# Nutritive Value of Hay from Nitrogen-Fertilized Blue Grama Rangeland

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**Highlight:** *Wether lambs were used in a feeding study (voluntary consumption, nutrient digestibility, metabolizable energy, and nitrogen retention) to evaluate the nutritive value of hays harvested from unfertilized and nitrogen-fertilized blue grama rangeland. Fertilization increased consumption by 29%; increased digestibility of dry matter, protein, and energy by about 5%; and increased the retention of nitrogen by about 7%, although the percentage retention of absorbed nitrogen (biological value) was apparently depressed.*

Increasing the productivity of native rangelands has received considerable attention within the past few years, and it has been demonstrated that nitrogen fertilization of native blue grama (*Bouteloua gracilis* (H.B.K.) Lag. ex Steud.) rangeland may increase forage production several fold (Reed, 1965; Banner, 1969, Schickedanz, 1970). However, information is lacking concerning the effect of nitrogen fertilization on forage consumption, digestibility of nutrients, and nitrogen retention by animals consuming nitrogen-fertilized rangeland forage. Observations of these functions presented herein were reported in a preliminary communication (Kelsey et al., 1971).

## Procedures

Forage was harvested as hay from nitrogen-fertilized and unfertilized (control) plots of native rangeland located at the Fort Stanton Cooperative Range Research Station in the foothills of the Sacramento Mountains of Southern Lincoln County, N.M., at elevations ranging from 6,200 to 7,000 ft. Average annual rainfall for the area is about 15.3 inches. The fertilized plot received 40 lb of nitrogen per acre in the form of urea (45% nitrogen), applied aerially in June, 1969. The forage was harvested from treated and untreated plots in August, 1969, when blue grama was in the full-bloom stage and stored in burlap bags until used in the animal feeding study (about 3 months). Additional hay was harvested from the treated and untreated plots in September of 1969 when blue grama was in the mature stage, and this supply was used as the hay with which the animals were adjusted to their respective diets during the feeding trial. The hay was composed mainly of blue grama (about 70%) and various other grasses and forb species, as described by Schickedanz (1970).

Four crossbred wether lambs from the New Mexico State University College Farm flock were used to evaluate nutritive value of the hays from treated and control plots. The lambs were uniform in size and condition, and averaged about 80 lb in body weight during the study. A "crossover" design was used in the feeding trial: two lambs were randomly assigned to each of the two hay sources during an initial feeding trial; afterwards the two treatments were reversed with the same lambs being fed. Within each of the two feeding periods, there was a 10-day adjustment period, followed by a 14-day preliminary period with measurement of *ad libitum* feed intake, and finally a 10-day period of equalized intake which was regulated at approximately 90% of the *ad libitum* intake. The lambs were fitted with canvas fecal collection bags and maintained in metabolism stalls throughout the study. During the last 5 days of the period involving equalized feed intake, feces and urine were collected and sampled for analysis, along with representative samples of the hays consumed.

Fecal samples collected were 10% of the total daily excretion; urine samples were obtained by diluting the daily excretion to 2 liters and taking 50-ml aliquots for the composite sample for each lamb.

Samples of hays, orts (refused feed), and feces were analyzed by methods of the A.O.A.C. (1965) for dry matter, organic matter and ash, nitrogen, ether extract, and crude fiber. Likewise, nitrogen content of urine samples was determined by the method of the A.O.A.C. (1965). Samples of hays, orts, and feces were analyzed for acid-detergent fiber (ADF) and acid-detergent lignin (ADL) by the method of Van Soest (1963), and for cell-wall constituents (CWC) by the method of Van Soest and Wine (1967). Samples of hay, feces, orts, and urine were analyzed for gross energy (heat of combustion) in a Parr oxygen bomb calorimeter (Parr Instrument Co., 1960). Urine samples were absorbed on filter paper to facilitate ignition. Samples of hays, orts, and feces were dried to constant weight at 65°C and ground in a Wiley mill to pass a 40-mesh screen in preparation for analyses.

