Technical Note: Utilization of Sainfoin by Grazing Steers and a Method for Predicting Daily Gain from Small-Plot Grazing Data

D. P. Mowrey*, A. G. Matches*, and R. L. Preston†

Departments of *Agronomy, Horticulture, and Entomology and †Animal Science, Texas Tech. University, Lubbock 79409

ABSTRACT: Sainfoin (Onobrychis viciaefolia Scop.) is adapted to the calcareous soils of the southern Great Plains and can provide early season forage that does not induce bloating; however, little is known about performance by ruminants grazing sainfoin. Our objective was to determine the effect of plant growth stage and grazing pressures on potential animal production from sainfoin as predicted from energy intake as a multiple of maintenance. Nitrogen-fertilized (100 kg of N/ha) Renumex sainfoin was grown under irrigation on a Pullman clay loam (fine, mixed, thermic Torrettic Paleustoll) near Lubbock, TX. Light (L), medium (M), and heavy (H) grazing pressures were applied with steers grazing sainfoin that was at the bud (B), flower (F), and seed shatter (S) stages of growth. The L, M, and H pressures were grazed to remove 50, 75, and 90% of the standing plant height. Across growth stages, L, M, and H grazing pressures averaged 52, 69, and 87% removal of pregrazed herbage mass. Dry matter intake as a percentage of BW of steers averaged 3.9, 2.8, and 1.7 for L, M, and H grazing pressures. Across growth stages, predicted live weight gain for L, M, and H grazing pressures averaged .86, .67, and .03 kg/d. Our findings indicate that the multiple of maintenance method may be useful for evaluating treatments from small-plot grazing experiments.

Key Words: Sainfoin, Grazing, Steers

Introduction

Most warm-season grasses of the southern Great Plains are grazed during summer months, and winter wheat (Triticum aestivum L.) or deferred summer pasture is grazed during winter months. Forage production shortfalls occur in the spring and autumn. Sainfoin, a legume that does not induce bloating, produces forage mainly during the early spring and autumn (Melton, 1973). Therefore, sainfoin may be useful for filling gaps in forage production that occur during spring and fall. However, information concerning grazing management and livestock response from sainfoin is limited. The objective of our study was to determine the effect of plant growth stage and grazing pressure on potential animal production from sainfoin as predicted from energy intake as a multiple of maintenance.

Materials and Methods

On June 11, 1984, inoculated, unhulled Renumex sainfoin was planted 20 mm deep at a rate of 40 kg/ha of pure live seed in rows 180 mm apart. The soil was a Pullman clay loam (fine, mixed, thermic Torrettic Paleustoll) located in north Lubbock County, TX. Sainfoin in the plot area was cut and baled twice yearly in 1985 and 1986. Grazing treatments on this 2-yr-old stand were initiated in the spring of 1987 and repeated in 1988. In spring 1987, plants grew slowly and showed signs of severe N deficiency; this had not been observed during the previous 2 yr. Poor N fixation ability as a result of poor nodulation or ineffective rhizobia has been reported in sainfoin (Burton and Curley, 1968; Sims et al., 1968; Walsh et al., 1983). Therefore, 100 kg of N/ha was applied on April 9,
1987, and on March 7, 1988. After N fertilization the plants became very green and healthy in appearance and exhibited a high growth rate. The fields planted with sainfoin were irrigated by an overhead, low-pressure traveling sprinkler as needed to maintain active growth during spring and early summer. In previous research (A. G. Matches and D. P. Mowrey, unpublished data) we observed little summer growth of sainfoin under irrigation, presumably because of high temperatures typical of the southern Great Plains. Therefore, very limited irrigation was applied during July and August. If moisture was limiting, irrigation was resumed in September. In 1987 and 1988, 360 and 190 mm of rain were received and 310 and 480 mm of irrigation water were applied, respectively.

Light (L), medium (M), and heavy (H) grazing pressures were applied with yearling steers (Bos taurus L.) at the bud (B), flower (F), and seed shatter (S) stages of growth. The steers were Hereford × Angus crossbreds that averaged 318 kg. The L, M, and H grazing pressures were grazed to remove 50, 75, and 90% of the standing plant height. Plant standing height was determined by measuring with a meter rule before grazing and just before removing steers from the plot. Three steers grazed freely within the plot (15 July and August. If moisture was limiting, irrigation, presumably because of high temperatures typical of the southern Great Plains. Therefore, very limited irrigation was applied during July and August. If moisture was limiting, irrigation was resumed in September. In 1987 and 1988, 360 and 190 mm of rain were received and 310 and 480 mm of irrigation water were applied, respectively.

