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Sequence grazing systems on the southern plains

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Abstract

Eastern gamagrass (*Tripsacum dactyloides* (L.) L.) is a perennial warm-season bunchgrass that starts growth earlier in the spring than most other warm-season grasses. This suggests that combining eastern gamagrass with other warm-season grasses in a sequence grazing system could lengthen the period of rapid livestock gain. We studied sequence grazing systems consisting of eastern gamagrass and Old World bluestem (*Bothriochloa ischaemum* L.) (EG-OWB) as compared to native mixed prairie and Old World bluestem (Native-OWB) from 1993 to 1997. Crossbred beef steers averaging 239 kg grazed eastern gamagrass or native pasture from early May to early June and again from late July through August. Old World bluestem was grazed in mid season. We measured forage yield and nutritive value and steer gain. Standing forage of eastern gamagrass above a 15-cm stubble height averaged 895 kg ha^{-1} at the start of the first grazing period and 2,430 kg ha^{-1} at the start of the second grazing period. Dry, cold winter and spring weather reduced this amount to 80 kg ha^{-1} in May 1996 and precluded grazing the eastern gamagrass that season. Crude protein content of eastern gamagrass was greater than 14% and in vitro dry matter disappearance (IVDMD) was greater than 65% in May. By August, crude protein content had dropped to 5–8% and IVDMD was 45–50%. Peak standing crop of Old World bluestem averaged 4,580 kg ha^{-1} over years. Steer gain over the entire grazing season, 103 days, did not differ between forage systems, averaging 1.02 kg head^{-1} day^{-1} in both systems. Steer gain was higher on native pasture than eastern gamagrass in the late grazing season (0.91 versus 0.60 kg head^{-1} d-1, p=0.02). As a result of higher stocking rates, steer gain was 257 kg ha^{-1} for the EG-OWB system and 103 kg ha^{-1} for the Native-OWB system (P<0.01).

Key Words: complementary forages, Old World bluestem, *Bothriochloa*, eastern gamagrass, *Tripsacum*, forage quality, livestock performance

Resumen

El "Eastern gamagrass" (*Tripsacum dactyloides* (L.) L.) es un zacate perenne, amacollado, de estación caliente y que en primavera inicia el crecimiento antes que otros zacates de estación caliente. Esto sugiere que combinando el "Eastern gamagrass" con otros zacates de estación caliente en un sistema de apacentamiento en secuencia se podría alargar el período de ganancias rápidas del ganado. De 1993 a 1997 estudiamos sistemas de apacentamiento en secuencia que consistieron de "Eastern gamagrass" y "Old World Bluestem" (*Bothriochloa ischaemum* L.) (EG-OWB) comparado con pastizal nativo mixto y "Old World Bluestem" (Nativo-OWB). Novillos comerciales para carne con peso promedio de 239 kg apacentaron "Eastern gamagrass" o pastizal nativo de inicios de Mayo a inicios de Junio y nuevamente de fines de Julio y Agosto, el "Old World Bluestem" se apacentó a mediados de la estación. Medimos el rendimiento de forraje y su valor nutritivo y la ganancia de los novillos. La producción de forraje del "Eastern gamagrass" arriba de 15 cm de altura del rastrojo remanente promedio 895 kg ha^{-1} al inicio del primer período de apacentamiento y 2340 kg ha^{-1} al inicio del segundo período. El clíma seco y frío del invierno y primavera redujo esta cantidad de forraje a 80 kg ha^{-1} en Mayo de 1996, lo que imposibilitó el apacentamiento del "Eastern gamagrass" en esa estación. En Mayo, el contenido de proteína cruda del "Eastern gamagrass" fue superior al 14% y la desaparición de la materia seca in vitro (DMSIV) más del 65%. Para Agosto, el contenido de proteína cruda había disminuido al 6-8% y la DMSIV fue del 45–50%. La producción máxima promedio de forraje en pie del "Old World Bluestem" fue de 4,850 kg ha^{-1}. La ganancia de peso de los novillos en toda la estación de apacentamiento, 103 días, no difirió entre sistemas de forraje promediando 1.02 kg dia^{-1} cabeza^{-1} en ambos sistemas. En la última estación de apacentamiento, la ganancia de los novillos fue mayor en pastizal nativo que en "Eastern gamagrass" (0.91 vs 0.6 kg dia^{-1} cabeza^{-1}, P=0.02). Como resultado de las altas cargas animal, la ganancia de los novillos en el sistema EG-OWB fue de 257 kg ha^{-1} y 103 kg ha^{-1} para el sistema Nativo – OBG (P<0.01).