Digestion coefficients were calculated after corrections were made for feed refusals and sorting effects associated with the orts. The value reported by Harris and Mitchell (1941) was used to calculate metabolic fecal nitrogen (i.e., 0.55 grams m.f.n. per 100 g dry matter intake), and the value reported by McLaren et al. (1959) was used to calculate endogenous urinary nitrogen (i.e., 33 mg e.u.n. per kilogram of body weight). The formula of Swift et al. (1948) was used to estimate methane production. Analysis of variance was performed on the data as described by Steel and Torrie (1960).

## Results and Discussion

The chemical composition of hays obtained from nitrogen-fertilized and unfertilized blue grama rangelands is shown in Table 1. The nitrogen-fertilized hay

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Table 1. Average chemical composition and gross energy of unfertilized and nitrogen-fertilized blue grama hay.

| Chemical composition | Treatment[a] Unfertilized | Fertilized |
|---|---|---|
| Dry matter (%) | 96.2 | 95.8 |
| Composition of dry matter (%) | | |
| Organic matter | 92.8 | 93.5 |
| Crude protein (N X 6.25) | 7.0 | 8.8 |
| Ether extract | 1.7 | 1.7 |
| Cell wall constituent | 76.1 | 73.9 |
| Crude fiber | 35.2 | 35.6 |
| Acid-detergent fiber | 46.3 | 42.7 |
| Acid-detergent lignin | 6.3 | 6.4 |
| Nitrogen-free extract | 48.8 | 47.4 |
| Gross energy (kcal/g) | 4.2 | 4.2 |

[a]Each value represents the mean for at least three measurements (on three sub-samples) on a single, representative sample for each hay. The statistical significance of differences between means for the various components was not tested.

Table 2. Dry matter intake, apparent digestion coefficients, and TDN intake for unfertilized and nitrogen-fertilized blue grama hay.

| Item | Treatment Unfert. | Fert. | Diff. | C.V.[a] |
|---|---|---|---|---|
| Dry matter intake (g/day) | 521.0 | 673.0 | 152.0** | 7.0 |
| Dry matter (%) | 48.2 | 54.2 | 6.0* | 4.7 |
| Organic matter (%) | 51.3 | 57.0 | 4.7* | 4.3 |
| Crude protein (%) | 41.0 | 52.6 | 11.6** | 0.8 |
| Ether extract (%) | 20.3 | 20.6 | 0.3 | 26.4 |
| Cell wall constituents (%) | 54.5 | 59.3 | 4.8 | 4.3 |
| Crude fiber (%) | 54.4 | 61.4 | 7.0* | 4.2 |
| Acid-detergent fiber (%) | 49.9 | 53.3 | 3.4 | 5.3 |
| Acid-detergent lignin (%) | 5.2 | 17.7 | 12.5* | 47.1 |
| Nitrogen-free extract (%) | 51.6 | 55.7 | 4.1 | 5.3 |
| Total digestible nutrients (%)[b] | 48.1 | 53.6 | 5.5* | 5.1 |
| TDN intake (g/day) | 251.0 | 361.0 | 110.0** | 10.6 |

[a] C.V. = Coefficient of variation (%).
[b] Total digestible nutrients expressed as a percent of dry matter.
* $P<0.05$.
** $P<0.01$.

was higher in crude protein content, and this reflects a lower content of nitrogen-free extract (NFE) when compared to the unfertilized hay. Contents of cell-wall constituents and acid-detergent fiber were higher in the unfertilized hay. A summary of data showing dry matter intakes, apparent digestion coefficients, and total digestible nutrient (TDN) values is presented in Table 2.

The lambs consumed 152 g per day more of the fertilized hay than the unfertilized hay, which amounted to 129% of the intake for unfertilized hay ($P<0.01$). In an extensive review of factors that influence intake of forage, Marten (1969) has cited numerous reports of increased forage intake due to nitrogen fertilization.

Nitrogen fertilization increased ($P<0.05$) the digestibility of dry matter, crude protein, crude fiber, and even acid-detergent lignin, thereby increasing the total digestible nutrients (TDN) of the fertilized hay. Similar findings with cool season grasses have been reported by Markley et al. (1959) and Merrill et al. (1961). Although the apparent digestibility of lignin (ADL) was increased, the coefficient of variation for ADL is notably larger than coefficients of variation for other components. There were slight differences in digestibility coefficients for cell-wall constituents, acid-detergent fiber, and nitrogen-free extract in favor of the fertilized hay; but these differences were not significant ($P<0.05$).