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The B stage was attained when 30 of 100 randomly selected tillers per plot had at least one bud. The F stage occurred when 80 of 100 randomly selected tillers per plot had at least one flower. The S stage was defined as the time that 80 of 100 seed-producing tillers per plot had shattered at least half their seed. Stage B was defoliated four and three times, in 1987 and 1988, and stages F and S were defoliated three and two times each year, respectively.

Potential ADG was calculated by harvest periods using energy intake as a multiple of maintenance as described by Preston (1988). Performance of cattle can be predicted using regression equations that require only the net energy value of a feed for maintenance (NEm) and intake as a multiple of the amount of feed required for maintenance. The overall coefficient of determination of this relationship was high (R² = .96) using NRC (1984) requirements (Preston, 1988), indicating that most of the variation in ADG of several classes of beef cattle is related to feed intake expressed as a multiple of maintenance. The equation for steer ADG (ADG kg = .844XM - 1), where XM = intake as a multiple of the amount of feed required for maintenance, R² = .98) can be used to estimate ADG from just three measurements: DMI, in vitro digestible OM, and BW. The NEm/kg of a feed can be determined using NRC (1984) equations (NEm = 1.37 [ME/kg] - .139 [ME/kg]² + .0105 [ME/kg] - 1.12; ME/kg = ME/kg of feed = 3.62 × percentage of in vitro OM digestibility). To derive the metabolizable energy/kilogram of feed component of the equation, it was assumed that 1 kg of TDN = 4.4 Mcal of DE = 3.62 Mcal of ME. The NEm (megacalories) required by the animal can be determined by the relationship .077 Mcal/BW.75 (NRC, 1984). Intake (kilograms) multiplied by net energy for maintenance per kilogram of the feed, divided by megacalories of net energy for maintenance required by the animal, equals XM.

Dry matter intake over time was determined by the difference between pregrazing herbage mass and postgrazing herbage mass and was expressed as a percentage of BW per day. Herbage mass was obtained by cutting five quadrats (10-m²) with hand shears at ground level pre- and postgrazing. Regrowth during grazing was minimal during the 72-h interval (or less) during which test plots were grazed. Stage B, which was the most rapidly growing treatment and had the least available herbage mass, averaged an 18-h grazing period between cutting pre- and postgrazing herbage samples. Stage F, which was completing the rapid growth phase, averaged 29 h. Stage S, which had little or no growth, averaged 39 h.

In vitro digestible OM (IVDOM) of the pregrazing herbage mass samples was determined using near-infrared reflectance spectroscopy (NIRS). Pregrazing herbage mass samples were dried in a forced-air oven at 60°C for 1 h, then ground in a shear mill to pass a 2-mm screen. A 50-g subsample of the pregrazing herbage mass sample was reground in a centrifugal mill to pass a 1-mm screen, then stored refrigerated at 4°C in plastic bags. A calibration set of 70 sainfoin samples was analyzed for IVDOM using a two-stage, pepsin-cellulase, conventional procedure (Assay No. 4) of Clarke et al. (1982), with modifications of the substitution of Onozuka 3s (FA) cellulase (cellulase:sample ratio of .325 g:.25 g) and the addition of chloramphenicol as a bacteriostat to the cellulase-buffer solution at .1 g/L (McLeod and Minson, 1978, 1980). Four NIRS equations were selected based on the standard error of calibration and were tested with 20 separate samples analyzed by the conventional
Table 1. Grazing dates for each growth stage of sainfoin

<table>
<thead>
<tr>
<th>Growth stage</th>
<th>1987</th>
<th>1988</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bud</td>
<td>May 1, June 18, July 9, August 2</td>
<td>April 20, May 30, July 6</td>
</tr>
<tr>
<td>Flower</td>
<td>May 18, June 18, July 28</td>
<td>May 13, June 16, July 19</td>
</tr>
<tr>
<td>Seed shatter</td>
<td>July 1, September 16</td>
<td>June 6, July 28</td>
</tr>
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</table>

procedure (Clarke et al., 1982). The final equation selected had five wavelengths. The coefficient of determination and standard error for the regression of conventional IVDOM values on NIRS IVDOM values for the 20 samples were .92 ($P < .05$) and 1.4, respectively.