Eastern gamagrass (*Tripsacum dactyloides* (L.) L.) is a large perennial warm-season bunchgrass, native from the southern and central plains of North America eastward to New York and Florida. It is highly palatable and is usually one of the first species eliminated by continuous heavy grazing (Stubbendieck et al. 1993). It is now most commonly found on higher moisture sites that are protected from grazing. Eastern gamagrass starts growth earlier in the spring than most warm-season grasses. It can be highly productive and a number of selection, breeding, and management studies on

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this species are underway (USDA-SCS 1993).

Experience of producers and our preliminary eastern gamagrass grazing studies (Berg et al. 1993) indicate cattle will repeatedly graze regrowth on some plants or portions of pastures to the near exclusion of grazing as yet ungrazed plants. This repeated intense grazing reduces plant vigor and may eventually reduce the stand. To avoid this problem, intensive grazing management with a maximum of 4 to 6 days per pasture, leaving a stubble height of 15 to 20 cm followed by a rest period of 3 to 5 weeks is suggested (C. L. Dewald, unpublished).

Old World bluestems (*Bothriochloa* spp.) have been extensively planted on retired cropland in the panhandles of Oklahoma and Texas. These grasses are highly productive and respond well to nitrogen fertilization (Berg 1990). Nutritive value is high early in the growth cycle (White and Dewald 1996) but declines rapidly if the grasses are not grazed rather intensively to keep herbage in an immature state.

Sequence grazing is a grazing method where 2 or more land units that support different forage species are grazed in succession (Forage and Grazing Terminology Committee 1991). Sequence grazing takes advantage of differences among forages grown in separate areas to meet management objectives. Our objective in this study was to evaluate and compare sequence grazing systems combining eastern gamagrass or native prairie with Old World bluestem.

Materials and Methods

This study was conducted from 1993 through 1997 at the USDA-ARS Southern Plains Range Research Station in northwestern Oklahoma (36°27'N, 99°23'W, elev. 625 m). The regional climate is continental. Average annual precipitation is 602 mm with 70% falling during the April–September growing season. Average monthly temperatures are 1.1°C in January and 28.8 °C in July. Minimum and maximum recorded temperatures are –28.3°C and 45.6°C.

Three forage types were included in the study. The first forage was 'Pete' eastern gamagrass seeded in 1990 on Enterprise fine sandy loam (coarse-silty, mixed, thermic Typic Ustochrepts) with a 1–3% slope. The pastures had been previously cropped to wheat or grain sorghum for at least 60 years. The soil tested adequate in P (75 ppm) and K (520 ppm) by Mehlich 3 extraction.

The second forage was 'WW-Iron Master' Old World bluestem (*Bothriochloa ischaemum* L.) seeded in 1991 on similar Enterprise fine sandy loam soils directly adjacent to the eastern gamagrass pastures. These fields had also been cropped for many years.

The third forage was native mixed grass prairie dominated by little bluestem [*Schizachyrium scoparium* (Michx.) Nash], sideoats grama [*Bouteloua curtipendula* (Michx.) Torr.], and sand bluestem [*Andropogon hallii* Hack.]. The soils were predominantly Woodward loams (coarse-silty, mixed, thermic family of Typic Ustochrepts) which are Loamy Prairie ecological sites. The pastures had been previously cropped and then seeded to a mixture of warm-season grasses about 40-years ago. At the time of the study, they were in a high seral ecological status. The native pastures were located 0.8 km from the eastern gamagrass and Old World bluestem pastures.

The 2 monocultures, eastern gamagrass and Old World bluestem, were burned each spring in early to mid April to remove excess residue. We did not burn these pastures in the spring of 1996 because of very low precipitation the previous winter. These 2 forages were fertilized annually with 67 kg N ha^{-1} as ammonium nitrate. Fertilizer was applied 1 to 2 weeks after burning. The eastern gamagrass was originally seeded with a row spacing of 122 cm and this spacing was maintained over the course of the study by annual spring cultivation. No cultural practices were applied to the native pastures.

