Corn Supplementation of Lambs Grazing Alfalfa


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ABSTRACT: We investigated the effects of supplementing Rambouillet × Suffolk wether lambs grazing irrigated 'Cimarron' alfalfa (Medicago sativa L.) with three levels (0 [C₀], 123 [C₁₂₃], and 247 [C₂₄₇] g of DM·lamb⁻¹·d⁻¹) of cracked corn. Each treatment group also received 190 g of a supplement designed to prevent bloat. Replicated pastures (three per treatment) grown on a fine, mixed, thermic Torretic Paleustoll soil were grazed rotationally (forage plus supplement allowance of 6.5% of BW/d) by lambs for 85 d during spring 1992. Supplemental corn levels were analyzed as single degree of freedom contrasts for linear and quadratic effects. At the start of the experiment, lambs weighed 30.7 ± 3.2 kg. Average daily gains for C₀, C₁₂₃, and C₂₄₇ were 141, 154, and 169 g/d, respectively. Lamb production per hectare increased quadratically (P < .01) with increasing corn level (C₀ [716 kg of lamb/ha], C₁₂₃ [816 kg of lamb/ha], and C₂₄₇ [964 kg of lamb/ha]). Supplementation with C₂₄₇ vs C₀ increased carcass weights (11%), dressing percentage (6%), and backfat thickness (30%). Plasma urea N (PUN) concentrations did not differ (P > .10) between C₀ and C₁₂₃ after 27 d of corn supplementation, but after 75 d PUN concentrations between C₀ and C₁₂₃ had decreased (P < .10) by 11%. For C₂₄₇, PUN concentrations after 27 and 75 d of corn supplementation had decreased (P < .10) by 17 and 18%, respectively, compared with C₀. Plasma urea N concentrations increased (P < .01) linearly (r² = .93) with an increase in digestible CP:DE ratio (DP:DE). Lambs with the greatest growth response had the lowest PUN and DP:DE levels. Feeding limited amounts of corn to lambs grazing alfalfa increased lamb production per hectare and per lamb, seemingly through more efficient use of the alfalfa protein.

Key Words: Lambs, Alfalfa, Maize, Supplements, Growth Rate

Introduction

In the United States, alfalfa is grown on more than 10.25 million hectares and constitutes more than 41% of all hay sold (USDA, 1992). Alfalfa also is known as the “Queen of Forages” because its high nutritive value for livestock (Barnes and Sheaffer, 1985). Energy most often limits the nutritive value of alfalfa pastures (Crampton, 1957; Van Keuren and Matches, 1988). High concentrations of plant N (> 30 g of N/kg of DM) associated with alfalfa result in production of excess ruminal ammonia N, which is absorbed into the bloodstream and excreted as urinary urea N (Dellow et al., 1988; Hammond, 1992). This urinary urea N represents a loss in the protein potentially available for amino acid synthesis and animal growth.

Dellow et al. (1988) showed that ruminal infusions of fermentable carbohydrate increased the efficiency of alfalfa protein utilization by sheep. Kennedy and Milligan (1980) suggested that grain could be used to increase urea utilization and protein synthesis. Little information is available on the effects of corn supplementation of lambs grazing alfalfa in the Southern Great Plains. Our objective was to determine the effects of three levels of corn supplementation on the BW gain, plasma urea nitrogen (PUN) status, and herbage utilization by lambs grazing alfalfa.

Materials and Methods

Experimental Site and Precipitation

Our experiment was conducted in 1992 at the Texas Tech University North Lubbock County Teaching and Research Laboratory near New Deal, TX (33°45' N, 101°47' W, 993 m elevation). From January 1 to the
end of the grazing trial, 260 mm of rainfall was recorded. At the first visible signs of wilting in alfalfa, pastures were irrigated using an overhead, low-pressure traveling sprinkler. Over the grazing period, 285 mm of water was applied to the pastures.

Treatments and Experimental Design

'Cimmaron' alfalfa was seeded (22 kg of pure live seed/ha) into a Pullman clay loam soil (Blackstock, 1979) on September 21, 1989, and fertilized according to soil test specifications (ammonium phosphate (56 kg of P/ha)). In 1992, lambs assigned to graze the alfalfa were group-fed three levels of cracked corn (0 [C0], 123 [C123], or 247 [C247] g of DM·lamb·d⁻¹). Each treatment was assigned randomly to three alfalfa pasture replicates (16.0 m x 49.5 m [792 m²]) in a randomized complete block design. Pasture replicates were subdivided into five paddocks (16.0 m x 9.9 m) to facilitate rotational grazing.

