Effects of Nitrogen Fertilization and Late-Spring Burning of Bluestem Range on Diet and Performance of Steers

JOHN S. WOOLFOLK, ED F. SMITH, ROBERT R. SCHALLES, BENNY E. BRENT, LENIEL H. HARBERS, AND CLENTON E. OWENSBY

Highlight: *Cattle were used to evaluate the effects of late-spring burning and nitrogen fertilization alone and in combination on a typical True Prairie range in the Flint Hills near Manhattan, Kans. Diet quality was improved by higher protein and hemicellulose, and by lower acid-detergent fiber (lignocellulose) of burned than nonburned pastures. Hemicullulose and neutral detergent fiber (cell-wall constituents) increased when 40 lb N/acre was applied. Cellulose and lignin were not affected by either treatment. Average daily gain and gain per acre were higher by steers on burned pastures than by those on nonburned pastures. Daily gain waa highest for steers on pastures burned and fertilized. Gain per acre on fertilized pastures exceeded gains from nonfertilized pastures primarily from heavier stocking rate rather than increased individual performance. Apparent dry-matter digestibility did not differ among treatments, but decreased June through August, then increased in October.*

The 4 million acres of bluestem range in the Kansas Flint Hills are recognized as one of the world's great native ranges for potential beef production. Research has aimed at ways to increase its productive capacity. Controlled late-spring burning has been recommended to increase beef gains (Smith and Owensby, 1973) and to decrease some undesirable weeds and cool-season grasses. Owensby and Anderson (1967) found that late-spring burning did not significantly reduce forage yields from Flint Hills range.

Nitrogen has the potential to increase bluestem herbage yields; Owensby (1969), comparing 0 and 50 lb N/acre to plots, recorded herbage dry matter yields of 0.99 tons/acre and 1.88 tons/acre for control and fertilized plots, respectively; however, some of the additional production was weeds and cool-season grasses. Rogler and Lorenz (1957) applied 40 and 80 lb N/acre to North Dakota native range and increased beef gains 42 and 70 lb/acre, respectively, over that from control (nonfertilized) range.

We studied the nutritive value of and performance of steers grazing bluestem range that was late-spring burned or fertilized with nitrogen or both.

Materials and Methods

Range used was that near Kansas State University that Anderson and Fly (1955) described as typical True Prairie. Big bluestem (*Andropogon gerardi* Vitman) and little bluestem (*A. Scoparius* Michx.) make up 50 to 60% of its total vegetation on ordinary upland and limestone break range sites.

Three other warm-season grasses, Indiangrass (*Sorghastrum nutans* (L.) Nash), switchgrass (*Panicum virgatum* L.), and sideoats grama (*Bouteloua curtipendula* (Michx.) Torr.), comprise another 10 to 20%. Numerous forb and grass species constitute the remainder. Shrubs are mainly confined to rocky ridges and lowland areas.

Two 44-acre pastures were burned April 28, 1972; two adjacent 60-acre pastures remained nonburned. Granular urea fertilizer (45% N) was aerially applied May 17 at 40 lb/acre to one burned and one nonburned pasture.

The pastures were stocked from May 2 to October 3 with Angus steers averaging 402 lb. They had been trucked from southeastern United States to Kansas in March and maintained in dry lot on rations of hay and silage until the grazing trials began. Unfertilized pastures were stocked at one animal unit per 5.0 acres; fertilized pastures at one animal unit per 3.3 acres. Individual animals were identified and weighed the first of each month after going overnight without feed or water. For starting and final weights, all steers were mixed and weighed. Salt was available *ad lib* in each pasture. Weight changes of fistulated steers and steers used for fecal collections were not included in pasture gains.

Two Holstein steers per pasture, esophageally fistulated by the Van

Table 1. Least square means of chemical constituents of treatment diet samples collected from steers grazing bluestem pasture.[1]

Cell component	Treatments: Control	40 lb N/acre	Burned	40 lb N/acre and burned
Crude protein	10.24[a][2]	10.89[a]	10.95[a]	11.15[b]
Neutral detergent fiber (cell-wall constituents)	80.70[a]	84.64[b]	82.41[a,b]	83.09[b]
Neutral detergent solubles (cell contents)	31.37[b]	27.59[a]	29.99[a,b]	28.85[a]
Acid detergent fiber (lignocellulose)	52.97[a,b]	54.35[b]	51.39[a]	50.78[a]
Hemicellulose	24.50[a]	26.86[a,b]	28.08[b]	29.30[b]
Cellulose (% of acid detergent fiber)	66.34	67.62	67.11	67.09
Lignin (% of acid detergent fiber)	24.07	21.96	22.09	23.10

[1] Values are percentages on an ash-free, moisture-free basis.
[2] Numbers in same row with different letters differ significantly ($P<.05$).