Experimental treatments consisted of 2 sequence grazing systems (Table 1). The first system combined eastern gamagrass and Old World bluestem (EG-OWB). The second system combined native pasture and Old World bluestem (Native-OWB). There were 2 replications of each system. The experimental units of eastern gamagrass were further subdivided into 7 paddocks of 0.23 ha to allow rotation grazing.

Stocking rates for eastern gamagrass and Old World bluestem were based on preliminary experimental work at this

Table 1. Management characteristics and livestock performance for 2 sequence grazing systems. Data are averaged over years.

Characteristic	Sequence Grazing System: Eastern Gamagrass + Old World Bluestem	Sequence Grazing System: Native + Old World Bluestem
Pasture Size (ha)		
Eastern gamagrass	1.6	---
Native	---	6.5
Old World bluestem	1.6	1.6
Total area	3.2	8.1
Stocking Rate (ha head^{-1})		
Eastern gamagrass	0.2	---
Native	---	0.8
Old World bluestem	0.2	0.2
Total	0.4	1.0
Average Daily Gain by Grazing Period (kg head^{-1} day^{-1})		
1st Eastern gamagrass or native	1.20	1.12
Old World bluestem	1.21	1.05
2nd Eastern gamagrass or native	0.60*[1]	0.91
Overall	1.02	1.02
Beef Production (kg ha^{-1})		
Eastern gamagrass or native	223*	66
Old World bluestem	291	251
Total	257*	103

station. At these stocking rates, forage production should be adequate to sustain the planned grazing periods as well as maintain plant vigor over years. Stocking rates for the native prairie were based on a recommended growing season stocking rate of 2.43 ha $steer^{-1}$ for 180 days or 74.0 steer-days ha^{-1} (McIlvain et al. 1955). To maintain a similar stocking rate but reduce the grazing period to 55 days for the sequence grazing system would require a land allowance of 0.74 ha $steer^{-1}$. Our actual stocking rate was slightly lower at 66.7 steer-days ha^{-1} with a land allowance of 0.81 ha $steer^{-1}$.

For the eastern gamagrass and Old World bluestem (EG-OWB) system, grazing started on eastern gamagrass when the canopy height reached 30–36 cm. Steers were allowed to graze the eastern gamagrass to a 15- to 25-cm stubble height before moving to the next paddock. The steers remained in a paddock for 2 days when the grazing season started and the stay lengthened to 3 to 5 days per paddock as the season progressed. After the steers had grazed each of the eastern gamagrass paddocks once they were moved to the Old World bluestem units. Canopy height for the Old World bluestem was 15 to 20 cm at this time. Steers grazed the Old World bluestem to a 7.5- to 10-cm stubble height and were then moved back to the eastern gamagrass. During this second grazing period on eastern gamagrass, paddocks were each grazed once using a 4- to 5-day grazing period. Grazing management in the Native-Old World bluestem (Native-OWB) system was similar except that native pasture was substituted for eastern gamagrass. Native pastures were not subdivided into paddocks. The management of the Old World bluestem units was identical between the 2 grazing systems. Average management dates were: a) start of grazing season 15 May; b) move to Old World bluestem 7 June; c) move back to eastern gamagrass 26 July, and d) end of grazing season 26 August. The first grazing period (eastern gamagrass or native pasture) averaged 23 days, the Old World bluestem grazing period averaged 49 days, and the second eastern gamagrass or native pasture grazing period averaged 31 days, for a total grazing season of 103 days.

Eight yearling beef steers were allocated to each experimental unit. Steers were typical crossbred yearlings and were assigned to treatment group by weight. Initial weights averaged 239 kg. The steers were grazed in common on rangeland prior to the start of the sequence grazing systems. Steers were weighed at the beginning and end of the grazing season and also at each change in forage type. At each weigh date, the steers were held for 18 hours without feed or water before weighing. Steers were implanted with Synovex[1] in early May. They had unlimited access to block salt and were not supplemented during the study period.

