

JOURNAL OF ANIMAL SCIENCE

The Premier Journal and Leading Source of New Knowledge and Perspective in Animal Science

Performance of steers grazing rhizomatous and nonrhizomatous birdsfoot trefoil in pure stands and in tall fescue mixtures

L. Wen, R. L. Kallenbach, J. E. Williams, C. A. Roberts, P. R. Beuselinck, R. L. McGraw and H. R. Benedict

J Anim Sci 2002. 80:1970-1976.

The online version of this article, along with updated information and services, is located on the World Wide Web at:

<http://jas.fass.org/cgi/content/full/80/7/1970>



American Society of Animal Science

www.asas.org

Performance of steers grazing rhizomatous and nonrhizomatous birdsfoot trefoil in pure stands and in tall fescue mixtures^{1,2}

L. Wen*, R. L. Kallenbach†, J. E. Williams^{3,*}, C. A. Roberts†, P. R. Beuselinck‡, R. L. McGraw†, and H. R. Benedict†

Departments of *Animal Science and †Agronomy, University of Missouri, Columbia 65211 and ‡USDA, ARS, Columbia, MO 65211

ABSTRACT: This study investigated the performance of steers grazing rhizomatous birdsfoot trefoil (*Lotus corniculatus* L.) (RBFT) compared to nonrhizomatous birdsfoot trefoil (BFT) in pure stands or when interseeded with endophyte-free tall fescue (*Festuca arundinacea* Schreb.; TF). Five forage treatments of RBFT, BFT, TF, RBFT+TF, and BFT+TF (four replicate paddocks per treatment) were continuously stocked in spring and fall of 1998 and spring of 1999. Grazing for individual treatments was terminated when pasture mass fell below 900 kg/ha. Average daily gain was greatest ($P < 0.10$) in pure stands of BFT and RBFT, but total forage production, and thus grazing days, for these treatments was low. Average daily gain for steers grazing BFT+TF and RBFT+TF treatments was not different from (spring and fall 1998) or greater ($P <$

0.10) (spring 1999) than that for TF. Total forage production of BFT+TF and RBFT+TF was greater ($P < 0.10$) than that of TF in spring 1998. In fall 1998, BFT+TF produced more ($P < 0.10$) total forage than either RBFT+TF or TF, and in spring 1999, RBFT+TF had less ($P < 0.10$) total forage than TF or BFT+TF. Total steer days on mixed pastures were greater ($P < 0.10$) than that for TF in spring and fall 1998 but not different from those for TF in spring 1999. In all three trials total weight gain/hectare was greater ($P < 0.10$) for RBFT+TF and BFT+TF than for TF. The RBFT+TF and BFT+TF had greater ($P < 0.05$) CP than TF in spring and fall 1998 and less ($P < 0.05$) NDF and ADF in fall 1998. We concluded that either RBFT or BFT could be interseeded with tall fescue to enhance ADG and total steer days.

Key Words: *Festuca arundinacea*, Forage, *Lotus corniculatus*, Performance, Quality, Steers

©2002 American Society of Animal Science. All rights reserved.

J. Anim. Sci. 2002. 80:1970–1976

Introduction

Tall fescue (*Festuca arundinacea* Schreb.) (TF) is the most widely planted grass species in the humid pasture region of the United States. Although TF is productive in pure stands, performance of livestock grazing TF can be improved by introducing legumes into TF pastures (Hoveland et al., 1985, 1991; Stephenson and Posler, 1988). One legume that grows well in a mixture with TF is birdsfoot trefoil (McGraw et al., 1989; Hoveland et al., 1988). Birdsfoot trefoil is an ideal companion legume for TF pastures because it does not cause bloat, withstands closer grazing than other legumes, and

grows well on acidic or infertile soils (Beuselinck and Grant, 1995).

Despite the advantages of birdsfoot trefoil, it has some limitations. Perhaps the single largest limitation is poor stand persistence. Henson (1962) and Beuselinck et al. (1984) reported stand losses of 68 to 90% within 2 yr of establishment. Most often these losses are caused by root- and crown-rot diseases (Beuselinck et al., 1984). Losses occur during warm, humid weather, and thus root- and crown-rot has its greatest influence in the central and southern United States. Although some producers maintain birdsfoot trefoil stands by encouraging reseeding, this practice has limited success.

A new cultivar of birdsfoot trefoil with rhizomes, 'ARS-2620,' was developed by the USDA-ARS (Beuselinck and Steiner, 1996). Because this new cultivar of birdsfoot trefoil has the ability to spread by rhizomes, it is less dependent on reseeding to maintain the stand. In addition, it differs from previous types of birdsfoot trefoil in that it contains higher concentrations of condensed tannin (Gebrehiwot and Beuselinck, 1997).

