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Forb and shrub influences on steer nitrogen retention

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Abstract

Two experiments with steers were conducted to evaluate the influence of native forbs and shrubs on nitrogen utilization by cattle. Diets in Exp. 1 were blue grama (*Bouteloua gracilis* [H.B.K.]) (BG), BG plus 23% alfalfa *(Medicago sativa)* hay (ALF), BG plus 42% forbs and BG plus 41% shrubs. Diets in Exp. 2 included barley (*Hordeum vulgare* L.) straw, and straw plus either 42% ALF, 63% forbs, or 62% shrubs. Forbs used in our study were scarlet globemallow (*Sphaeralcea coccinea* Nutt.) and leatherleaf croton (*Croton pottsii* Lam.). Shrubs included fourwing saltbush (*Atriplex canescens* [Pursh.]) and mountain mahogany (*Cercocarpus montanus* Raf.) Forb and shrub mixtures were 50:50 of each species. Blue grama and straw basal diets contained 7.6 and 3.5% CP, respectively. Diets containing ALF, forbs, and shrubs were isonitrogenous (10.5% CP) in both experiments. In Exp. 1, no differences ($P>.10$) were observed among treatments for N retention (g/d). In Exp. 2, N retention was least ($P<.05$) for the straw diet, greatest for the ALF and shrub diets ($P>.05$), and intermediate for the forb diet. Inclusion of forbs or shrubs with low-quality forage diets was, in most instances, comparable to inclusion of ALF. Our results indicate that maintaining palatable forbs and shrubs on rangelands should reduce the need to supply cattle with protein during periods when grasses are dormant.

Key Words: rangelands, ruminants, grazing, forage, nutrition

Reviews by Van Dyne et al. (1980) and Holechek et al. (1989) show that cattle grazing native rangeland in the USA and other parts of the world vary their diets seasonally. A heterogenous forage base allows cattle to maintain a high-quality diet during grass dormancy by shifting dietary botanical composition from grasses to more nutritious forbs or shrubs (e.g., Holechek et al. 1982, Judkins et al. 1985). Krysl et al. (1987), summarizing data from 20 studies in New Mexico, found that cattle shifted forb consumption from 25% to 53% of their diet as grasses approached dormancy. Similar shifts have been reported for shrub consumption by cattle during periods of grass dormancy (Connor et al. 1963, Holechek et al. 1982).

Actively growing forbs typically have greater CP, P, and cell solubles than grasses or shrubs at similar growth stages (Holechek et al. 1989). During dormancy, forbs generally have greater concentrations of these nutrients than grasses, but less than shrubs. Shrub leaves and buds contain more CP, cell solubles, vitamin A, and P than grasses or forbs when forage is dormant (Holechek et al. 1989).

Data related to actual cattle nutritional response to forbs and shrubs under controlled conditions are not available. Anti-quality factors (soluble phenolic and condensed tannin compounds) in some forbs and shrubs may interfere with N utilization (Holechek et al. 1989); however, studies in New Mexico showed that palatable shrubs like fourwing saltbush (*Atriplex canescens* [Pursh.]), common winterfat (*Ceratoides lanata* Raf.), and mountain mahogany (*Cercocarpus montanus* Raf.) fed in a grass basal diet resulted in nitrogen retention and intake by goats comparable to alfalfa (*Medicago sativa* L.): grass mixtures with the same CP content (Nunez-Hernandez et al. 1989).

The present study examined the effect of including native forbs, shrubs, or alfalfa hay on N retention in beef steers consuming barley straw (*Hordeum vulgare* L.) or blue grama hay.

Materials and Methods

Two independent, 4 × 4 Latin square experiments were conducted in conventional digestion stalls using Hereford × Angus steers (avg BW 213 kg). Blue grama hay (BG; 1.21% N) served as the basal diet in Exp. 1, and alfalfa (ALF) hay, forbs, or shrubs were added to the basal diet in quantities sufficient to increase the N content of mixed diets to 1.68%. In Exp. 2, barley straw (.56% N) was used as the basal diet, with ALF, forbs, or shrubs added to increase total N content of the diets to 1.68%. Ingredient and chemical composition of diets used in both experiments are shown in Table 1.