Authors are graduate research assistant, range management research scientist, research geneticist, and research nutritionists, Department of Animal Science and Industry; and crop research scientists, Department of Agronomy, Kansas State University, Manhattan.

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John Woolfolk is now with the Obion Company Extension Office, Union City, Tenn.

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Dyne and Torell (1965) method, were used to collect representative diet samples from all pastures. Fistula samples were taken the first week of each month June through October. Steers were penned late in the evening of the day before sampling to reduce sample contamination from regurgitation. Adequate samples usually were obtained in less than one hour.

Total fecal collections were made simultaneously with diet-sample collections from the same pastures using two Angus steers per pasture. Steers were randomly selected from the large group of research animals before the first trial and were trained to carry fecal collection bags. Bags and harnesses were similar to those described by Lesperance and Bohman (1961). Feces were collected and weighed twice during a 24-hour period. Morning and evening collections were pooled and samples of approximately 200 g each were taken for analyses.

All samples were dried in a forced-air oven at 50° C (until a nearly constant weight was achieved), ground in Wiley mill (40-mesh screen), and stored in glass bottles until laboratory analyses were completed. Crude protein, dry matter, and ash were determined by the procedures set forth by the Association of Official Agricultural Chemists (1970). Analyses of cell constituents were conducted using procedures outlined by Goering and Van Soest (1970). Dry matter digestibility values were determined by the summative digestibility equation (Goering and Van Soest, 1970).

Least squares analysis of variance (Kemp, 1972) and Duncan's New Multiple Range Test (Steele and Torrie, 1960) were used for data analyses.

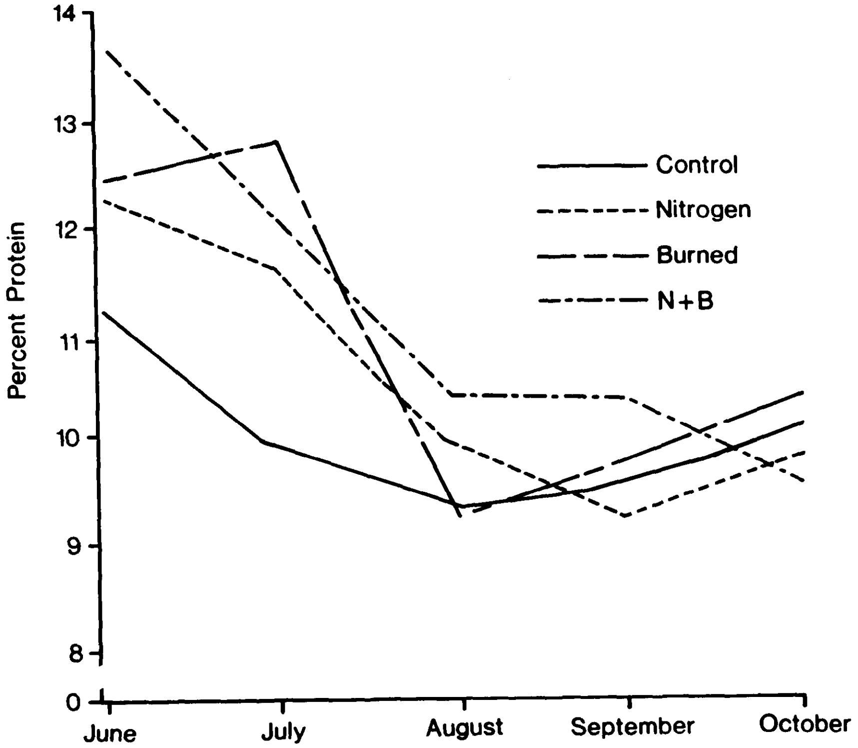

Fig. 1. *Protein contents of diet samples (moisture free basis) collected by esophageally-fistulated steers grazing bluestem range.*

Results and Discussion

Composition of Diet Sample

The mean protein of 11.15% of the diet forage sample from the burned-fertilized pasture was higher ($P<.05$) than the average from any other treatment (Table 1). The high mean was from June and mid summer samples because protein declined in the burned-fertilized pasture to the lowest of all pastures by October (Fig. 1). Protein in the control pasture was lowest of all in early summer (Fig. 1). That may partially explain the low gain in early summer on our nonburned pasture in contrast to gains from mid- and late-spring burned pastures that Smith and Owensby (1972) reported. Growing steers (400-600 lb) require 11.1% protein for maximum growth, according to the National Research Council (1970). After June the protein content of the forage in the control pasture remained lower than that amount.

