Production and Economics of Grazing Alfalfa
in the Southern Great Plains

Twain J. Butler,* Jon T. Biermacher, Sindy M. Interrante, Mary K. Sledge, Andrew A. Hopkins, and Joseph H. Bouton

ABSTRACT
Alfalfa (Medicago sativa L.) is a high-quality forage legume that may have potential to improve net returns to stocker cattle producers in the southern Great Plains. The objective of this 3-yr field study was to compare the agronomic and economic performance of alfalfa grazing systems under two management strategies. Treatments were (i) continuous stocking for the entire growing season, referred to as full-season grazing; and (ii) a late-season rest, which was continuous stocking of alfalfa until 1 August. Steers (250 ± 25 kg initial body weight) were weighed every 28 d during each grazing season, and stocking rates were adjusted with put-and-take steers based on forage mass. In each 28-d grazing period, forage mass and total gain (TG) were measured, allowing calculation of average daily gain (ADG). Animals had ADG of 0.93 and 1.05 kg d⁻¹ and TG of 449 and 379 kg ha⁻¹ on alfalfa for the full-season grazing treatment and the late-season rest (August termination), respectively. The 3-yr average production cost ($278 ha⁻¹) did not differ between the two management treatments; however, expected net return was greater (P < 0.01) for the full-season alfalfa grazing treatment ($314 ha⁻¹) compared to the 1 August termination date ($145 ha⁻¹). Therefore, a late-season rest from grazing was not economically beneficial to grazing alfalfa in this 3-yr experiment, and grazing alfalfa with summer stockers may be a viable option for producers in the southern Great Plains.
three harvest frequencies, and Hermann et al. (2002) reported no difference in persistence between hay-type and grazing-type alfalfa when grazed in a rotational stocking system. Lauriault et al. (2005) reported that pastures containing grazing-tolerant alfalfa increased average daily gain (ADG) by 15% and total gain (TG) by 107% compared to monocultures of tall wheatgrass [Thinopyrum ponticum (Podp.) Barkworth & Dewey]. Cassida et al. (2006) reported that bermudagrass [Cynodon dactylon (L.) Pers.] provided longer grazing season, greater number of grazing days, and fewer grazing interruptions compared to grazing-tolerant alfalfa; however, the net returns to grazing bermudagrass were negative. They found the profitability of the alfalfa system to be dependent on harvesting and marketing some of the forage as hay. Utilizing alfalfa for grazing has potential; however, research documenting the economics of grazing alfalfa is limited. It is generally thought that for maximum stand persistence, perennial legumes need a deferment period between grazings to replenish carbohydrate reserves. Butler et al. (2007) reported that a late-season rest (September) increased rhizoma peanut (Arachis glabrata Benth.) dry matter (DM) yields compared to an early-season (July) rest period. It is hypothesized that a late-season rest would increase alfalfa production by increasing persistence compared to continuously grazed alfalfa. In addition, there is limited information on the economics and profitability of continuously grazed alfalfa production systems. Therefore, the objective of this study were to determine the effects on animal performance and economic net return of a late-season rest period (1 August termination) system compared to a full-season grazing system of continuously grazed alfalfa in the southern Great Plains.

MATERIALS AND METHODS

Experimental Site

The field experiment was conducted at the Noble Foundation’s Headquarter Farm located in south-central Oklahoma (34°10’ N, 97°10’ W; elevation 266 m), in 2002, 2003, and 2004. The precipitation data for the study area are presented in Fig. 1. The soil type of the experimental site was a Heiden clay (fine, montmorillonitic, thermic Udic Chromusterts) with average pH of 7.1 and organic matter of 31 g kg⁻¹. At the beginning of the study, the average Mehlich III–extractable soil P, K, Ca, and Mg at 15-cm depth were 3, 143, 7537, and 708 mg kg⁻¹, respectively. The grazing experiment was a split-plot design with three replicates. Main plot included grazing treatment (August rest or continuously grazed), while the subplot included alfalfa cultivars within each paddock.