Forage standing crop was measured on each eastern gamagrass paddock the day grazing began on that paddock for both the first and second grazing periods. We hand-clipped 5 random 3-m lengths of row to a 15-cm stubble height. Standing crop was not measured in the second grazing period in 1996. On the Old World bluestem units, we hand-clipped 5 quadrats, 0.5 x 1.0 m, to a stubble height of 5 cm at the beginning of grazing. Peak standing crop of Old World bluestem in each pasture was determined in July by harvesting 1.3 x 4.9-m plots with a sickle bar harvester within each of 5 exclosures. The exclosures were moved each year. Forage samples were dried at 60°C. Two forage samples from each experimental pasture were randomly selected for analysis of nutritive value on each sampling date. Samples were uniformly ground and analyzed for N (kjeldahl procedure, Bremner and Breitenbeck 1983) and in vitro dry matter disappearance (IVDMD, Tilley and Terry 1963 as modified by White et al. 1981). Nitrogen concentration was multiplied by 6.25 to estimate crude protein.

Eastern gamagrass standing crop was analyzed as a repeated measures design with year and month within year (May or August) as independent variables. For this analysis, standing crop was averaged over all paddocks within replicate and month. Crude protein content and IVDMD of the forage were analyzed using the same methods.

Old World bluestem standing crop was analyzed as a repeated measures design with year and date within year (start of grazing in June or peak standing crop in July) as independent variables. Crude protein content and IVDMD of the forage were analyzed using the same methods.

Steer gains were analyzed as a completely randomized design with repeated measures. Forage system was the independent variable and year was the repeated variable. Gain per head was analyzed for each grazing period and for the entire season. Gain per ha was analyzed for each forage component within the forage systems and for the overall forage system.

Gain per head results were then combined over years by correlating average daily gain against grazing pressure. Grazing pressure was expressed as forage demand divided by forage availability on a daily basis (Heitschmidt and Taylor 1991). Animal units were calculated as $BW^{.75}/500^{.75}$ with BW as body weight at the start of a grazing period and a base weight of an animal unit of 500 kg. An animal-unit-day was assumed to equal 12 kg forage. Grazing pressure on eastern gamagrass included the effect of higher stock density as a result of the 7-paddock rotation (livestock grazing pressure of Heitschmidt and Taylor (1991)). Correlations were calculated separately for each forage and grazing period.

For all analyses-of-variance, we assessed treatment effects with a target probability level of 5%. Where treatment effects were significant, the least significant difference (LSD) was used to separate treatments.

Results and Discussion

Weather

Precipitation during the study period was generally favorable (Fig. 1). Only 1994 was below average for both annual and growing season precipitation. While precipitation totals for 1996 were above average, the distribution was highly skewed. Only 66 mm were received during the October 1995 to April 1996 period. This is a record low and is less than one-third of the average of 236 mm for this period. In this same year, 665 mm (3.5 times the average amount) were received in the months of July, August, and September.

[1]Names are necessary to report factually on available data, the USDA neither guarantees nor warrants the standard of the product, and the use of the name by USDA implies no approval of the product to the exclusion of others that may also be suitable.