At present, no studies have examined how rhizomatous birdsfoot trefoil might alter the performance of

¹Contribution from the Missouri Agric. Exp. Sta. Journal series no. 13,179.

²Mention of a trade name or proprietary product does not constitute endorsement by the University of Missouri or the USDA over products of other manufacturers that may also be suitable.

³Correspondence: E-mail: williamsje@missouri.edu.

Received September 22, 2001.

Accepted February 15, 2002.

grazing steers when interseeded into TF pastures. The objective of this study was to investigate the performance of steers grazing 'ARS-2620' compared to a non-rhizomatous birdsfoot trefoil cultivar in pure stands and in TF mixtures.

Materials and Methods

Experimental Design

The five pasture treatments used in this study were 1) birdsfoot trefoil cultivar 'ARS-2620,' **RBFT**; 2) birdsfoot trefoil without rhizomes 'Norcen,' **BFT**; 3) endophyte-free 'Phyter' TF; 4) RBFT+TF; and 5) BFT+TF. The RBFT+TF and BFT+TF pastures in this paper are referred to collectively as the "mixed" pastures. These treatments were established in pastures located at the University of Missouri South Farm near Columbia, MO. The soils at this location are classified as Mexico silt loam (fine, montmorillinitic, mesic, Udollic Ochraqualf) Moniteau silt loam (fine-silty, mixed, mesic, Typic Ochraqualf) and Mandeville silt loam (fine-loamy, mixed, mesic, Typic Hapludalfs). Each treatment pasture was 0.53 ha and replicated four times in a randomized complete block design.

Pasture Establishment and Management

The pure stands of both cultivars of birdsfoot trefoil were seeded at 7.9 kg/ha, the pure TF at 16.8 kg/ha, and the mixtures at 13.5 kg/ha of TF and 7.9 kg/ha of birdsfoot trefoil. In the summer prior to seeding, sudangrass (*Sorghum bicolor* [L.] Moench) was planted as a smother crop. Prior to planting the following spring, 387 mL/ha active ingredient glyphosate [N-(phosphonomethyl) glycine] was applied to kill any existing vegetation. Planting occurred between April 1 and 3, 1997, using a Tye Pasture Pleaser no-till drill. Seeds were planted 0.5 to 1 cm below the soil surface. The birdsfoot trefoil seeds were inoculated with *Bradyrhizobium loti* before planting.

Lime, P, and K fertilizer were applied according to the recommendations provided by the University of Missouri Soil Testing Laboratory. Nitrogen was applied at 67.4 kg N/ha in March 1997, and again in March 1999, to the TF pastures. Except for 33.7 kg N/ha at planting in 1997, no N was applied to mixed pastures. All N applied was in the form of ammonium nitrate.

In February 1998 and 1999, hexazinone (3-cyclohexyl-6-[dimethylamino]-1-methyl-1,3,5-triazine-2,4[1H,3H]dione) was applied at 875 mL/ha (active ingredient) to the pure stands of birdsfoot trefoil to control grassy weeds. In addition, a 205-mL/L solution of glyphosate (N-[phosphonomethyl] glycine) was applied each year using a rope-wick applicator to control escape weeds.

Grazing Trials

In 1997, spring grazing was initiated May 11, 1998, and terminated when pasture production ended for

each treatment (late June or early July). A second spring grazing trial started on April 19, 1999, and continued until summer drought ended pasture production (late June or early July). Fall grazing was conducted in 1998 from September 22 to November 17 but was not carried out in 1999 because of a severe drought (Figure 1).

Angus crossbred steers were used for these three grazing trials. Initial weight of steers was 305, 209, and 267 kg for spring and fall of 1998 and spring of 1999, respectively. Steers were approximately 1 yr of age in spring 1998 and 1999 and approximately 7 mo of age in fall 1998. In each grazing trial, the initial and final full BW of steers were determined on two consecutive days. Steers were also weighed every 14 d during each grazing trial to monitor performance. Prior to each grazing trial, steers were implanted with Revalor-G (Hoeschst-Roussel Agri-Vet, Somerville, NJ), dewormed with Ivermectin (Merial, Iselin, NJ), and vaccinated with Bovashield (Pfizer, Eaton, PA) and with Clostridium 7-way, Ultrabac (Pfizer). Water and trace mineral salt blocks were provided to steers in each paddock.