Land Preparation, Planting, and Management

Paddocks, each 0.81 ha in area, were prepared by chiseling in June, followed by tillage with an offset disk in July, followed by a tandem disk in August (John Deere, Moline, IL). All paddocks were fertilized each year with P according to the soil test recommendation (Zhang et al., 2009) in September with triple super phosphate (0–46–0) at the rate of 34 kg P (77 kg P₂O₅) ha⁻¹. A preemergent application of S-ethyl dipropylthiocarbamate (EPTC) (Eptam, Gowan, Yuma, AZ) at 3.36 kg a.i. ha⁻¹ was incorporated before planting. Each paddock was drilled (17.8-cm row spacing) with three grazing-tolerant alfalfa cultivars (Alfagraze, AmeriGraze 702, and AmeriGraze 401+Z) and one conventional cultivar (Magnum V) randomly in separate areas of each paddock during September 2001 at 15 kg pure live seed ha⁻¹. In early March of each year, 0.028 kg a.i. ha⁻¹ S-cyano(3-phenoxyphenyl)methyl (+) cis/trans 3-(2-2-dichloroethenyl)-2,2 dimethylcyclopropene carboxylate (Mustang Max, FMC, Philadelphia, PA) was applied to control alfalfa
weevil (Hypera postica Gyllenhal). During each summer grazing season, paddocks received a single application of 0.84 kg a.i. ha$^{-1}$ 4-(2,4-dichlorophenoxy)butyric acid (2,4-DB) (Butyrate, Albaugh, Ankeny, IA) to control broadleaf weeds and 0.14 kg a.i. ha$^{-1}$ clethodim (E)-2-[(3-chloro-2-propenyl)oxy]iminodipropyl]-5-[(2-ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one (Select, Winfield Solutions, St. Paul, MN) to control grass weeds. Alfalfa stand counts were made in 2002 before initiation of grazing, and in 2004 after termination of grazing for each variety by counting plants in 30 random 0.5-m$^{-2}$ quadrats for each cultivar. Stand counts were converted to stand survival by dividing final stand count by initial stand count.

Animal Assignment, Data Collection, and Processing

Forage mass was measured at 28-d intervals during the experiment by hand-cutting six randomly located 0.1-m$^{2}$ quadrat samples in each paddock to 5-cm stubble height. Grazing was initiated when forage mass was adequate (>1.7 Mg DM ha$^{-1}$) and was terminated on 27 to 31 July (early season) or when forage mass was limiting (full season) (<1.0 Mg DM ha$^{-1}$). Each year, grazing was initiated on both grazing management systems on the same day. In 2002, grazing was initiated on 7 June, and was terminated on 31 July in the August termination system and on 27 September in the full-season grazing system. In 2003, grazing was initiated on 11 April, and was terminated on 31 July in the August termination system and on 28 August in the full-season grazing system. In 2004, grazing was initiated on 7 April, and was terminated on 27 July in the August termination system and on 23 September in the full-season grazing system.

Paddocks were continuously stocked using a variable put-and-take stocking rate (Bransby, 1989) with preconditioned Angus and Angus × Brangus steers (250 ± 25 kg initial body weight) of local origin. Steers were provided with poloxalene blocks the first 14 d while grazing alfalfa paddocks each year to prevent bloat; however, no additional bloat block was provided thereafter. Each year, two “tester” steers were randomly assigned to each paddock and grazed the paddock for the duration of the experiment that year. To calculate ADG, initial and final weights of the tester steers were averaged after weighing each animal at every 28 d such that total forage mass in each paddock was approximately 1 Mg forage DM ha$^{-1}$. The number of grazing days for each system was calculated by summing the number of days the tester and grader animals grazed. Total gain was calculated by multiplying ADG of the tester animals by the total number of grazing days for each system.

Economic Analysis

The relative economic value for each forage system was determined by calculating the difference between the expected revenues and costs for each forage system. Because the goal of the study was to compare the economics of two systems, full detailed enterprise budgets were developed to account for all the costs that varied between the two systems. Costs included tillage and seedbed preparation, seed and establishment, fertilizer management, weed management, and interest on operating expenses, including the opportunity cost of owning stocker cattle during the grazing period. Costs for each system were calculated using the 3-yr average quantities of inputs multiplied by expected market prices for the region for each input used by each system. Alfalfa seed prices of $9.24 kg$^{-1}$ pure live seed were used. Expected prices for herbicides EPTC, 2,4-DB, and clethodim were assumed to be $13.74, $10.04, and $33.03 L$^{-1}$, respectively. Expected price for insecticide was assumed to be $530.86 L$^{-1}$. The average cost of $0.65 kg$^{-1} P ($1.48 kg$^{-1} P$_2$O$_5$) was used in the study. Regional custom rates for P application ($24.25 ha$^{-1}$) and land and seedbed preparation operations (chisel [$26.45 ha$^{-1}$], offset disk [$28.66 ha$^{-1}$], cultivating [$24.25 ha$^{-1}$], cultipacking [$17.63 ha$^{-1}$], and drilling [$26.45 ha$^{-1}$]) were used (Doyle and Sahs, 2010). An annual interest rate of 7.5% was used to calculate the opportunity cost of capital during the growing season. The actual stand life of 3 yr was used for analysis.