Table 2. Chemical constiuents (%) of diet samples as affected by late spring burning.

Constituent	Treatments: Non-burned	Burned	Level of sig.
Protein	10.55	11.15	.10
Acid detergent fiber (ligno-cellulose)	53.63	51.07	.005
Hemicellulose	25.68	28.69	.002

Protein in diet samples from fertilized pastures were slightly higher (nonsignificant) than from nonfertilized ones (Table 3). Owensby (1969) found that increases in protein by native forage on Flint Hills range from nitrogen fertilization depended somewhat on adequate soil moisture. Precipitation during the 1972 grazing season was 87% of normal, or the increase in protein from nitrogen fertilization may have been larger. For all treatments combined, protein was highest in June, July, and October and lowest in August and September (Table 4).

Neutral detergent fiber (NDF) in forage samples increased the first four months of the grazing season, but decreased to a seasonal low of 76.05% in October (Table 4). The late season decline we found in NDF differed from Allen's (1973). He reported NDF in big and little bluestem clipped samples higher in October than any earlier month of the grazing season. Rapidly growing, cool-season species like Kentucky bluegrass (*Poa pratensis* L.) may have caused the decline in NDF in our diet samples in October.

As the dry matter of forage may be divided into NDF and neutral

Table 3. Chemical constituents (%) of diet samples as affected by 40 lb N/acre.

Constituent	Nitrogen (lb/acre): 0	40	Level of sig.
Protein	10.59	11.01	.17
Neutral detergent fiber (cell wall constituents)	81.43	83.97	.005
Neutral detergent solubles (cell contents)	30.80	28.13	.008
Hemicellulose	26.29	28.08	.05

detergent solubles (NDS), an increase in NDF is accompanied by a decrease in NDS. Goering and Van Soest (1970) reported NDS to be 98% digestible by ruminants. The declining NDS concentration June through August (Table 4) may partially explain a decline in apparent dry matter digestibility during those months (Table 5). Nitrogen fertilization increased NDF and decreased NDS in diet samples (Table 3). Neither NDF nor NDS was significantly affected by burning (Table 1).

The monthly trend of acid detergent fiber (ADF) was similar to the previously discussed NDF trend (Table 4). Burned pastures were 2.56% lower in ADF than nonburned pastures (Table 2).

Burning and nitrogen fertilization each increased hemicellulose of grazed forage (Tables 2 and 3). Hemicellulose declined as the grazing season progressed (Table 4).

Neither burning nor nitrogen fertilization significantly changed cellulose or lignin in diet samples (Table 1). Lignin in forage was higher in October than in any other month of the trial (Table 4).

Animal Performance

Burning increased daily gain by steers, while burning plus fertilization produced the largest daily gain (Fig. 2). Greater gains due to mid spring and late spring burning have been reported by Smith and Owensby (1973).

Steer gains per acre were increased by burning, fertilization, and a combination of the two (Fig. 3). Burning and fertilization more than doubled gain per acre (46 to 98 lb) from the control pasture.

Apparent dry matter digestibility was lower each month from June through August (Table 5). Dry matter digestibility increased in October, perhaps because NDS increased. Differences in digestibility due to treatments were not significant, but digestibility was lower for forages from fertilized pastures. Smith et al. (1960) reported significant increases in dry matter digestibility from mid-spring burning.

Conclusions

Protein level of forage collected from bluestem pastures by esophageal fistulated steers declined monthly June through September (from 12.5%

Table 4. Least square means of chemical constituents of diet samples collected by months from steers grazing bluestem pasture.[1]

Cell components	Months				
	June	July	August	September	October
Crude protein	12.45[a][2]	11.74[a]	9.80[b,c]	9.72[c]	10.23[b]
Neutral detergent fiber (cell-wall constituents)	82.89[a]	83.11[a]	85.69[b]	85.84[b]	76.05[c]
Neutral detergent solubles (cell contents)	28.66[a]	28.28[a]	25.71[b]	26.37[b]	38.22[c]
Acid detergent fiber (lignocellulose)	47.76[a]	53.93[b]	53.64[b]	55.26[c]	52.27[b]
Hemicellulose	31.87[a]	27.26[b]	27.91[b]	27.05[b]	22.50[c]
Cellulose (% of acid detergent fiber)	67.89[a]	69.08[a]	66.84[a]	67.92[a]	64.41[a]
Lignin (% of acid detergent fiber)	19.90[a]	20.73[a]	22.83[a]	22.82[a]	27.20[b]

[1] Values are percentages on an ash-free, moisture-free basis.
[2] Numbers in same row with different letters differ significantly ($P<.05$).