At least three steers for RBFT+TF, BFT+TF, and TF treatments and two steers for RBFT and BFT treatments remained on each treatment paddock from the beginning to the end of the grazing trial as tester steers. Similar amounts of available forage on pastures were maintained by using the put-and-take method with non-tester steers (Bransby, 1989; Hoveland et al., 1991). Available forage measurements are described in the *Forage Sampling* section below. Grazing for individual treatments was terminated when pasture DM fell below 900 kg/ha. Total weight gain of tester steers was determined from the difference in live weight at the beginning and end of the grazing trial.

Performance Measurement Indices

Steer days were computed as the sum of the days tester and non-tester steers remained on each treatment paddock. Average daily gain was computed by dividing total tester gain by the number of grazing days for tester steers. Total weight gain/hectare was calculated as steer days per 14-d period multiplied by ADG of tester steers for that period; the products of each 14-d period were summed to determine total weight gain/hectare.

Forage Sampling

At the beginning of each grazing trial and at 14-d intervals, paddocks were sampled for forage yield by clipping forage 5 cm above the ground from two randomly placed strips ($0.76 \times 7.6 \text{ m}^2$) in 1998 or six strips ($0.76 \times 4.6 \text{ m}^2$) in 1999. Two exclosures were also randomly placed in each paddock. Forage from a 3-m² area inside each exclosure was clipped at the same time as the strips were clipped from the rest of the paddock.

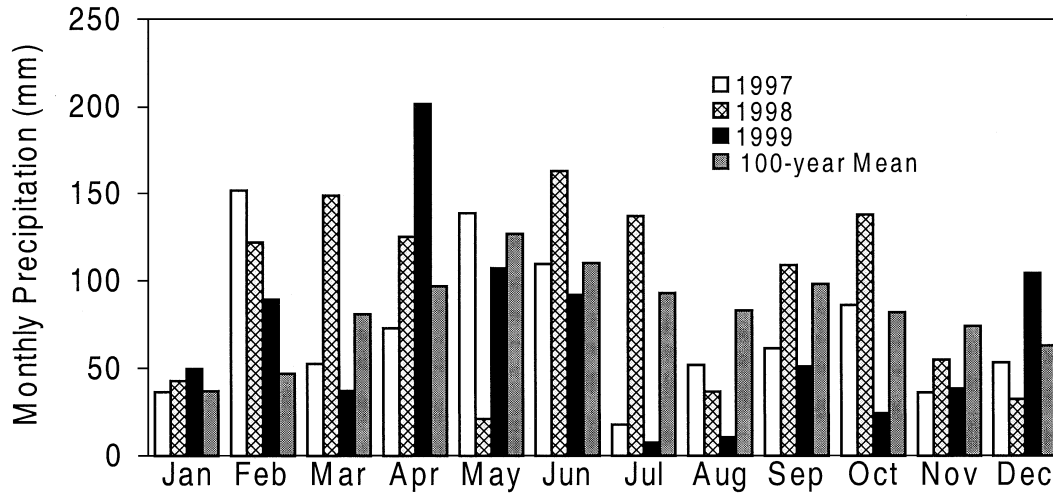


Figure 1. Monthly precipitation from January 1997 through December 1999 and the 100-yr mean monthly precipitation for Columbia, MO.

After each clipping, the exclosures were moved to a new location within each pasture. The difference in forage yield between strips and exclosures was used to determine the forage growth in each paddock since the previous sampling date. The forage yield estimated from strips was used to determine the stocking rate on each paddock for the following 14-d period. Total forage production for each pasture was calculated using the following formula:

$$\text{Total forage production} = (\text{Pasture forage yield of 1st sampling}) + \text{forage growth (between the 1st and the 2nd sampling date)} + \text{forage growth (between the 2nd and the 3rd sampling date)} + \dots + \text{forage growth [between the } (n-1)^{\text{th}} \text{ and the } n^{\text{th}} \text{ sampling date]}$$

In this formula, the pasture forage yield and forage growth were calculated on a dry matter basis. On each sampling date, the stocking rate for the following 14-d period was estimated by dividing the forage yield by estimated forage consumption (estimated at 3% of steer BW) using 50% utilization rate. Specifically, the stocking rate (and thus steer days) for each pasture was based on forage yield estimates from strips harvested on each sampling date, and the total forage production was the sum of forage yield from the first sampling date plus the forage growth from every 14-d period thereafter.