Sward Measurements

Sward measurements were taken the day before lambs were placed in a paddock (pregrazing) and the day lambs were removed from a paddock (postgrazing).

Herbage Dry Matter Accumulation and Residue. Pregrazing herbage accumulation and postgrazing residue were estimated using the mean herbage mass (HM) per quadrat. Herbage mass per paddock was obtained by clipping herbage to ground level with hand shears from within five randomly placed quadrats (0.32 cm x 0.32 cm [0.1 m²]). For each treatment replicate, samples from individual quadrats were weighed and combined and two subsamples (0.3 kg) were taken. One of the subsamples was weighed and dried in a forced-air oven at 55°C for 7 d and used for nutritive value determinations; the other subsample was dried at 110°C for 24 h to determine DM.

Herbage Nutritive Value. Before analyses, subsamples for nutritive value determinations were ground in a shearer mill (2mm), reground in a cyclone mill (1 mm), and stored (4°C) in sealed plastic packets. Herbage samples (2 g) were scanned with monochromatic light (1,100 to 2,500 nm) using a Pacific Scientific (NIR Systems, Silver Springs, MD) Model 6250 Near Infrared Scanning Monochromator (NIRS). Based on the spectral properties of the pre- and postgrazing herbage samples, the "Select" program (InfraSoft International [Port Matilda, PA] software [Release 2.0]) selected samples representative of the population for calibration and chemical analyses.

Herbage samples selected for calibration (n = 80) were assayed in duplicate for OM disappearance (OMD) and CP. Organic matter disappearance was determined by a modified two-stage pepsin-cellulase procedure (Clarke et al., 1982). Modification involved substitution of Onozuka 3S cellulase at a cellulase:sample ratio of 1.25 (McLeod and Minson, 1980). Crude protein was determined as Kjeldahl N x 6.25 (AOAC, 1984). Sample spectra and corresponding wet chemistry values were used to calibrate the NIRS as described by Windham et al. (1989). InfraSoft International software was used to develop the calibration equations by modified partial least squares regression. The R² and SE of calibration were .98 and 8.8 g/kg and .98 and 14.9 g/kg for CP and OMD, respectively.

Animal Management

During early April 1992, 110 weaned Rambouillet x Suffolk wether lambs were purchased from a single flock near San Angelo, TX. Lambs were injected i.m. with 2 mL of Tylan 200 (Tylosin, Elanco, Indianapolis, IN) on three successive days after arrival to decrease the symptoms associated with shipping fever. One week later lambs were dewormed using Ivermectin (22,23-Dihydroavermectin B1; 1 mL; MSD-Agvet, Rahway, NJ) and inoculated against enterotoxemia (Clostridium perfringens Types C and D; 2 mL/lamb). A booster inoculation for enterotoxemia was administered to the lambs 21 d after the first inoculation. Lambs grazed separate separate reserve Jose tall wheatgrass (Thinopyron ponticum [Podp.] Barkw. and D. R. Dewey) and sainfoin (Onobrychis vicifolica Scop.) pastures for 2 wk before the experiment began. Lambs were maintained in excellent health and were treated humanely at all times.

A put-and-take system was used to evaluate the treatments (Mott and Lucas, 1952). Herbage mass from pregrazing harvests was used to adjust the number of lambs per pasture (between four and nine lambs/week). Lambs were weighed at the start of the experiment and every 14 d thereafter, weather permitting, following a 14- to 16-h shrink without feed or water. Lambs whose BW were closest to the group mean at the initial weighing were selected as testers. Four testers (mean BW 30.7 ± 32 kg) were assigned randomly to each pasture replicate for the duration of the grazing season. Two days after the final weighing, the tester lambs were humanely slaughtered at a commercial slaughterhouse. Twenty-four hours after the lambs were slaughtered, backfat thickness, carcass weight, and yield grade were determined for each chilled carcass.