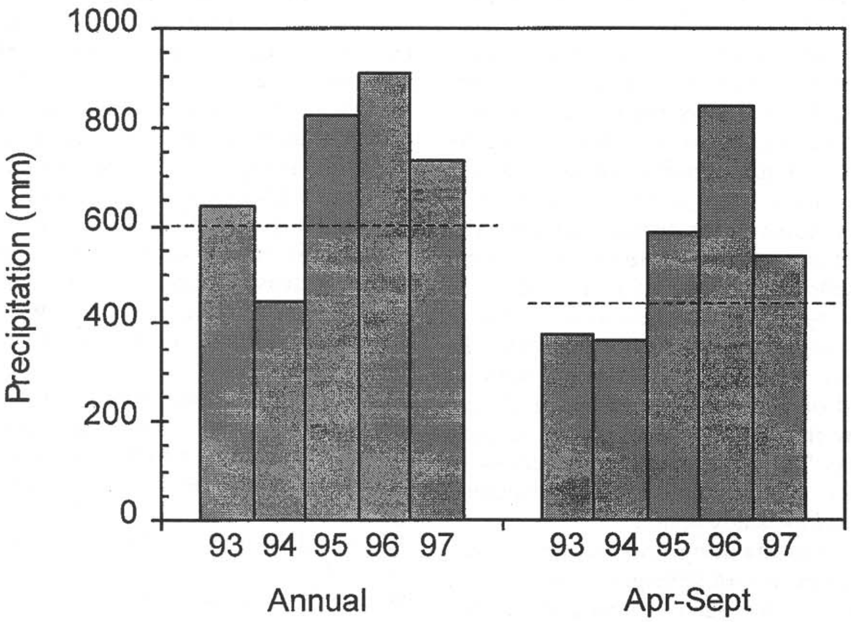

Fig. 1. Precipitation at Woodward, Okla., during the study period. Annual precipitation was totaled from October to September. Dashed lines denote 83-year average.

Eastern Gamagrass Standing Crop

Eastern gamagrass forage above a 15-cm stubble height averaged 1,100 kg ha^{-1} in May, excluding 1996 (Table 2). Weather conditions from late fall 1995 through early spring 1996 severely damaged the eastern gamagrass. A record low amount of precipitation was received during the period. In addition, average daily temperatures were 2°C below normal for the months of November and December and 3°C below normal for March. Average daily minimum temperatures were below normal in every month, ranging from 2.7°C to 5.2°C below the long-term average from November to April. A record minimum temperature for February, –26.7°C, was observed on 4 February. As a result of drought and cold temperatures, average standing crop in May of 1996 was only 80 kg ha^{-1} (Table 2). We attributed the lack of growth in May 1996 to low precipitation and cold temperatures since the standing crop in August 1995 was the highest measured during the study. Grazing was suspended on the eastern gamagrass during the spring and summer of 1996 because of this low vigor. Abundant July–September precipitation in 1996 allowed the gamagrass to recover and standing crops in 1997 were similar to the early study years, especially in August. Because of the sensitivity of eastern gamagrass to early-season drought it is probably better adapted to higher precipitation areas or subirrigated sites.

Standing forage in August averaged 2830 kg ha^{-1} and was significantly greater than standing crop in May for 1993 and 1997 (Table 2). Precipitation in June and July of 1995 was 308 mm which was 222% of normal for that period. The eastern gamagrass produced vigorous regrowth after the first grazing period. The forage growth overwhelmed the electric fence used to delineate the rotation paddocks. The fences were removed and the steers were allowed to use the entire eastern gamagrass grazing unit (within each replication). The standing crop of 4,030 kg ha^{-1} represents a 1-time sample taken over all paddocks on 31 July 1995. This data was not used in the statistical comparisons between years and months because of the difference in sampling methods.

Old World Bluestem Standing Crop

Standing crop of Old World bluestem averaged 1780 kg ha^{-1} (canopy height 15-20 cm) at the start of grazing in early June (Table 3). Standing crop increased significantly by July and averaged 4,580 kg ha^{-1}. July standing crop was significantly correlated with May-June precipitation (r=0.91, P=0.03). This peak standing crop is substantially higher than the 2,845 kg ha^{-1} reported by Berg (1990) at this same location for 'WW-Spar' Old World bluestem. Growing season precipitation was 130% of average in the current study and 104% of average in the earlier study.

Table 2. Standing crop and nutritive value of eastern gamagrass in May and August. Data are averaged over paddocks within month.

Characteristic	May	August
Standing Crop (kg ha^{-1})		
1993	1650b[1]	2840[a]
1994	1140[c]	1380[bc]
1995	800[d]	4030[2]
1996	80[e]	---[3]
1997	830[d]	3080[a]
Crude Protein (%)		
1993	14.6[c]	7.2[de]
1994	17.0[b]	7.6[d]
1995	17.8[b]	6.5[e]
1996	---[3]	---[3]
1997	19.6[a]	5.3[f]
IVDMD (%)		
1993	64.6[b]	46.0[d]
1994	68.2[a]	50.3[c]
1995	66.9[a]	45.4[de]
1996	---[3]	---[3]
1997	68.2[a]	44.0[e]

[1]Within component, means with different letters are significantly different (P<0.05).
[2]Not included in overall statistical analysis because of different sampling methods.
[3]No samples collected.

Table 3. Standing crop and nutritive value of Old World bluestem in early June, before grazing began, and in exclosures in late July. Data are averaged over grazing systems within month.