Forbs and shrubs used in this study were typical of those selected by cattle grazing native rangeland, and were hand-harvested from different rangelands near Las Cruces, N.Mex., in summer, 1986. After harvesting, forbs, and shrubs (current year's growth of leaves) were air-dried and ground to pass a 2.5-cm screen. Forbs were a 50:50 mixture (as-fed-basis) of scarlet globemallow *(Sphaeralcea coccina)* and leatherleaf croton *(Croton corymbulosus)*, whereas shrubs were a 50:50 mixture of fourwing saltbush *(Atriplex canescens)* and mountain mahogany *(Cercocarpus montanus)*. Barley straw and BG hay also were ground to pass a 2.5-cm screen and mixed daily with either forbs, shrubs, or ALF.

In both experiments, steers were fed ad libitum, and feed offered, and orts were recorded and subsampled. Water was available free choice, but no salt was provided. Each period of the Latin squares was 15 days. Total collections of feces and urine were obtained during the last 5 days of each period. Feces from each steer were mixed thoroughly daily, and a 10% subsample was dried (50° C for 48 hours) in a forced-air oven, ground to pass a 2-mm screen and composited by steer within period. Total urine output was collected in vessels containing 10 ml of 6 N HCL. A 100-ml subsample was obtained daily, stored at –20° C and later pooled by steer within period.

Feed, orts, and fecal samples were analyzed for DM and ash (AOAC 1984) and for N content by the Kjeldahl method (AOAC 1984). Neutral detergent fiber and ADF contents were measured using nonsequential procedures outlined by Goering and Van Soest (1975).

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Table 1. Ingredient and chemical composition of blue grama (BG), barley staw, and alfalfa (ALF), forb, and shrub mixtures fed to beef steers.

Item	Exp. 1 Blue grama dies[a]			
	BG	BG + ALF[c]	BG + forbs[c]	BG + shrubs[c]
Ingredient, %[b]				
Blue grama hay	100	77	58	59
Alfalfa hay		23		
Forbs			42	
Shrubs				41
Analysis, %				
CP[d]	7.6	10.5	10.5	10.5
NDF[d]	72.9	66.2	62.1	64.9
ADF[d]	47.3	43.8	41.2	41.2
Acid detergent insoluble N[d]	0.24	0.23	0.27	0.26
GE, Mcal/kg	4.15	4.21	4.27	4.27
	Exp. 2 Barley straw diets[a]			
	Straw	Straw + ALF[c]	Straw + forbs[c]	Straw G + shrubs[c]
Ingredient, %[b]				
Barley straw	100	58	37	38
Alfalfa hay		42		
Forbs			63	
Shrubs				62
Analysis, %				
CP[d]	3.5	10.5	10.5	10.5
NDF[d]	72.9	60.7	56.7	60.7
ADF[d]	46.4	40.4	37.8	37.8
Acid detergent insoluble N	0.18	0.20	0.26	0.26
GE, Mcal/kg	4.12	4.23	4.31	4.32

[a]Forbs = 50:50 mixture (as-fed basis) of scarlet globemallow and leatherleaf croton, shrubs = 50:50 mixture (as-fed basis) of fourwing saltbush and mountain mahogany.
[b]As-fed basis.
[c]Calculated from components of the mixture.
[d]DM basis.

Statistical Analysis

Analysis of variance was conducted using GLM procedures of SAS (1984). Intake, digestibility, energy, and N data were analyzed by analysis of variance with a model that included treatment (diets), periods, and animal as sources of variation. Preplanned orthogonal contrasts were made between diets containing forbs and shrubs. If forbs and shrubs differed ($P<0.10$), means were separated by least significant difference. If forbs and shrubs were not different ($P>0.10$), they were contrasted with ALF. If no differences ($P>0.10$) were observed, diets containing forbs, shrubs, and ALF were contrasted with the basal diet (BG alone in Exp. 1 or barley straw alone Exp. 2). If ALF was different ($P<0.10$) from forb and shrubs, the ALF diet was contrasted with the basal diet.