To decrease the incidence of bloat, all lambs were fed 190 g of a salt-free supplement (48% rolled corn, 22% whole oats, 21% ground alfalfa, 7% molasses, and 2% Bloat Guard [SmithKline Beecham, Exton, PA]) per lamb daily (Bloat Guard intake = 2 g of poloxalene [bis(Hydroxyethyl)poly(ethyleneoxyethyl)polypropylene glycol]·lamb⁻¹·d⁻¹). Organic matter disappearance and CP analyses of the Bloat Guard and corn supplements were determined using the west chemistry procedures described for the herbage samples. The Bloat Guard supplement contributed 19.6 g of digestible CP and 55.7 Mcal of DE·lamb⁻¹·d⁻¹.
Table 1. Responses of lambs to three levels of corn supplementation while they grazed alfalfa

<table>
<thead>
<tr>
<th>Added corn, g·lamb⁻¹·d⁻¹</th>
<th>0</th>
<th>123</th>
<th>247</th>
<th>SEM⁺</th>
<th>Contrast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average daily gain, g/d</td>
<td>141.1</td>
<td>154.4</td>
<td>168.9</td>
<td>7.8</td>
<td>Lⁿ⁽ⁿ⁾,Qᵗ⁻</td>
</tr>
<tr>
<td>Cumulative BW gain, kg/lamb</td>
<td>11.9</td>
<td>13.1</td>
<td>14.4</td>
<td>.7</td>
<td>Lⁿ⁽ⁿ⁾,Qᵗ⁻</td>
</tr>
<tr>
<td>Production, kg of lamb/ha</td>
<td>716.5</td>
<td>816.3</td>
<td>964.0</td>
<td>35.6</td>
<td>Lⁿ⁽ⁿ⁾,Q⁺⁺⁺</td>
</tr>
<tr>
<td>Stocking rate, 35-kg lamb unit/ha</td>
<td>61.2</td>
<td>62.6</td>
<td>69.5</td>
<td>1.7</td>
<td>Lⁿ⁽ⁿ⁾,Q⁺⁺⁺</td>
</tr>
</tbody>
</table>

⁻Standard error of treatment means; n = 3.
⁺The number of 35-kg lamb units/ha = total weight of lambs carried per hectare/35 kg.
⁽ᵗ⁾,⁽⁺⁾,⁽⁺⁺⁺⁾Linear (L) or quadratic (Q) effect significant at P < .10, P < .05, and P < .01, respectively.
⁽ⁿ⁾Linear (L) or quadratic (Q) effect not significant (P > .10).

At the start of the trial (d 0) and after 27 and 75 d of grazing, blood samples were collected from lambs (four testers per replication) by jugular venipuncture and placed into 10-mL vacutainers that contained 1 mL of EDTA. After each collection, blood samples were centrifuged (3,000 x g) for 15 min (4°C) and the plasma was removed and frozen (-20°C) until analysis. Plasma urea N was determined using sodium phenate and hypochlorite (Chaney and Marbach, 1962; Searle, 1984).

Grazing Management

Within each of the three replications per treatment, pastures were grazed rotationally in a five-paddock system. For the first growth, the period of grazing was varied (2 to 7 d) to prevent the pastures from becoming too mature. After the initial grazing, treatments were grazed for 7 d, with a regrowth interval of 28 d. Treatments were allotted for grazing at a feed (alfalfa plus added corn) DM allowance of 6.5% of BW/d. Based on pregrazing HM and added corn level, the number of put-and-take lambs was adjusted to maintain the target feed allowance. Grazing began on April 17 and ended July 10, 1992 (85 d).

Animal Measurements

The following lamb responses were recorded:

1. lamb days/hectare = number of lambs/hectare × calendar days of grazing;
2. rate of herbage disappearance (kilograms of DM·lamb⁻¹·d⁻¹) = (pregrazing HM – postgrazing HM)/number of lamb-unit days, where a lamb unit = a 35-kg lamb (Meijs et al., 1982);
3. cumulative weight gain = tester end BW – tester beginning BW;
4. seasonal average daily gain (ADG) = tester cumulative weight gain/tester grazing days;
5. lamb production/hectare = ADG × lamb days/hectare;
6. stocking rate/hectare = (number of lamb days per hectare)/number of grazing days; and
7. feed conversion (kilograms of DM consumed per kilogram of live weight gain = herbage plus supplement disappearance/ADG.

Statistical Analyses

A fixed model was assumed in which the pasture was the experimental unit and the components of the model were blocks and supplemental corn level. Animal data were analyzed as single degree of freedom contrasts for linear and quadratic effects of the supplemental corn levels. Differences among treatments in herbage mass and nutritive value were compared using Fisher’s LSD (α = .05). Linear regression was used to describe the data presented in the figures (Steel and Torrie, 1980).