Characteristic	June	July
Standing Crop (kg ha^{-1})		
1993	2700^{c1}	5070^{b}
1994	1680^{de}	2450^{c}
1995	1290^{e}	7600^{a}
1996	1900^{d}	5080^{b}
1997	1330^{e}	2850^{c}
Crude Protein (%)		
1993	10.2^{d}	4.9^{g}
1994	12.2^{c}	8.5^{e}
1995	14.7^{a}	4.8^{g}
1996	12.5^{bc}	7.3^{ef}
1997	14.0^{ab}	5.6^{g}
IVDMD (%)		
1993	67.8^{ab}	56.2^{cd}
1994	71.0^{a}	65.9^{b}
1995	69.8^{a}	52.0^{e}
1996	68.7^{ab}	53.5^{de}
1997	65.8^{b}	58.3^{c}

[1]Within component, means with different letters are significantly different (P<0.05).

Nutritive Value of Forage

The nutritive value of eastern gamagrass declined significantly from May to August (P<0.05, Table 2). Crude protein content in May was greater than 14% for all years, ranging from 14.6% in 1993 to 19.6% in 1997. In vitro dry matter disappearance in May was always above 64%. In contrast, crude protein content in August was 5 to 8% (Table 2). Aiken (1997) reported late summer crude protein levels for eastern gamagrass leaves at about 6% over 3 years.

In vitro dry matter disappearance was 44 to 50% in August and varied slightly over years although these differences are probably not practically significant. These nutritive values are similar to those reported by Burns et al. (1992). The crude protein values in this study are similar but the IVDMD levels are slightly higher than results from Illinois (Faix et al. 1980).

Crude protein content of Old World bluestem was also relatively high, 10 to 15%, early in its growth cycle and was affected by year. In vitro dry matter disappearance in June ranged from 65 to 71% and was affected by year (Table 3). Crude protein in July ranged from 4.8 to 8.5% and was significantly lower in 1993, 1995, and 1997 than in 1994 and 1996. The highest and lowest crude protein levels, June and July 1995, were associated with the lowest and highest standing crops. In vitro dry matter disappearance in July ranged from 52 to 66% and was significantly higher in 1994. In vitro dry matter disappearance in the other 4 years averaged 55%.

Steer Gain

Early season (May-early June) average daily gain (ADG) of the steers was not different between eastern gamagrass and native pasture, averaging 1.16 kg $head^{-1}$ day^{-1} (P<0.05, Table 1). Daily gain was also equal for the 2 systems during the Old World bluestem grazing period in June and July, averaging 1.13 kg $head^{-1}$ day^{-1}.

During the second grazing period on eastern gamagrass or native pasture, steers on native pasture gained more per head than steers on eastern gamagrass (P<0.05). Gains may have been lower on eastern gamagrass pastures in late summer because stocking densities were 28 times greater than on native pastures. Peak standing crop on similar native pastures in this region is estimated at 2890 kg ha^{-1} (Nance and Gray 1978). Average standing crop (above 15 cm) in the eastern gamagrass pastures in August was 2,830 kg ha^{-1} (Table 2). The exact herbage allowance cannot be calculated but it was clearly much higher in the native pastures. It is likely that the steers on native pasture increased the quality of their diet through selective grazing. Livestock performance is more sensitive to stocking density as the growing season progresses (Owensby et al. 1973, 1988, Hart 1978).

Gains on eastern gamagrass in May and August were 1.12 and 0.14 kg $head^{-1}$ day^{-1} in Arkansas (Aiken 1997). These gains are similar to the gains of 1.20 kg $head^{-1}$ day^{-1} in May but much lower than the gains of 0.60 kg $head^{-1}$ day^{-1} during August in this study. In the Arkansas study, cattle were continually stocked, not rotationally stocked as in this study. Stocking rates were similar at 5 head ha^{-1} in both studies. Stocking density was much higher in the current study because the eastern gamagrass units were sub-divided into 7 paddocks. Forage standing crop was lower in the current study averaging 2,830 kg ha^{-1} above 15 cm compared to 6,300 kg ha^{-1} above 12.5 cm in Arkansas. The one-seventh stocking density combined with the 2.22 times standing crop results in a forage allowance approximately 15 times greater in Arkansas. The lower gains in the Arkansas study in August are unexpected given the greater forage allowance. Forage crude protein and IVDMD were not greatly different for the 2 locations.