Value of gain was determined using the 2011 May, July, and September futures prices quoted by the Chicago Board of Trade and adjusted to reflect the Oklahoma City National Stockyard regional price using BeefBasis.com (http://beefbasis.com/ [accessed 13 Jan. 2012]) (Crosby et al., 2005). Values of $1.81 and $2.03 kg$^{-1}$ were used to place value on total gain produced ha$^{-1}$ by stocker cattle for the late-season rest (1 August termination) and full-season grazing systems, respectively.

Statistical Analysis

Data on forage mass, ADG, number of grazing days, and TG were subjected to analysis of variance using PROC MIXED (SAS Institute, 2002). Grazing system, evaluation date, year, and their interactions were considered fixed effects, while replicate and its interactions were considered random effects. Year was considered fixed because of the potential for carryover effects of the grazing management treatments from Years 1 and 2. Year was included in the model as a subplot treatment in a split-plot arrangement, with the grazing management treatments being the main plots. Differences between grazing management treatments were based on F tests and significance was determined at $P \leq 0.05$. Stand count data were subjected to analysis of variance using PROC MIXED (SAS Institute, 2002). Grazing system, evaluation date, cultivar, and their interactions were considered fixed effects, while replicate and its interactions were considered random effects. The PDFIFF function of the LSMEANS procedure was used to compare means. For forage mass responses measured multiple times per year, evaluation date was treated as a repeated measure. Value of gain, gross revenue, total cost, and net return for each forage system were analyzed using random-effects mixed models, with production year and replication modeled as random effects, and grazing system modeled as a fixed effect. Year was considered random for the economic analysis so inferences could be made across years. The statistical models for the economic variables applied the autoregressive (AR1) spatial power covariance structure to help account for temporal autocorrelation in data collected across production years. Individual paddocks were utilized as local subjects within all analyses, as they represented the units in the study that received the specified forage management systems over the course of the study. The null hypothesis of no production year
random effect was tested with the likelihood ratio test (LR) and rejected at $P \leq 0.0001$ for all dependent variables analyzed. The LR (l) was obtained as a ratio of the maximum likelihood value obtained when the mixed model was analyzed with and without the random constraint associated with study site and year. The LR depended on the restricted and unrestricted models and under regularity, the test statistic (−2lnl) followed a chi-square distribution with a degrees of freedom equal to the number of restrictions imposed (Greene, 2005).

RESULTS AND DISCUSSION

Precipitation

Precipitation during the autumn establishment (September through December) of 2001 was 35% above the 30-yr average of 342 mm (Fig. 1), which resulted in successful establishment of alfalfa. Precipitation during the growing season, defined as March through October, ranged from 508 to 793 mm, which was 31% below and 7% above, respectively, the 30-yr average (741 mm). Therefore, these results would be considered within the normal expectations for alfalfa production in this region.

Forage Mass

Forage mass was estimated across the four cultivars for each paddock. The focus of forage mass analysis was identifying differences in forage mass between the grazing management systems during the grazing season. Forage mass was affected by an interaction of evaluation date and year ($P < 0.001$), so data were analyzed by year. There were no effects of grazing management system ($P = 0.5$) or evaluation date ($P = 0.6$) on forage mass in 2002. In 2003, forage mass was affected by grazing management system ($P = 0.05$; $SE = 0.17$) and evaluation date ($P < 0.001$; $SE = 0.20$). There was greater forage mass associated with the August termination treatment (1.3 Mg ha$^{-1}$) than the full-season grazing system (1.0 Mg ha$^{-1}$). There was greater forage mass in May and June (1.6 and 1.9 Mg ha$^{-1}$, respectively) than in April, July, and August (0.5, 0.7, and 0.8 Mg ha$^{-1}$, respectively). Forage mass was affected by evaluation date ($P < 0.001$; $SE = 0.23$) in 2004, in that forage mass was greater in May and July (2.0 and 2.1 Mg ha$^{-1}$, respectively) than in April, June, August, and September (0.8, 1.1, 0.8, and 0.5 Mg ha$^{-1}$, respectively). Forage mass was similar between the two grazing systems at all common evaluation dates in all years, and was similar between the two grazing systems in 2002 and 2004. This could be attributed to the put-and-take system of additional grazers, which nullified any difference in forage mass. Therefore, it would be expected that ADG would not differ from the two grazing management treatments.