A flail-type mower was used to clip forage from each strip, and subsamples were taken after the total forage mass from the strips in each paddock was determined. The subsamples included 1) 200 g of forage for DM determination using the microwave oven method (Stevens et al., 1986) and 2) 300 g of forage for analysis of chemical composition. The subsamples taken for DM determination were used to calculate the forage yield on each sampling date. The samples for analysis of chemical composition were placed on dry ice in the field and then lyophilized.

Compositional Analysis

Forage quality and botanical composition were quantified by near-infrared reflectance spectroscopy (NIRS) according to the procedures of Westerhaus et al. (1985). All forage samples were analyzed using a NIRSystems 5000 scanning monochromator (NIRSystems, Silver Spring, MD) with software developed by Infrasoft International (Port Matilda, PA). Samples were scanned with near infrared light from 1,110 to 2,490 nm, and $\log 1/\text{reflectance}$ (**log 1/R**) was recorded.

Before NIRS analysis, lyophilized forage samples were ground through a 1-mm screen using cyclone-type grinder. All samples were then scanned by NIRS, and 10% of the samples were selected with WinISI II software (Version 1.02, Port Matilda, PA) for laboratory data determination with the following procedures. Total N was determined with a Leco FP-480 Nitrogen Analyzer (Leco, St. Joseph, MI), and CP was calculated as $N \times 6.25$. The NDF and ADF were quantified using the procedure of Goering and Van Soest (1970). The percentage of TF in BFT+TF and RBFT+TF pastures was determined using a calibration equation developed from harvested samples according to the procedure of Moore et al. (1990). The equation used to predict the botanical composition of mixed pastures quantified the amount of TF and assumed the difference to be birdsfoot trefoil. Although the percentage of volunteer legumes and weeds other than birdsfoot trefoil in the mixed pastures was quite small, it likely was included with the birdsfoot trefoil component.

Prediction equations for NDF, ADF, CP, and the percentage of TF in mixed forage were developed by regressing reference data against first and second derivatives of $\log 1/R$. Equations were developed and validated using modified partial least square regression with cross-validation (Shenk and Westerhaus, 1991). Validation accuracy was evaluated with high values of 1 –

Table 1. Calibration and validation statistics for near-infrared reflectance spectroscopy determination of chemical and botanical composition in mixed pastures

Item	R ^{2a}	1 – VR ^b	n	Mean		SECV ^c
				% of DM		
NDF	0.98	0.97	65	51.9		2.5
ADF	0.99	0.97	63	35.1		1.4
CP	0.98	0.96	65	15.9		0.9
% TF ^d	0.99	0.99	94	50.6		2.8

^aCalibration coefficient of determination achieved in forward stepwise multiple regression of spectra on chemical data.

^b1 – VR = 1 minus the variance ratio calculated in cross validation in modified partial least squares regression.

^cSECV = standard error of cross validation.

^dPercentage of tall fescue (TF) in mixed pastures.

variance ratio (1 – VR) and low standard errors (Table 1).

Statistical Analysis

Data were analyzed using GLM procedure of SAS (SAS Inst. Inc., Cary, NC). The statistical model included treatment and block as main effects. Data collected in the three grazing trials were analyzed individually, because the length of grazing trials and environmental conditions were different. Least significant difference (LSD) was used to compare pasture treatments. The designated significance level of LSD for steer performance and total forage production was $P < 0.10$ and the significance level of LSD for forage quality and percentage of birdsfoot trefoil was $P < 0.05$. For forage quality and percentage of birdsfoot trefoil analyses, the data presented are the mean values obtained over sampling dates within each grazing trial.

Results and Discussion

Spring 1998

In spring 1998, ADG of steers grazing BFT and RBFT were 39 to 109% greater ($P < 0.10$) than that of steers grazing the other three treatments (Table 2). However, total forage production was lower ($P < 0.10$) for RBFT and BFT than for the other treatments. The BFT and RBFT supported only 38 d of grazing compared to 50 d for the other treatments. Thus, fewer total steer days/hectare were recorded for BFT and RBFT than for the other treatments.

Although steers grazing BFT+TF, RBFT+TF, and TF had no difference in ADG, total steer days/hectare, and total forage production were greater ($P < 0.10$) for BFT+TF and RBFT+TF than for TF (Table 2). Our data suggest that a mixture of birdsfoot trefoil and TF will produce more total weight gain/hectare than will TF alone. Burns and Standaert (1985) found that ADG was greater for steers and calves grazing legume-grass pastures than for those grazing grass monocultures top-dressed with N. However, they also found that steer

gain was lower for TF than for other grasses in a legume-grass system.