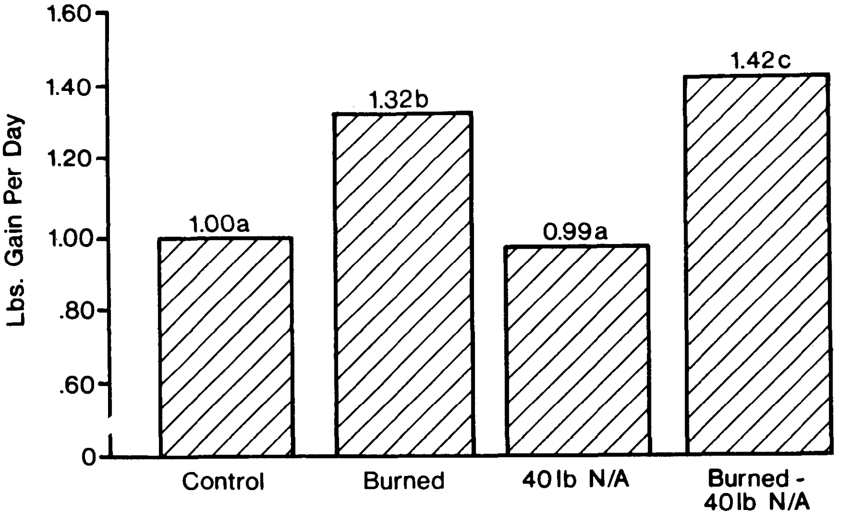

Fig. 2. *Daily gains per steer on bluestem pasture, May 2 to October 3, 1972. Numbers with different letters differ significantly (P<.05).*

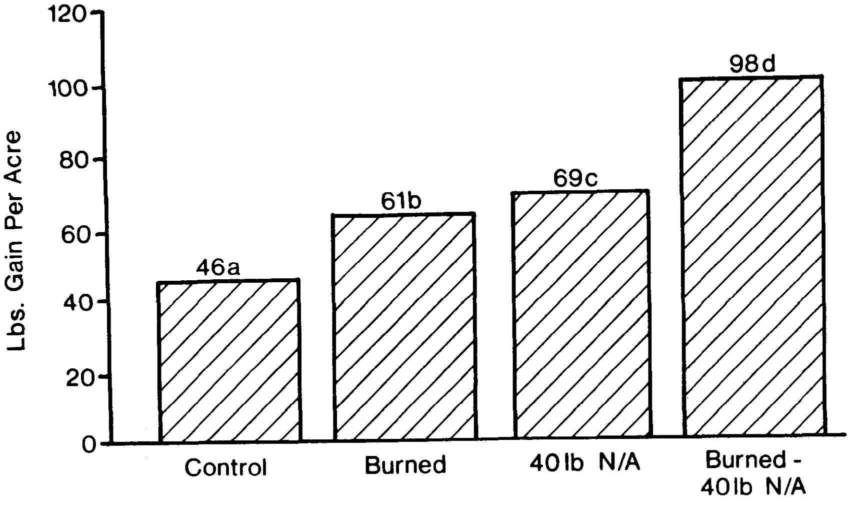

Fig. 3. *Gains per acre by steers on bluestem pasture, May 2 to October 3, 1972. Numbers with different letters differ significantly (P<.05).*

Table 5. Apparent dry matter digestibility (%) of forage collected by esophageally fistulated steers grazing bluestem pasture.

Month	Treatments				
	Control	40 lb N/acre	Burned	40 lb N/acre and burned	Mean
June	52.62	51.47	52.06	52.74	52.33[a 1]
July	51.25	50.20	49.43	50.36	50.31[b]
August	46.61	45.46	47.13	45.42	46.16[c]
September	46.57	45.84	48.22	46.87	46.88[c]
October	51.74	46.65	48.95	45.97	48.33[d]
Mean	49.76	47.92	49.16	48.27	

[1] Numbers in the same column with different letters differ significantly ($P<.05$).

to 9.7%), then increased slightly in October. Protein content of samples was increased .91% by combining pasture burning and nitrogen fertilization. Neutral detergent and acid detergent fiber increased as plants matured through the growing season until cool-season species appeared in diets during September and lowered fiber. Burning decreased ADF, while nitrogen increased NDF. Hemicellulose concentration was increased both by burning and fertilization.

Daily gains were increased by burning. Combining 40 lb N/acre with burning produced the highest average daily gain. Gain per acre was increased from least to most by burning, fertilization, and a combination of the two.

Apparent dry matter digestibility decreased June through August, then increased in October. No treatment affected digestibility of dry matter.

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