Average Daily Gain

Year × grazing system interactions were not significant ($P = 0.55$) for ADG; therefore, means are reported across years. Stocker ADG did not differ ($P = 0.21$; $SE = 0.06$) between the two grazing management treatments. The full-season grazing treatment had 0.93 kg head$^{-1}$ d$^{-1}$ compared to 1.05 kg head$^{-1}$ d$^{-1}$ ADG for the late-season rest (August termination) treatment, which was expected since forage mass did not differ between the two treatments (Table 1). Lauriault et al. (2005) reported ADG of 0.94 kg head$^{-1}$ d$^{-1}$ and Hermann et al. (2002) reported ADG of 1.2 kg head$^{-1}$ d$^{-1}$, for rotationally grazed monoculture stands of alfalfa, which is similar to our findings. Cassida et al. (2006) reported ADG of continuously grazed alfalfa of 0.46 kg head$^{-1}$ d$^{-1}$, which is substantially lower than these findings. Bates et al. (1996) reported ADG values ranging from 0.36 to 1.06 kg head$^{-1}$ d$^{-1}$ depending on forage allowance and year for continuously grazed alfalfa in a 3-yr study. They reported that low forage allowance (453 kg forage 499-kg animal unit [AU]$^{-1}$) resulted on lower ADG (0.62 kg head$^{-1}$ d$^{-1}$), while high forage allowance (1361 kg forage 499-kg AU$^{-1}$) resulted in higher ADG (0.94 kg head$^{-1}$ d$^{-1}$).

### Grazing Days

Year × grazing system interactions were not significant ($P = 0.95$) for the number of grazing days; therefore, means are reported across years. The number of grazing days varied between the two grazing management treatments

<table>
<thead>
<tr>
<th>Economic variable</th>
<th>Management system</th>
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<tbody>
<tr>
<td></td>
<td>Full-season grazing</td>
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<tr>
<td>Preplant herbicide cost ($ ha$^{-1}$)</td>
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<tr>
<td>Phosphorus application costs ($ ha$^{-1}$)</td>
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<td>Seedbed preparation costs ($ ha$^{-1}$)</td>
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<td>Seed and establishment costs ($ ha$^{-1}$)</td>
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<td>Postemergent pest management ($ ha$^{-1}$)</td>
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<td>Total establishment costs ($ ha$^{-1}$)</td>
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<td>Establishment costs amortized over 3 yr at 7.5% annual percentage rate ($ ha$^{-1}$)</td>
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<tr>
<td>Annual phosphorus costs ($ ha$^{-1}$)</td>
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<td>Annual pest management cost ($ ha$^{-1}$)</td>
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<td>Bloat prevention block ($ ha$^{-1}$)</td>
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<td>Interest on operating capital ($ ha$^{-1}$)</td>
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<td>Total establishment plus annual costs ($ ha$^{-1}$)</td>
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<td>Grazing days (d ha$^{-1}$)</td>
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<td>Average daily gain (kg head$^{-1}$ d$^{-1}$)</td>
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<td>Total gain (kg ha$^{-1}$)</td>
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<td>Value of gain ($ kg$^{-1}$)</td>
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<tr>
<td>Gross revenue ($ ha$^{-1}$)</td>
<td>898.17</td>
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<tr>
<td>Expected net return ($ ha$^{-1}$)</td>
<td>314.64 a</td>
</tr>
</tbody>
</table>

*Means followed by the same letter within a row do not differ by the LSMEANS test ($P > 0.05$).
(Table 1). The full-season grazing treatment had 483 grazing d ha$^{-1}$ compared to 361 d ha$^{-1}$ for the late-season rest (August termination) treatment ($P = 0.001; \text{SE} = 40$), which was expected due to the defined rest period. The number of grazing days is dependent on stocking rate and forage mass, which also depends on the amount of precipitation received during the growing season. Cassida et al. (2006) reported that the number of grazing days for continuously stocked alfalfa ranged from 594 to 1221 d ha$^{-1}$, and was less than the number of grazing days for bermudagrass pastures. Bates et al. (1996) reported the number of grazing days for continuously grazed alfalfa increased from 317 to 706 d ha$^{-1}$ when forage allowance decreased from high (1361 kg forage 499-kg AU$^{-1}$) to low (453 kg forage 499-kg AU$^{-1}$).