Results and Discussion

Nitrogen Retention

Nitrogen retention (g/day) by steers revealed differences ($P<0.05$) between feeds in Exp. 2, but not Exp. 1 (Table 2). Nitrogen retention values were all positive, with the exception of the straw diet in Exp. 2. The straw diet had a lower ($P<0.05$) N retention value than the other 3 diets in Exp. 2.

Nitrogen retention in our study was primarily a function of N intake. The coefficient of determination of between mean N retention and N intake values when Exps. 1 and 2 were combined was 0.94 (N = 8). Other recent studies also have shown a strong association between N retention and N intake when ruminants were fed forage diets containing varying levels of forbs and shrubs (Nunez-Hernandez et al. 1989, Boutouba et al. 1990).

The low N retention of the straw diet was the result of both a low N concentration in the feed and low forage intake. Milford and Minson (1965) found that forage intake dropped precipitately when sheep were fed forages with CP levels below 7% (DM basis). Below 7% CP in the diet, forage intake declines because microbial needs of the host ruminant for N are not satisfied. The straw diet in Exp. 2 had a crude protein level of 3.5% compared with 7.6% for BG and 10.5% for the other diets in which ALF, forbs, or shrubs had been added to straw or BG. These results are consistent with studies by Cook and Harris (1968), Rittenhouse et al. (1970), and Kartchner (1981) that show increases in forage intake from supplemental protein when diet CP levels are less than 7.0%.

Fecal N losses as a percentage of N intake varied from 40 to 48%, with the exception of straw diet, which had a value of 92%. Urinary N losses as a percentage of N intake varied from 21 to 27%, with the exception of the straw diet, which had a value of 45%. Elevated losses of fecal and urinary N from the straw diet are probably explained by greater endogenous N losses. Some shrubs (those with high levels of soluble phenolic/tannin compounds) tend to cause elevated fecal N losses and reduced urinary N values when fed to ruminants in mixtures with grasses or legumes (Nastis and Malechek 1981, Barry et al. 1986, Nunez-Hernandez et al. 1989). Our study is consistent with that of Nunez-Hernandez et al. (1989) using goats and Rafique et al. (1988) using sheep that showed fourwing saltbush and mountain mahogany in grass mixtures resulted in fecal and urinary N losses similar to those for alfalfa in grass mixtures with similar CP concentrations. Our study further confirms that mountain mahogany and fourwing saltbush have no adverse impacts on N utilization when fed at moderate levels to ruminants.

We attribute the reduced N retention of the forb diet compared with the shrub diet in Exp. 2 to the low acceptance as indicated by low intake of this diet (Table 2). Although forbs involved in our study often make sizeable contributions to diets of grazing cattle in the western USA (Holechek et al. 1989), their acceptability in a dried, ground form, as used in this study, was reduced, confirming

Table 2. Intake, digestibility and nitrogen retention by steers fed blue grama and straw hays with or without alfalfa, forbs, or shrubs.