Estimated ADG for the grazing season was the mean of projected ADG by grazing date values. The experimental design was a randomized complete block with three field-plot replications. The experimental unit was the field plot. Components of the model were blocks, growth stages, grazing pressures, and years. Main effects were growth stages and grazing pressures in a factorial arrangement. Years formed a split-plot in time. Analysis of variance was done on all data by harvest date, by year, and over years. No interactions were detected ($P > .05$); therefore, data are presented as means over years.

Table 2. Sainfoin herbage yield means averaged over 2 years

<table>
<thead>
<tr>
<th>Growth stage and grazing pressure</th>
<th>Total herbage harvested$^a$</th>
<th>Total IVDOM harvested$^b$</th>
<th>Total herbage available$^c$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg/ha</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bud Light</td>
<td>5.800</td>
<td>3.306</td>
<td>11.800</td>
</tr>
<tr>
<td>Medium</td>
<td>7.400</td>
<td>4.292</td>
<td>10.938</td>
</tr>
<tr>
<td>Heavy</td>
<td>8.800</td>
<td>5.280</td>
<td>9.687</td>
</tr>
<tr>
<td>Flower Light</td>
<td>7.900</td>
<td>4.286</td>
<td>15.429</td>
</tr>
<tr>
<td>Medium</td>
<td>10.600</td>
<td>6.048</td>
<td>15.492</td>
</tr>
<tr>
<td>Heavy</td>
<td>11.400</td>
<td>6.598</td>
<td>12.680</td>
</tr>
<tr>
<td>Shatter Light</td>
<td>5.200</td>
<td>2.286</td>
<td>9.716</td>
</tr>
<tr>
<td>Medium</td>
<td>6.700</td>
<td>3.015</td>
<td>9.760</td>
</tr>
<tr>
<td>Heavy</td>
<td>7.500</td>
<td>3.375</td>
<td>9.166</td>
</tr>
</tbody>
</table>

$^a$Total herbage mass harvested by steers on a dry matter (DM) basis.
$^b$Total in vitro digestible organic matter harvested by steers.
$^c$Total herbage available on a DM basis.
$^d$Least significant difference ($P < .05$).

Table 3. Main effect and interaction $P$-values over years for sainfoin grazed at bud, flower, or seed shatter stages of growth and light, medium, or heavy grazing pressures

<table>
<thead>
<tr>
<th>P-value</th>
<th>IVDOM$^a$</th>
<th>DMI$^b$</th>
<th>Predicted ADG$^c$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth stage (GS)</td>
<td>.00001</td>
<td>.00199</td>
<td>.00001</td>
</tr>
<tr>
<td>Grazing pressure (GP)</td>
<td>.00004</td>
<td>.00001</td>
<td>.00001</td>
</tr>
<tr>
<td>GS $\times$ GP</td>
<td>.19914</td>
<td>.56630</td>
<td>.42193</td>
</tr>
<tr>
<td>Year ($Y$)</td>
<td>.48010</td>
<td>.31029</td>
<td>.37151</td>
</tr>
<tr>
<td>$Y \times$ GS</td>
<td>.12887</td>
<td>.23725</td>
<td>.12299</td>
</tr>
<tr>
<td>$Y \times$ GP</td>
<td>.61254</td>
<td>.74445</td>
<td>.56856</td>
</tr>
<tr>
<td>$Y \times$ GS $\times$ GP</td>
<td>.30637</td>
<td>.91790</td>
<td>.62119</td>
</tr>
</tbody>
</table>

$^a$IVDOM = in vitro digestible organic matter.
$^b$DMI = dry matter intake.
$^c$ADG = average daily gain.