**Total Cattle Gain**

Year × grazing system interaction was not significant ($P = 0.39$) for TG; therefore, means are reported across years. Total gain in the full-season grazing treatment (449 kg ha$^{-1}$) did not differ ($P = 0.13; \text{SE} = 45$) from the late-season rest (August termination) treatment (379 kg ha$^{-1}$), which was unexpected due to the greater number of grazing days with the full-season grazing treatment (Table 1). This lack of difference could be attributed to variability (insufficient replication) and the numerical trend of greater ADG with the hay-type cultivar may have been realized from a late-season rest; however, this is speculation. It has also been observed that other grazing-tolerant type alfalfas (Alfagraze 300RR and Bulldog 505) have not persisted >3 yr under continuous grazing (data not shown). Bates et al. (1996) also reported excessive alfalfa stand decline after the third grazing season; however, their decline was attributed to bermudagrass encroachment.

**Economics**

Estimates of average production costs, gross revenue, and net return to land, labor, overhead, and management are reported in Table 1. Average production cost over 3 yr (2002–2004) did not differ between the two grazing management systems. The full-season grazing system had greater expected net return ($314.64$ ha$^{-1}$) compared to the late-season rest (August termination) treatment ($145.31$ ha$^{-1}$). This was primarily attributed to the full-season grazing treatment realizing a greater value of gain associated with market prices at the time of grazing termination. Cassida et al. (2006) reported that grazing monoculture stand of alfalfa in Arkansas was profitable ($89$ ha$^{-1}$) only when combined with haying alfalfa, and that grazing bermudagrass with summer stockers was not profitable ($-148$ ha$^{-1}$). However, major differences between the report of Cassida et al. (2006) and our report are that their soils required limestone, gypsum, K, and B for growing alfalfa. Selecting a fertile site that does not require additional inputs will greatly affect profitability of alfalfa production in the short term until inputs may eventually be required. Sensitivity analysis showed that expected net returns would have increased to $463$ ha$^{-1}$ if no P fertilizer was required, that expected net returns would have decreased to $212$ ha$^{-1}$ if moderate inputs (2240 kg Effective Calcium Carbonate Equivalent [ECCE] limestone ha$^{-1}$, 51 kg $P_2O_5$, and 67 kg $K_2O$) were required, and that expected net returns would have decreased to $-17$ ha$^{-1}$ if high inputs (4480 kg ECCE limestone ha$^{-1}$, 103 kg $P_2O_5$, and 134 kg $K_2O$) were required to grow alfalfa (data not shown). Selecting a site free from competition may also be important. Grazing alfalfa interseeded into existing bermudagrass was less profitable ($86.39$ ha$^{-1}$) than interseeding clover (Trifolium vesiculosum Savi)–vetch (Vicia villosa Roth) mixture in bermudagrass ($130.02$ ha$^{-1}$) or bermudagrass fertilized with 112 kg N ha$^{-1}$ ($211.68$ ha$^{-1}$) (Biermacher et al., 2011). Islam et al. (2011) reported that a rye (Secale cereale L.)–annual ryegrass (Lolium multiflorum Lam.) system produced an average expected net return of $279$ ha$^{-1}$ compared to $217$ ha$^{-1}$ for a perennial tall fescue (Schedonorus annuusus [Schreb.] ’Texoma Max Q II’) system in the southern Great Plains, which is similar to values reported for grazing alfalfa.
CONCLUSIONS
The late-season rest did not extend the life of the alfalfa stand beyond the third season in this experiment, and it resulted in less net return; therefore, it would not be recommended. Expected net returns from grazing monoculture alfalfa during the summer were greater than those reported by others for grazing bermudagrass and were similar to values reported for autumn and spring grazing of other cool-season forages, like rye–annual ryegrass and perennial tall fescue with a nontoxic endophyte. Therefore, monoculture stands of alfalfa may have potential for grazing in a summer stocker program in the southern Great Plains. However, the relatively high value of alfalfa hay and the perceived higher level of management required may limit the use of alfalfa for grazing. Alfalfa grown in monoculture could supplement warm-season perennial grass like bermudagrass in a system; however, further research is needed to confirm this.

References