Item	Exp. 1 Diets					Exp. 2 Diets				
	BG	BG + ALF	BG + forbs	BG + shrubs	SEM[g]	Straw	Straw + ALF	Straw + forbs	Straw +shrubs	SEM[h]
DM intake, kg • 100 kg BW^{-1}• d^{-1}	1.85^{b}	2.03^{c}	1.76^{b}	2.09^{c}	.04	1.16^{b}	1.71^{c}	1.38^{b}	1.98^{c}	.1
Digestible DM intake kg • 100 kg BW^{-1}• d^{-1}	0.96	0.99	0.89	1.04	—	0.70	1.03	0.81	1.09	—
Apparent digestibility, %										
DM	51.8	48.9	50.8	49.6	1.6	60.5^{b}	60.0^{b}	58.5^{b}	53.5^{c}	1.2
OM	58.8	55.8	57.6	55.2	1.5	63.8^{b}	63.5^{b}	63.3^{b}	56.8^{c}	1.3
CP	51.5^{c}	57.3^{b}	51.7^{c}	55.5^{b}	.9	8.9^{c}	59.7^{b}	51.9^{b}	54.6^{b}	1.7
NDF	54.4^{c}	47.8^{ef}	46.3^{f}	45.8^{f}	2.8	62.5^{b}	56.3^{c}	45.8^{d}	45.6^{d}	1.3
ADF	44.4^{e}	42.7^{e}	33.1^{f}	33.3^{f}	2.1	57.3^{b}	50.8^{b}	38.0^{c}	29.0^{c}	2.7
Nitrogen, g/d										
Intake	52.1^{c}	76.8^{b}	67.4^{b}	76.8^{b}	3.1	14.0^{e}	61.2^{c}	53.6^{c}	71.6^{b}	2.2
Fecal	23.6^{b}	32.8^{c}	32.2^{c}	32.8^{c}	1.3	12.7^{d}	24.5^{c}	25.4^{c}	32.1^{b}	1.3
Urinary	11.7^{d}	19.8^{bc}	15.0^{cd}	21.2^{b}	2.1	6.0^{b}	16.0^{c}	12.4^{c}	15.2^{c}	1.1
Retained	16.9	24.2	20.2	21.5	2.9	-4.5^{d}	20.7^{bc}	15.8^{c}	25.2^{b}	2.3

[a]BG = blue grama, ALF = alfalfa, forbs = 50:50 mixture (as-fed basis) of scarlet globemallow and leatherleaf croton, shrubs = 50:50 mixture (as-fed basis) of fourwing saltbush and mountain mahogany.
[b,c,d,e]Means in the same row and Exp. with different letters in their superscripts differ ($P<0.05$).
[e,f]Means in the same row and Exp. with different letters in their superscripts differ ($P<0.10$).
[g]n = 4.

the findings of Rafique et al. (1988).

Intake and Digestibility

Shrub or alfalfa inclusion improved ($P<0.05$) DM intake over pure grass diets in both experiments (Table 2). The greater CP content or the shrub of alfalfa diets presumably improved ruminal fermentation conditions and caused more rapid forage turnover. The lower fiber content (Table 1) of the alfalfa and shrub diets also explains why their intake was greater than observed with pure grass diets. Fiber is more slowly digested than cell solubles and shows a strong negative correlation with forage intake (Van Soest 1982). Our results support the conclusion of Holechek et al. (1989) that dry matter intakes by cattle average about 2% body weight for medium quality forages, but fall below 1.5% body weight for forages low in CP concentration (below 6%).

Generally, in vivo digestibility values showed little difference among diets (Table 2). Forage intake in our study showed a negative association with in vivo DM digestibility ($r = -0.83$, $n = 8$) and in vivo OM digestibility ($r = -0.88$, $n = 8$). Based on our data, in vivo digestibility has little value as an indicator of diet quality when ruminants consume forage diets with varying levels of grasses, forbs, and shrubs. We believe the higher digestibility coefficients of the low-quality diets, such as straw only, are probably a result of a long ruminal retention time that would allow more complete fiber digestion. Digestibility of NDF and ADF generally were greater ($P<0.05$) for the blue grama and straw diets than diets with forbs or shrubs.

Management Implications

It has long been speculated that forbs and leaves from shrubs can be effective N supplements for cattle consuming mature grass diets. However, no in vivo digestion trials to test this hypothesis have been available. Higher levels of soluble phenolics, condensed tannins, and lignin associated with some forbs and shrubs may reduce N availability, making N less valuable than indicated by CP concentration. It also has been speculated that shrubs are inferior to grasses as energy sources because their cell walls have a high cellulose: lignin ratio. Our study with steers indicates that N retention of palatable forbs and shrubs fed at levels up to 62% of the diet will improve both N retention over low-quality mature grass diets. Forbs and shrubs fed in mixtures with low-quality grasses had an effect on N retention similar to inclusion of alfalfa hay with these grasses. Our findings with cattle are consistent with similar studies involving goats and sheep that show fourwing saltbush and mountain mahogany are excellent N sources for range livestock and big game animals.

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