Forage samples from the RBFT and BFT treatments contained less NDF ($P < 0.05$) and more CP ($P < 0.05$) than forage from the other treatments (Table 3). These differences correlate with the greater ($P < 0.10$) ADG of steers grazing BFT and RBFT (Table 2). In mixed pastures, the proportion of birdsfoot trefoil was 31 and 32% for RBFT+TF and BFT+TF, respectively (Table 3). Although adding birdsfoot trefoil to grass pastures would be expected to increase the quality of available forage (Burns and Standaert, 1985; Hoveland et al., 1991), the differences in ADF and NDF between BFT+TF, RBFT+TF, and TF were not consistent. The NDF was less ($P < 0.05$) for BFT+TF than for RBFT+TF or TF, but ADF was not different among treatments. Crude protein was not different for BFT +TF and RBFT+TF (average of 11.9%) but was greater ($P < 0.05$) than that for TF (9.1%).

In spring 1998, the major benefit of birdsfoot trefoil in the mixed pastures seemed to be greater total forage production rather than increased forage quality. Our results for spring 1998 are in contrast to those of Hoveland et al. (1991). In that study, 'Fergus' birdsfoot trefoil and volunteer white clover comprised an average of 19% of the total forage in a TF-legume system during spring grazing. Daily gain and gain/steer were improved on TF-legume pastures compared to TF pastures. However, the stocking rate was lower for TF-legume pastures than for TF pastures, because less total forage was available in the mixtures.

Fall 1998

In fall 1998, the growth of RBFT and BFT was not sufficient to support grazing for more than a few days. Thus, steer performance for these treatments was not measured. The other three treatments, however, were able to support grazing for 57 d. In fall 1998, the ADG of steers was not different for BFT+TF, RBFT+TF, and TF (Table 2). Total forage production for BFT+TF pastures was 7,466 kg/ha, which was 26 and 39% more total forage ($P < 0.10$) than RBFT+TF and TF pastures,

Table 2. Total forage production and performance of steers grazing pure and mixed pastures

Treatment ^a	ADG	Total steer days	Total weight gain	Total forage production
	kg/d	d/ha	kg/ha	
Spring 1998				
BFT	1.53 ^f	289 ^f	442 ^g	3,304 ^e
RBFT	1.29 ^f	220 ^e	284 ^e	3,523 ^e
BFT+TF	0.93 ^e	442 ^h	411 ^f	8,977 ^g
RBFT+TF	0.93 ^e	432 ^h	402 ^f	8,132 ^g
TF	0.73 ^e	362 ^g	264 ^e	7,007 ^f
SE ^b	0.10	26	23	981
Fall 1998				
BFT+TF	0.69 ^e	370 ^g	251 ^g	7,466 ^f
RBFT+TF	0.68 ^e	320 ^f	221 ^f	5,927 ^e
TF	0.66 ^e	271 ^e	178 ^e	5,377 ^e
SE ^c	0.06	17	11	532
Spring 1999				
BFT	1.26 ^g	341 ^e	429 ^{fg}	4,266 ^f
RBFT	1.43 ^h	288 ^e	411 ^f	1,970 ^e
BFT+TF	0.82 ^f	587 ^f	480 ^h	8,918 ^h
RBFT+TF	0.82 ^f	544 ^f	446 ^g	7,556 ^g
TF	0.65 ^e	541 ^f	354 ^e	8,475 ^h
SE ^d	0.06	20	28	797

^aTreatments were rhizomatous birdsfoot trefoil (RBFT), nonrhizomatous birdsfoot trefoil (BFT), tall fescue (TF), and mixtures of rhizomatous birdsfoot trefoil and tall fescue (RBFT+TF) and nonrhizomatous birdsfoot trefoil and tall fescue (BFT+TF).

^bSE = standard error; n = 52 for ADG, total steer days, and total weight gain and n = 20 for total forage production.

^cSE = standard error; n = 36 for ADG, total steer days, and total weight gain and n = 12 for total forage production.

^dSE = standard error; n = 52 for ADG, total steer days, and total weight gain and n = 20 for total forage production.

^{e,f,g,h}Within a column, means lacking a common superscript differ ($P < 0.10$).