Results and Discussion

Lamb Response

Lamb Weight Change. Average daily gain increased quadratically (P < .10) with increased corn, despite maintaining a constant feed allowance (Table 1). Average daily gain ranged from 141 g/d for C₀ to 169 g/d for C₂₄₇, a 20% increase for lambs on C₂₄₇. The ADG recorded for C₀ was within the upper ranges of ADG reported by Douglas (1986) and Van Keuren and Matches (1988) for lambs grazing alfalfa in New Zealand and the United States. Daily gain was lower by lambs on C₁₂₃ and C₂₄₇ than by lambs fed concentrate diets (240 to 280 g/d; McClure and Van Keuren, 1985).

Cumulative weight gain also increased quadratically (P < .10) with increasing levels of supplemental corn (Table 1). After 85 d of grazing, lambs on C₀ had
Figure 1. Trends in cumulative live weight gain per lamb for the 1992 grazing season (each data point = treatment mean [n = 12; four lambs × three replications]). Standard errors for cumulative weight gain for 0, 123, and 247 g of corn·lamb -1 ·d -1 were .5, .4, and .3 kg, respectively.

Table 2. Alfalfa pre- and postgrazing herbage mass, crude protein, and organic matter disappearance from the pasture treatments

<table>
<thead>
<tr>
<th>Added corn, g·lamb -1 ·d -1</th>
<th>0</th>
<th>123</th>
<th>247</th>
<th>SEM a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pregrazing herbage mass, kg of DM/ha</td>
<td>12,200</td>
<td>12,410</td>
<td>13,340</td>
<td>100</td>
</tr>
<tr>
<td>Postgrazing herbage mass, kg of DM/ha</td>
<td>5,480b</td>
<td>6,190c</td>
<td>6,860d</td>
<td>196</td>
</tr>
<tr>
<td>Pregrazing CP, g/kg</td>
<td>249.1</td>
<td>247.2</td>
<td>245.8</td>
<td>2.2</td>
</tr>
<tr>
<td>Postgrazing CP, g/kg</td>
<td>143.0</td>
<td>153.8</td>
<td>162.0</td>
<td>4.8</td>
</tr>
<tr>
<td>Pregrazing OM disappearance, g/kg</td>
<td>679.6</td>
<td>673.6</td>
<td>665.6</td>
<td>4.6</td>
</tr>
<tr>
<td>Postgrazing OM disappearance, g/kg</td>
<td>463.9</td>
<td>482.5</td>
<td>498.5</td>
<td>9.1</td>
</tr>
</tbody>
</table>

aStandard error of treatment means, n = 3.

b,c,dMeans in a row that do not have common superscripts differ (P < .10).
fed C247 were 11% greater than those of lambs fed C0. Supplemental corn increased the dressing percentage from 51% on C0 to 54% on C247. Backfat thickness from lambs on C247 was 30% greater than that from lambs fed C0, indicating that excess energy was stored as fat. Corn supplementation tended to increase backfat thickness (backfat thickness = 4.80 + .007 × [corn level]; \( r^2 = .94 \)) and yield grade (yield grade = 1.58 + .001 × [corn level]; \( r^2 = .97 \)).

**Plasma Urea Nitrogen.** At the start of the trial (d 0), the lamb PUN concentrations among the treatments did not differ (\( P > .10 \); mean PUN = 21.9 mg/dL). Across the sampling days, PUN concentrations ranged between 19.1 and 33.5 mg/dL. Preston et al. (1965) reported that PUN concentrations in lambs of 10 mg/dL indicated adequate CP intake, and that PUN values above 10 mg/dL were probably associated with protein wastage. As lambs fattened, PUN concentrations increased (44.4% from 27 to 75 d; Table 4). A similar trend in PUN concentrations with maturing lambs was reported by Pfander et al. (1975).

The PUN concentrations in lambs decreased linearly at 27 d (\( P < .05 \)) and at 75 d (\( P < .01 \)) in response to increasing levels of supplemental corn (Table 4). For lambs on C0, PUN concentrations after 27 d of grazing did not differ from those of lambs on C123, but PUN concentrations were 17% lower for lambs on C247 than for lambs on C0. At 75 d of grazing, PUN concentrations in lambs on C0 were 11 and 18% greater than those in lambs on C123 and C247, respectively (linear decrease, \( P < .01 \)). Hence, lower concentrations of PUN were associated with greater ADG and cumulative weight gain by C123 and C247 lambs compared with C0 lambs (Tables 1 and 4). For example, at d 75 there was a linear increase in cumulative weight gain with decreasing PUN concentrations (cumulative weight gain = 23.8 - .41 × [PUN], \( r^2 = .73, n = 36 \)).

