a	13.2 ^a	20.4 ^a
Scarlet globemallow	1.4 ^a	2.7 ^b	0.3 ^d	1.1 ^a	0.2 ^e	0.6 ^c	0.8 ^c	2.1 ^a	0.5 ^e	1.8 ^a	1.1 ^c	2.4 ^a
Tall globemallow	2.8 ^d	1.1 ^a	1.7 ^d	0.2 ^c	1.1 ^d	—	2.1 ^d	0.6 ^d	0.7 ³	—	—	—
Verbena	—	—	—	—	—	—	10.6 ^c	1.8 ^a	9.8 ^a	2.2 ^a	12.4 ^a	4.2 ^a
Others ²	0.5	0.4	0.2	0.5	0.9	1.1	0.8	1.1	—	0.8	1.0	—
Total perennial forbs	5.3	5.2	2.7	2.7	2.6	2.7	36.2	27.9	32.9	36.4	27.7	27.0
Annual forbs												
Portulaca	24.0 ^a	18.6 ^a	36.5 ^a	10.3 ^c	36.7 ^a	11.3 ^c	—	—	—	—	—	—
Others ²	5.2	2.9	2.5	1.2	1.2	0.7	0.4	0.2	—	—	—	—
Total annual forbs	29.2	21.5	39.0	11.5	37.9	12.0	0.4	0.2	—	—	—	—
Unidentified	1.1	1.6	1.6	3.5	2.5	2.2	3.0	3.7	1.3	1.7	2.6	2.9

¹ Preference rank and meanings are derived from the following preference indices:

Preference Index	Preference Rank	Interpretation
1.8 or greater	a	Definite preference
1.3 – 1.7	b	Some preference
0.8 – 1.2	c	Same in diet as available
0.3 – 0.7	d	Some avoidance
0.2 or less	e	Avoidance

² "Others" include plant species that never composed more than 2% of the diets for any pasture or period in the study.

³ Species occurred in the diet but was not available in herbage, therefore no preference rank could be assigned.

There were no significant differences in grass or forb content in diets between the fertilized pasture and unfertilized pasture (Table 4).

Preference trends were generally inconsistent. Only blue grama had consistent preference trends. Cattle invariably preferred the fertilized blue grama more than the unfertilized. However, cattle consumed more blue grama on the unfertilized pasture (Table 3). Lower availability of blue grama in the fertilized pasture (Table 2) probably accounts for the higher preference indices calculated for blue grama in this pasture.

Inconsistencies in preference trends indicated that availability affected preference. Studies have shown that as grazing intensity increases, preference is altered. Leigh and Mulham (1966) found that 56% of sheep diets were comprised of a species that formed 1% of available herbage. Rosiere et al. (1975) noted that

yucca furnished 70% of spring diets of cattle while comprising less than 4% of available herbage and dropped to less than 10% of summer diets when availability dropped to less than 2%. Similar results were found in this study, with Carruth sagewort furnishing approximately 22% of winter and spring diets, while comprising only 2.5% of available herbage.

High preference indices for certain species in this study exceeded those reported for any species on shortgrass ranges (Beck 1969) and sandhill ranges (Scales 1972), while these higher indices were similar to ones calculated for semidesert grassland (Rosiere et al. 1975). Van Dyne and Heady (1965) concluded that less abundant species were either highly selected or rejected, while abundant ones furnished the bulk of diets and appeared to be neither preferred nor avoided.

Observations that cattle graze primarily grass (Cook et al. 1967) were substantiated in this study under both fertilization and nonfertilization and during all seasons (Table 3). Cattle preferences for grass were inconsistent, except for blue grama. Quantities of grass consumed were affected by treatment (Table 3), with cattle selecting larger amounts of grass from the unfertilized pasture. However, total grass consumption did not change with seasons (Table 4). Fertilization combined with low precipitation during the growing season (Table 1) reduced grass production on the fertilized pasture during the summer of 1974 (Table 2). This lower availability of grass probably caused unusual shifts in forage selection by cattle.

Blue grama furnished the bulk of the grass portion of diets during the growing season, but declined in importance after frost. Sand dropseed was second in grass consumption during the growing season. Sand dropseed also made up lesser amounts of diets after frost, but its consumption did not decline as rapidly as that of blue grama.

Major shifts in grass species composition of diets occurred after frost. Most notable was the dramatic increase of mat muhly in diets (Table 3). Increase in diet composition of mat muhly

Table 4. Seasonal proportions (%) of grasses and forbs in cattle diets.