Table 3. Forage quality and botanical composition of pure and mixed pastures^a

Treatment ^b	NDF	ADF	CP	Proportion birdsfoot trefoil ^c
				%
Spring 1998				
BFT	58.4 ^e	38.1 ^e	17.5 ^g	100 ^g
RBFT	57.3 ^e	38.5 ^e	16.4 ^g	100 ^g
BFT+TF	69.5 ^f	40.7 ^{ef}	12.5 ^f	32 ^f
RBFT+TF	72.7 ^g	44.8 ^f	11.2 ^f	31 ^f
TF	74.7 ^g	44.1 ^f	9.1 ^e	0 ^e
SE ^d	1.0	1.7	0.6	2.2
Fall 1998				
BFT+TF	63.2 ^e	38.1 ^e	14.8 ^g	19 ^f
RBFT+TF	64.9 ^e	38.3 ^e	13.1 ^f	8 ^e
TF	69.1 ^f	41.9 ^f	10.9 ^e	0 ^e
SE	1.0	0.9	0.2	3.1
Spring 1999				
BFT	50.3 ^e	39.4 ^e	16.8 ^g	100 ^h
RBFT	50.3 ^e	37.0 ^e	15.8 ^g	100 ^h
BFT+TF	60.7 ^f	37.3 ^e	13.1 ^f	14 ^g
RBFT+TF	64.7 ^g	39.6 ^g	11.4 ^e	9 ^f
TF	64.9 ^g	39.2 ^e	10.9 ^e	0 ^e
SE	1.2	1.2	0.5	2.0

^aValues presented are the mean of individual sampling dates for each grazing trial.

^bTreatments were rhizomatous birdsfoot trefoil (RBFT), nonrhizomatous birdsfoot trefoil (BFT), tall fescue (TF), and mixtures of rhizomatous birdsfoot trefoil and tall fescue (RBFT+TF) and nonrhizomatous birdsfoot trefoil and tall fescue (BFT+TF).

^cProportion of birdsfoot trefoil in pasture, expressed on a % DM basis.

^dSE = standard error; for spring 1998, n = 60; fall 1998, n = 36; spring 1999, n = 60.

^{e,f,g,h}Within a column, means lacking a common superscript differ ($P < 0.05$).

respectively. As a result, steer days/hectare and gain/hectare were greatest ($P < 0.10$) for BFT+TF, intermediate for RBFT+TF, and lowest for TF (Table 2).

Forage from the BFT+TF and RBFT+TF pastures contained less ($P < 0.05$) NDF and ADF than that from the TF pastures, even though birdsfoot trefoil comprised only 19 and 8% of the total forage on offer in the BFT+TF and RBFT+TF pastures, respectively (Table 3). Whereas BFT+TF and RBFT+TF had less NDF and ADF and more CP than TF ($P < 0.05$), these differences were not reflected in ADG (Table 2). These results may be attributed to the selectivity of grazing steers as well as to different stocking rates among the three treatments. In another study, Wen (2001) showed that cattle selected forage with less NDF and ADF but greater CP contents compared to the concentration of these components in the pasture forage. The steer days/hectare were highest for BFT+TF, lowest for TF, and intermediate for RBFT+TF, corresponding to total forage production on the three treatments. Therefore, the greater availability and consumption of preferred species and plants may have limited differences in ADG.

Although our data are not conclusive in this regard, it does reiterate the need to test forages using grazing livestock instead of relying exclusively on chemical analysis. Similarly, Vogel et al. (1993) found that differences in forage composition did not necessarily explain differences in steer ADG.

Spring 1999

In spring, 1999, ADG of steers grazing RBFT pastures was greater ($P < 0.10$) than that of steers on any other treatment (Table 2). Steers grazing BFT had about 12% lower ($P < 0.10$) ADG than those grazing RBFT but gained faster ($P < 0.10$) than those grazing BFT+TF, RBFT+TF or TF. In the mixed pastures, steers grazing BFT+TF and RBFT+TF gained 0.82 kg/d^{-1} , which was approximately 26% more ($P < 0.10$) than steers grazing TF.

Total forage production for RBFT was only about one-fourth ($P < 0.10$) of that produced by RBFT+TF, BFT+TF, or TF (Table 2). Total forage production for BFT pastures was about two times greater ($P < 0.10$) than for RBFT pastures, but BFT pastures produced only about half as much total forage as RBFT+TF, BFT+TF, or TF. The lower ($P < 0.10$) total forage production for BFT and RBFT contributed to fewer steer days on these treatments. However, despite the low total forage production for RBFT and BFT pastures, the higher ($P < 0.10$) ADG of steers grazing RBFT and BFT resulted in total weight gains/hectare that were greater ($P < 0.10$) than those reported for TF.