**Digestible Protein:Digestible Energy Ratio.** The digestible CP and energy estimates of total feed disappearance (alfalfa + supplement + corn) were determined using NRC (1985) equations (Digestible CP = \( .9 \times [CP] - 3 \); DE = \( (3.62 \times [OMD]/.82) \)). A limitation of this method is that alfalfa disappearance was determined as the difference between pre- and postgrazing herbage mass, which does not account for plant growth between the two harvest dates. Across treatments, the digestible protein (DP):DE ratio of feed disappearance ranged between 57 and 76 g of DP/Mcal of DE (Figure 2). These DP:DE ratios were greater than the suggested optimum ratio (20 to 25 g of DP/Mcal of DE) for growing-finishing sheep (Preston et al., 1965; Hogan, 1981). Lambs from the C247 treatment had the greatest ADG and had feed disappearances with the lowest DP:DE ratios. Plasma urea N concentrations in lambs increased \( (r^2 = .93, P < .01) \) linearly with an increase in the DP:DE ratio (Figure 2). These data suggest that the DP:

### Table 3. Carcass data from lambs fed three levels of corn supplementation while they grazed alfalfa

<table>
<thead>
<tr>
<th>Response variable</th>
<th>Added corn, g/lamb(^{-1})-d(^{-1})</th>
<th>SEM(^a)</th>
<th>Contrast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carcass weight, kg</td>
<td>22.3 23.5 24.8</td>
<td>.7</td>
<td>( L^{ns} Q^T )</td>
</tr>
<tr>
<td>Dressing percentage</td>
<td>51.4 52.5 53.8</td>
<td>.3</td>
<td>( L^T Q^{**} )</td>
</tr>
<tr>
<td>Backfat thickness, mm</td>
<td>4.7 5.7 6.1</td>
<td>.2</td>
<td>( L^{ns} Q^{ns} )</td>
</tr>
<tr>
<td>Yield grade</td>
<td>1.6 1.7 1.9</td>
<td>.2</td>
<td>( L^{ns} Q^{ns} )</td>
</tr>
</tbody>
</table>

\( ^a \)Standard error of treatment means, \( n = 3 \).

\( ^T \), \( ^* \), \( ^{**} \)Linear (L) or quadratic (Q) effect significant at \( P < .10 \), \( P < .05 \), and \( P < .01 \), respectively.

\( ^{ns} \)Linear (L) or quadratic (Q) effect not significant (\( P > .10 \)).

### Table 4. Plasma urea nitrogen (PUN) concentrations of lambs after 27 and 75 days of corn supplementation while they grazed alfalfa

<table>
<thead>
<tr>
<th>Day</th>
<th>Added corn, g/lamb(^{-1})-d(^{-1})</th>
<th>PUN, mg/dL</th>
<th>SEM(^a)</th>
<th>Contrast</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>22.4 21.8 21.6</td>
<td>.8</td>
<td>( L^{ns} Q^{ns} )</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>22.4 22.2 19.1</td>
<td>.6</td>
<td>( L^{ns} Q^{ns} )</td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>33.5 30.2 28.3</td>
<td>.7</td>
<td>( L^{ns} Q^{ns} )</td>
<td></td>
</tr>
</tbody>
</table>

\( ^a \)Standard error of treatment means, \( n = 3 \).

\( ^T \), \( ^* \), \( ^{**} \)Linear (L) or quadratic (Q) effect significant at \( P < .10 \), \( P < .05 \), and \( P < .01 \), respectively.

\( ^{ns} \)Linear (L) or quadratic (Q) effect not significant (\( P > .10 \)).
DE ratio of the feed consumed can be estimated from PUN concentrations in lambs grazing alfalfa and perhaps could be used to determine appropriate levels of energy supplementation. Lamb ADG decreased ($r^2 = 57, P < 0.01$) linearly with an increase in the DP:DE ratio of the feed consumed (Figure 3). Adding corn to a high-protein diet such as alfalfa increases ADG because excess ammonia N is captured as microbial protein that is digested in the lower gut, providing amino acids for lamb growth (Kennedy and Milligan, 1980; Dellow et al., 1988).

**Implications**

In alfalfa, low levels of available energy relative to the high levels of protein tend to limit its potential for lamb weight gains. Supplementing lambs grazing alfalfa with limited amounts of corn increased lamb growth rates, production per hectare, and carcass dressing percentage, seemingly through a more efficient use of pasture protein.

**Literature Cited**