Dates	Treatment	Growth form			
		Grass	Perennial forbs	Annual forbs	Unident.
July 1974	Fertilized pasture	64.5 a ¹	5.1 a	30.3 ab	0.1
	Unfertilized pasture	71.7 a	5.2 a	22.9 ab	0.2
August 1974	Fertilized pasture	56.0 a	2.7 a	39.1 b	2.2
	Unfertilized pasture	82.4 a	2.7 a	11.8 ab	3.1
October 1974	Fertilized pasture	57.0 a	2.5 a	37.9 b	2.6
	Unfertilized pasture	83.2 a	2.7 a	12.0 ab	2.1
November 1974	Fertilized pasture	60.5 a	36.1 b	0.4 a	3.0
	Unfertilized pasture	68.2 a	27.9 b	0.2 a	3.7
January 1975	Fertilized pasture	65.8	32.9	0.0	1.3
	Unfertilized pasture	62.0	36.3	0.0	1.7
March 1975	Fertilized pasture	69.6 a	27.8 b	0.0 a	2.6
	Unfertilized pasture	70.1 a	27.0 b	0.0 a	2.9
Average	Fertilized pasture	62.2	17.8	18.0	2.0
	Unfertilized pasture	72.9	17.0	7.8	2.3

¹ Means in the same column followed by different letters are significantly different ($P < .05$) as tested by Tukey's W procedure. Means for January were not compared due to lack of an adequate sample.

was probably due to its increasing availability as blue grama decreased in herbage composition (Table 2) and the fact that mat muhly retains some green leaf material which cattle selected. Mat muhly averaged only 2% of cattle diets during the growing season, but furnished 38% of the total diet after frost. Preference for mat muhly was not expressed until early spring (Table 3) which agrees with results of Pieper (1970) for the same area.

Although grass comprised the major portion of cattle diets, certain perennial forbs made up considerable proportions of cattle diets. Perennial forb content of diets varied from 2.9% in summer and fall to 20.7% in winter and early spring and averaged 16.8% over all seasons and treatments (Table 3). Carruth sagewort was the most prominent perennial forb in cattle diets. It was important in winter and early spring when it furnished over 21% of diets. Cattle generally consumed higher proportions of Carruth sagewort in the unfertilized pasture over all seasons, possibly because of its higher availability there (Table 2). Carruth sagewort was generally avoided during the growing season. Preference for Carruth sagewort increased dramatically after frost, suggesting that cattle select plants containing green leaf material after other species are dormant. Low availability of Carruth sagewort contributed to extremely high preference indices.

Verbena was another important perennial forb in cattle diets during winter and spring. Although a perennial, verbena did not initiate growth until cooler weather and was not available in herbage until winter (Table 2). Verbena comprised about 11% of diets on the fertilized pasture during winter and spring, but only made up 2.7% of diets on the unfertilized pasture. Low availability of verbena on unfertilized rangeland contributed to higher preference indices (Table 3) than was exhibited on fertilized range. Increased availability of verbena would probably coincide with a decrease in preference indices.

Other perennial forbs, largely globemallow, contributed approximately 1% to cattle diets, across all seasons and treatments.

Due to their short life-span, annual forbs were eaten only during summer and fall. Portulaca was the only annual forb eaten in substantial amounts during this study (Table 3). This forb furnished approximately 32% of summer diets of cattle grazing fertilized rangeland. It increased in importance on the fertilized pasture as the growing season progressed and declined slightly in diets on the unfertilized pasture (Table 3). Cattle exhibited higher preference for portulaca during the early part of the growing season, but preference declined as the growing season progressed and it became more available in herbage (Table 2). Low precipitation received on this area during the summer of 1974 (Table 1) and fertilization probably contributed to higher proportions of portulaca in herbage than would normally be expected. This agrees closely with studies con-

ducted on semidesert grassland (Rosiere 1973), where cattle expressed preference for this forb.

Conclusions

Perennial grasses comprised major portions of cattle diets on nitrogen fertilized and unfertilized blue grama rangeland. Although perennial grasses composed the most stable portions of diets, perennial forbs made up 31% of cattle diets during the winter and spring, while portulaca, an annual forb, composed 32% of summer and fall diets.

While perennial grasses should be used as a base in determining stocking rates, forb production should be taken into account. During dry years, such as this study, forbs may furnish large proportions of cattle diets.

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