Steers grazing BFT+TF and RBFT+TF pastures had greater ($P < 0.10$) ADG than those on TF, but total forage production (except for RBFT+TF) and total steer days were not different among these three treatments. Therefore, ADG was largely responsible for the greater ($P < 0.10$) total weight gain/hectare of steers grazing

BFT+TF and RBFT+TF pastures rather than TF pastures. Fiber and CP of forage from RBFT+TF and TF did not differ. However, BFT+TF had less ($P < 0.05$) NDF and greater ($P < 0.05$) CP than RBFT+TF and TF (Table 3). Therefore, the birdsfoot trefoil component contributed to improved forage quality in BFT+TF pastures, but not in RBFT+TF pastures. However, steers achieved greater ($P < 0.10$) ADG on the two mixed pastures than on TF. These findings again show that the chemical composition of different cultivars of forage do not always account for all the improvement in ADG. Moore et al. (1995) also found significant differences in ADG of beef cattle grazing wheatgrass (*Agropyron desertorum* [Fisch. ex Link] Schult) pastures; however, they noted few differences in forage quality among treatments.

The proportion of birdsfoot trefoil was 9 and 14% for RBFT+TF and BFT+TF, respectively, in this grazing trial. Apparently, birdsfoot trefoil even at this low percentage in a TF pasture can contribute to better steer performance. Birdsfoot trefoil contains condensed tannins that improve protein utilization and livestock gain (Douglas et al., 1995). Wen (2001) found that RBFT contained nearly three times more condensed tannin than BFT. So, although the proportion of RBFT in the mixed pastures was less than BFT, the greater condensed tannin content of RBFT may have led to the equal ADG for the RBFT+TF and BFT+TF treatments.

Hoveland et al. (1991) found that both birdsfoot trefoil and clovers improved steer ADG compared to TF+N in the 1st yr, but as legumes comprised less of the forage each year, the advantage disappeared. By the 3rd yr of their study, birdsfoot trefoil comprised only 3% of the total forage in the pasture. In our study, the proportion of birdsfoot trefoil in the mixed pasture decreased ($P < 0.05$) by 56 and 71% for BFT+TF and RBFT+TF, respectively, from spring 1998 to spring 1999. We noted that about 90% of RBFT plants in mixed pastures produced 8 to 10 rhizomes/plant in the autumn of each year. This is in contrast to the results reported by Kallenbach et al. (2001), who found that RBFT in a spaced-plant experiment produced as many as 47 rhizomes/plant in autumn. While unexpected, this might be attributed to the following factors: 1) the continuous grazing management limited the number of rhizomes that were produced each autumn; 2) selectivity of birdsfoot trefoil by the steers grazing mixed pastures; and 3) competition from the TF. In addition, allelopathy from TF has also been reported (Peters and Zam, 1981) and may have contributed to the decline of birdsfoot trefoil in the mixed pastures.

Implications

Beef producers could improve the performance of grazing steers by interseeding birdsfoot trefoil to tall fescue pastures. In addition, no N fertilizer would be needed for interseeded pastures compared to pure tall fescue pastures, and thus the cost to produce beef would

likely be lower for interseeded pastures. Compared to nonrhizomatous birdsfoot trefoil, the ability of rhizomatous birdsfoot trefoil to spread by rhizomes did not lead to greater total forage production or livestock performance in this short-term study. Perhaps rhizomatous birdsfoot trefoil will have improved persistence in the longer term, but at present it appears that nonrhizomatous birdsfoot trefoil provides the same benefits.