The intake of TDN (Table 2) associated with the fertilized hay was 144% of the value for unfertilized hay ($P<0.01$), a difference which reflects not only a greater digestibility of nutrients but also a greater intake.

Values for digestible energy and metabolizable energy are shown in Table 3. Both digestible energy and metabolizable energy were increased as a result of nitrogen fertilization ($P<0.10$).

Nitrogen balance data are summarized in Table 4. Fertilization increased values for nitrogen intake, fecal nitrogen, apparent nitrogen digestibility, metabolic fecal nitrogen, nitrogen absorption, true digestibility of nitrogen, urinary nitrogen, and nitrogen retention. The increase in true digestibility of nitrogen due to fertilization (1.8%), though significant ($P<0.01$), is considerably less than the difference in apparent digestibility (11.9%), an observation which indicates the importance of the correction for metabolic fecal nitrogen in such studies where differences in intake occur.

Although the biological value of nitrogen (Table 4) is significantly greater ($P<0.01$) for unfertilized hay, the difference is due, in part at least, to difference in nitrogen intake (Forbes et al., 1958) as well as possible differences in

Table 3. Digestible and metabolizable energy as affected by unfertilized and nitrogen-fertilized blue grama hay.

| Item | Unfert. | Fert. | Diff. | C.V.[a] |
|---|---|---|---|---|
| Gross energy digested (%) | 46.5 | 51.3 | 4.8 | 5.3 |
| Digestible energy, (kcal/g) | 2.0 | 2.1 | 0.1 | 5.0 |
| Digestible energy intake, (kcal/day) | 1023.0 | 1439.0 | 416.0* | 11.2 |
| Gross energy metabolized (%) | 38.6 | 43.2 | 4.6 | 6.6 |
| Metabolizable energy,(kcal/g) | 1.6 | 1.8 | 0.2 | 7.2 |
| Metabolizable energy intake, (kcal/day) | 849.0 | 1211.0 | 362.0* | 11.8 |

[a]C.V. = Coefficient of variation (%).
*$P < 0.05$.

Table 4. Nitrogen metabolism in lambs fed unfertilized and fertilized blue grama hay.

| Determination | Unfert. | Fert. | Diff. | C.V.[a] |
|---|---|---|---|---|
| Nitrogen intake (g/day) | 5.9 | 9.5 | 3.6** | 5.5 |
| Fecal nitrogen (g/day) | 3.5 | 4.5 | 1.0** | 5.8 |
| Apparent nitrogen digestibility (%) | 40.7 | 52.6 | 11.9** | 0.7 |
| Metabolic fecal nitrogen (g/day) | 2.9 | 3.7 | 0.8** | 7.0 |
| Nitrogen absorption (g/day) | 5.3 | 8.7 | 3.4** | 5.6 |
| True nitrogen digestibility (%) | 89.8 | 91.6 | 1.8** | 0.3 |
| Urinary nitrogen (g/day) | 2.4 | 4.3 | 1.9** | 3.4 |
| Nitrogen retention (g/day) | 0.0 | 0.7 | 0.7* | 77.8 |
| Nitrogen intake retained (%) | 0.0 | 7.4 | 7.4 | 171.9 |
| Endogenous urinary nitrogen (g/day) | 1.2 | 1.2 | 0.0 | 4.2 |
| Nitrogen utilized (g/day) | 4.1 | 5.6 | 1.5* | 9.1 |
| Biological value (%) | 77.4 | 64.4 | – 13.0** | 4.5 |

[a] C.V. = coefficient of variation (%).
* $P < 0.05$.
**$P < 0.01$.

the actual nutritive value of the nitrogenous components of the hays. The fertilized hay is actually the more nutritious.

The increases in nutritive value of blue grama rangeland forage due to fertilization, together with increased yields (Banner, 1969; Schickedanz, 1970), suggest that fertilization of this type of rangeland promises economic returns of considerable magnitude to many areas of the western United States.

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