When the early and late period are averaged, steers gained 0.84 kg $head^{-1}$ day^{-1} on eastern gamagrass. This is close to the 0.82 kg $head^{-1}$ day^{-1} reported by Burns et al. (1992) in North Carolina. Steers in their study were continuously stocked under put-and-take management to maintain an average canopy height of 32 cm. Steer gains for the entire 103-day grazing period were similar between eastern gamagrass-Old World bluestem (EG-OWB) and Native-OWB forage systems at 1.02 kg $head^{-1}$ day^{-1}.

Average daily gains were not related to grazing pressure for eastern gamagrass or Old World bluestem (Fig. 2, 3; P>0.50). Grazing pressure was much higher on eastern gamagrass because of 7-paddock rotation grazing. Average daily gain is expected to decline as grazing pressure increases above the critical grazing pressure (Bransby et al. 1988, Manley et al. 1997). Because the critical grazing pressure was not exceeded, average daily gains were apparently maximized. However, gain per ha could have been increased on both forages by increasing stocking rate.

Gain per ha for eastern gamagrass was about 4 times higher than for native pasture (Table 1). This difference is largely a function of stocking rate, 0.2 ha $head^{-1}$ for EG-OWB versus 0.81 ha $head^{-1}$ for Native-OWB, during periods when steers grazed the eastern gamagrass or native pasture. Although gains on native pasture exceeded gains on eastern gamagrass during the second grazing period,

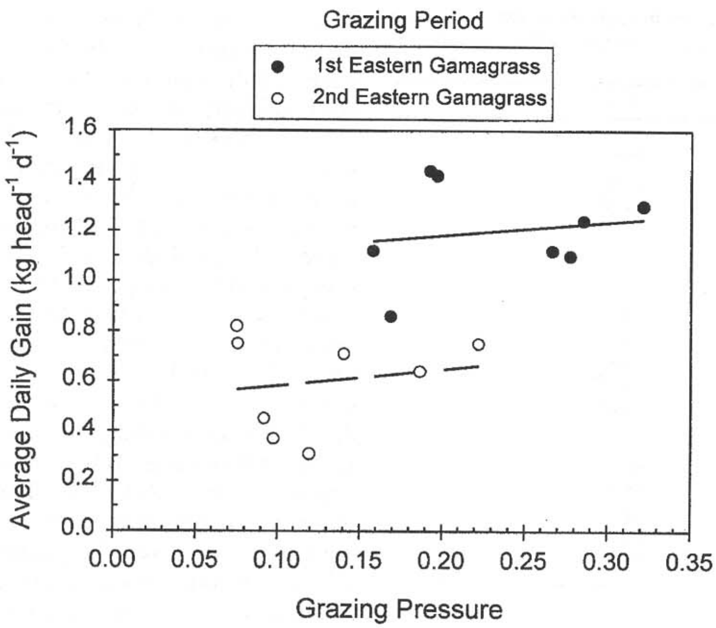

Fig. 2. Relationship between average daily gain and grazing pressure for early and late grazing periods on eastern gamagrass. Correlations are nonsignificant (P>0.50).

the difference was not large enough to compensate for the difference in stocking rate.

Gain per hectare for the Old World bluestem grazing period was similar between forage systems (Table 1). This was expected since stocking rates and ADG were also similar between systems. Gain per hectare overall was about 2.5 times higher in the EG-OWB system. This was again a function of stocking rate since ADG was equal between systems. There were no significant interactions for any livestock response variable and year, indicating treatment responses between forage systems were consistent over years.

While beef production was higher in the EG-OWB forage system, input costs were also higher. These include initial establishment costs, burning, N fertilization, cultivation (for eastern gamagrass), and increased capital costs for livestock because of higher stocking rates. Eastern gamagrass is generally slow to establish and routinely requires 2 growing seasons of deferment for successful establishment, especially on upland sites.