Literature Cited

- Beuselinck, P. R., and W. F. Grant. 1995. Birdsfoot trefoil. In: R. F. Barnes, D. A. Miler and C. J. Nelson (ed.) *Forages: An Introduction to Grassland Agriculture*. vol. 1. pp 237–248. Iowa State University Press, Ames.
- Beuselinck, P. R., E. J. Peters, and R. L. McGraw. 1984. Cultivar and management effects on stand persistence of birdsfoot trefoil. *Agron. J.* 76:490–492.
- Beuselinck, P. R., and J. J. Steiner. 1996. Registration of 'ARS-2620' birdsfoot trefoil. *Crop Sci.* 36:1414.
- Bransby, D. I. 1989. Compromises in the design and conduct of grazing experiments. In: G. C. Marten (ed.) *Grazing Research: Design, Methodology and Analysis*. pp 53–57. CSSA Spec. Publ. 16. Crop Sci. Soc. Am., Madison, WI.
- Burns, J. C., and J. E. Standaert. 1985. Productivity and economics of legume-based vs. nitrogen-fertilized grass-based pasture in the United States. In: R. F. Barnes, P. R. Ball, R. W. Brougham, G. C. Marten, and D. J. Minson (ed.) *Forage Legumes for Energy-Efficient Animal Production*. Proc. Trilateral Workshop, Palmerston North, NZ. pp 56–71.
- Douglas G. B., Y. Wang, G. C. Waghorn, T. N. Barry, R. W. Purchas, A. G. Foote, and G. F. Wilson. 1995. Live weight gain and wool production of sheep grazing *Lotus corniculatus* and lucerne (*Medicago sativa*). *N. Z. J. Agric. Res.* 38:95–104.
- Gebrehiwot, L., and P. R. Beuselinck. 1997. Cyanogens and condensed tannin concentration in three *Lotus* species. In: 1997 Agronomy Abstracts. p 144. Am. Soc. Agron., Madison, WI.
- Goering, H. K., and P. J. Van Soest. 1970. Forage fiber analyses (apparatus, reagents, procedures, and some applications). *Agric. Handbook No. 379*. ARS, USDA, Washington, DC.
- Henson, P. R. 1962. Breeding for resistance to crown and root rots in birdsfoot trefoil. *Crop Sci.* 2:429–432.
- Hoveland, C. S., D. R. Hardin, P. C. Worley, and E. E. Worley. 1991. Steer performance on perennial vs. winter annual pastures in north Georgia. *J. Prod. Agric.* 4:24–28.
- Hoveland, C. S., R. R. Harris, R. L. Haaland, J. A. Mcguire, W. B. Webster, and V. H. Calvert II. 1985. Birdsfoot trefoil lotus-corniculatus and grass pasture for steers in the Tennessee valley USA. *Alabama Agric. Exp. Stn. Bull.* (567) 3–11, Auburn.
- Hoveland, C. S., N. S. Hill, R. S. Lowery Jr., S. L. Fales, M. E. McCormick, and A. E. Smith Jr. 1988. Steer performance on birdsfoot trefoil and alfalfa pasture in Central Georgia. *J. Prod. Agric.* 1:343–346.
- Kallenbach, R. L., R. L. McGraw, P. R. Beuselinck, and C. A. Roberts. 2001. Summer and autumn growth of rhizomatous birdsfoot trefoil. *Crop Sci.* 41:149–156.
- McGraw, R. L., P. R. Beuselinck, and G. C. Marten. 1989. Agronomic and forage quality attributes of diverse entries of birdsfoot trefoil. *Crop Sci.* 29:1160–1164.
- Moore, K. J., C. A. Roberts, and J. O. Fritz. 1990. Indirect estimation of botanical composition of alfalfa-smooth bromegrass mixtures. *Agron. J.* 82:287–290.
- Moore, K. J., K. P. Vogel, T. J. Klopfenstein, R. A. Masters, and B. E. Anderson. 1995. Evaluation of four intermediate wheatgrass populations under grazing. *Agron. J.* 87:744–747.
- Peters, E. J., and A. H. B. M. Zam. 1981. Allelopathic effects of tall fescue genotypes. *Agron. J.* 73:56–58.
- Shenk, J. S., and M. O. Westerhaus. 1991. Population structuring of near infrared spectra and modified partial least squares regression. *Crop Sci.* 31:1548–1555.
- Steevens, B. J., R. Belyea, and R. J. Crawford, Jr. 1986. Using a microwave oven to determine moisture in forage. *MU Guide G3151*. Univ. of Missouri-Columbia Ext. Div., Univ. of Missouri, Columbia.
- Stephenson, R. J., and G. L. Posler. 1988. The influence of tall fescue on the germination, seedling growth and yield of birdsfoot trefoil. *Grass Forage Sci.* 43:273–278.
- Vogel, K. P., B. C. Gabrielsen, J. K. Ward, B. E. Anderson, H. F. Mayland, and R. A. Masters. 1993. Forage quality, mineral constituents, and performance of beef yearlings grazing two crested wheatgrasses. *Agron. J.* 85:584–590.
- Wen, L. 2001. Steer performance on birdsfoot trefoil and tall fescue pastures. Ph.D. dissertation. Univ. of Missouri, Columbia.
- Westerhaus, M. O. 1985. Equation development.. In: G. C. Marten, J. S. Shenk, and F. E. Barton, II (ed.) *Near Infrared Reflectance Spectroscopy (NIRS): Analysis of Forage Quality*. USDA Agric. Handbook No. 643. p 38. U.S. Govt. Printing Office, Washington, DC.

References

This article cites 14 articles, 10 of which you can access for free at:
<http://jas.fass.org/cgi/content/full/80/7/1970#BIBL>