Results and Discussion

Grazing B stage began May 1, 1987 and April 20, 1988. Cool temperatures in April 1987 slowed spring growth and delayed grazing on all treatments (Table 1). Regrowth period between grazing dates averaged 32, 34, and 64 d for the B, F, and S stages, respectively. Plant growth was slow or dormant during August. All treatments resumed growth in October; however, autumn plant growth was vegetative and was not grazed. Root total nonstructural carbohydrate concentrations showed that sainfoin stores all energy reserves for winter survival during autumn growth (Mowrey and Matches, 1991). Because energy reserves may be required for winter survival, grazing sainfoin during autumn may be detrimental to plant persistence.

The L, M, and H grazing pressures averaged 52, 69, and 87% removal of herbage mass, respectively (Figure 1). Stubble heights after grazing for L, M, and H pressures averaged 20, 12, and 5 cm, respectively. As grazing pressure increased, the total amount of herbage and the total amount of digestible OM harvested increased ($P < .05$; Table 2). Average available herbage mass at the beginning of each grazing period was less ($P < .05$) during Stage B than during Stages F or S; however, total herbage available was similar between Stages B or S because of less frequent harvesting of Stage S.

Growth stage and grazing pressure ($P < .05$) affected IVDOM, DMI, and ADG. No interactions were found within or between years ($P > .05$). Within growth stages and grazing pressures, IVDOM, DMI, and predicted ADG did not differ among harvest dates. Digestibility was greater ($P < .05$) at B and F stages than at the S stage (Figure 2). Across growth stages, DMI averaged 3.9, 2.8,
and 1.7% of BW for L, M, and H grazing pressures, respectively (Figure 3). As grazing pressure increased, DMI decreased.

Predicted ADG ranged from 1.5 kg/d on the BL treatment to -0.3 kg/d on the SH treatment (Figure 4). Within growth stages, L consistently gave the greatest predicted ADG. At the S stage, the M defoliation level provided only for maintenance intake.

Nutritive value of a forage for livestock production is a function of its voluntary intake and its yield of available energy (Crampton et al., 1960; Mott and Moore, 1970). Heaney (1970) concluded that intake was the major component that influenced animal production from forages, because intake contributed nearly twice as much to the numerical value of the intake of DE as digestibility did. Forage intake declines with increasing utilization of the available forage (Raymond et al., 1956; Tayler and Rudman, 1965; Minson, 1981). Our data support these conclusions. Although both were significant, grazing pressure had a greater effect on DMI than did growth stage (Table 3). The P-value also showed that growth stage had more effect on IVDOM, but

Figure 1. Herbage mass removed as a percentage of available herbage mass averaged over years when grazed at bud, flower, or seed shatter stages of growth and light, medium, or heavy grazing pressures. Bars indicate ± SE.

Figure 2. In vitro digestible organic matter (IVDOM) of the available herbage averaged over years when grazed at bud, flower, or seed shatter stages of growth and light, medium, or heavy grazing pressures. Bars indicate ± SE.

Figure 3. Dry matter intake of available herbage as a percentage of body weight averaged over years when grazed at bud, flower, or seed shatter stages of growth and light, medium, or heavy grazing pressures. Bars indicate ± SE.

Figure 4. Predicted average daily gain in response to grazing pressure, averaged over years when grazed at bud, flower, or seed shatter stages of growth and light, medium, or heavy grazing pressures. Bars indicate ± SE.
grazing pressure was the major component that influenced DMI. Low DMI on H treatments resulted in lower predicted ADG than for other grazing pressures. Within growth stages, the L grazing pressure consistently yielded the greatest predicted ADG values. Predicted ADG under M grazing pressure was similar to actual gains reported on sainfoin (Parker and Moss, 1981, .96 kg/d; Marten et al., 1987, .80 kg/d).

During a grazing season, sainfoin could be expected to vary in growth stage. It seems that steer gains can be manipulated by adjusting grazing pressure. For example, to obtain high animal gains, grazing pressure should be decreased as plants advance in maturity to give the animal a greater opportunity to select higher-quality herbage.

Implications

Much of the small-plot or less than full-scale grazing research done to date has not considered the effect that grazing pressure has on intake. Because intake is the major component that influences animal production, forage quality measurements without intake data are of only limited value. If intake and digestibility of herbage are measured, the multiple of maintenance method for predicting live weight gain seems useful for evaluating treatments on small-plot grazing experiments.

Literature Cited