The Native-OWB system produced considerably higher gain per ha than would be expected from a system consisting solely of native pasture. Moderate stocking of native pasture at 2.0 ha steer^{-1} for a May to August grazing season would be expected to produce 67 kg of beef gain per ha (McIlvain et al. 1955) compared to 103 kg of beef gain per ha for the Native-OWB system.

Eastern gamagrass did not produce dramatically more steer-days of grazing per ha than Old World bluestem. Eastern gamagrass produced 267 steer-days ha^{-1} over 54 days while Old World bluestem produced 242 steer-days ha^{-1} over 49 days. Standing forage at the end of the growing season was relatively high in the eastern gamagrass pastures and stocking rates could probably have been increased. In a higher precipitation zone, eastern gamagrass produced 573 steer-days ha^{-1} (0.2 ha steer^{-1} for 116 days, Aiken 1997). The contribution of eastern gamagrass in this study was its earlier growth that allowed an average of 24 days of grazing before the Old World bluestem was ready to graze.

Average daily gains were maximized on eastern gamagrass and Old World bluestem. Maximum gains per ha and maximum economic returns usually occur at stocking rates greater than those stocking rates that maximize average daily gains (Bransby et al. 1988). For this reason, potential gains per ha are probably higher than those observed in this study. Further work on stocking rate relationships is warranted for these forages.

Site productive potential was roughly similar between the eastern gamagrass and native grass pastures. The increase of 400% in stocking rate of eastern gamagrass compared to native pasture is a reasonable comparison. In many cases, eastern gamagrass will be established on soils with higher productive potential than surrounding rangeland and the difference in stocking rate may be greater than with this study. It is unlikely that native pasture would be directly converted to either eastern gamagrass or Old World bluestem. The common scenario would be the establishment of the introduced forages on cropland formerly

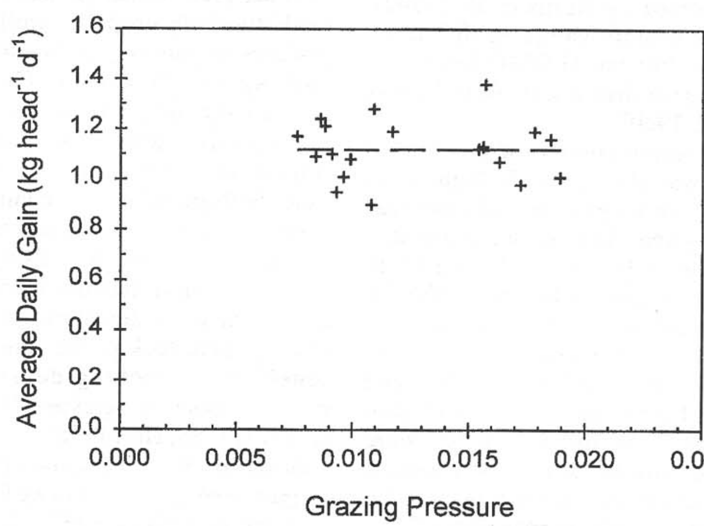

Fig. 3 Relationship between average daily gain and grazing pressure for Old World bluestem. Correlation is nonsignificant (P>0.50).

used for wheat production. The different forage types would than be combined into complementary forage systems.

Grazing management consisting of high stocking densities for relatively short time periods was effective on Old World bluestem. This plan increases beef production per ha by concentrating all grazing days during the period when the Old World bluestem is high in nutritive value. This is the same principle used in intensive early stocking of tallgrass prairie (Owensby et al. 1988).

Our grazing management objective was to heavily graze the Old World bluestem during its rapid growth period in an attempt to keep it in a vegetative state. To be successful, grazing should not start until the canopy is 15–20 cm high and growth is rapid. At this point, forage growth rate will be greater than forage demand and forage standing crop will continue to increase. If grazing is started earlier, demand may be greater than growth, forage standing crop will decline, and production for the season will be reduced. In some cases, grazing may have to end sooner than planned. Using this guideline, we were able to maintain adequate forage throughout the planned grazing period for Old World bluestem in 4 of 5 years. The shortest forage supply occurred in 1994, when under June and July drought the Old World bluestem was grazed to a 7.5-cm stubble height by 12 July and the steers were switched back to eastern gamagrass. Intensive grazing of Old World bluestem was effective in combination with both eastern gamagrass and native grasses.

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