Grazing Intensity and Nitrogen Fertilization to Manage Invasive Kleberg Bluestem on Pangolagrass Pastures in Northern Mexico

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ABSTRACT

This study was conducted at the Aldama Experimental Station of the National Research Institute of Forestry, Crops, and Livestock in Aldama, Tamaulipas, Mexico. The objective was to determine the effect of grazing intensity (I) and nitrogen fertilization (F) on botanical composition and forage accumulation (FA) of a pangolagrass (*Digitaria decumbens* Stent.) (P) pasture with Kleberg bluestem (*Dichanthium annulatum* Forsk.) (D). Treatments evaluated resulted from the combinations of two levels of I (High= 80% and Medium= 50% utilization), and two levels of F (0 and 45 lb acre^{-1} of nitrogen). Response variables were seasonal and annual FA and percentage aerial canopy cover of D and P. Response variables were analyzed in complete randomized block design with a 2x2 factorial arrangement of treatments replicated twice. A selected set of orthogonal linear contrast comparisons was made to quantify differences attributable to grazing intensity and fertilization. Each single degree of freedom was tested for significance with the Student's t-test. Differences were considered significant at the 0.05 level. Percentage of D and P varied inversely, and statistical difference was found only for F, D decrease averaged 39% in treatments with F. Forage accumulation was similar during the dry season. A significant ($P<0.03$) interaction between I and F was found for FA in the rainy season. The best results were obtained in the treatment of moderate grazing intensity and fertilization with a forage accumulation of 7213 lb ac^{-1} year^{-1} with 30% D aerial canopy cover compared to the treatment of high grazing intensity without fertilization which had a FA of 4086 lb ac^{-1} year^{-1} with 55% D.

KEY WORDS: Grazing management, nitrogen fertilization, *Digitaria decumbens*, *Dichanthium annulatum*, pangolagrass, Kleberg bluestem, invasive species

INTRODUCTION

Overgrazing has been identified as one of the most overwhelming factors affecting productivity of cattle operations in Northern Mexico (Martinez et al. 1997). Cattle stocking rates higher than what grazinglands can safely sustain causes weakening and death of native and introduced desirable species creating optimum conditions for the invasion of less valuable plants. Invasive species have become a problem in many native and cultivated areas, reducing plant diversity and wildlife habitat in rangeland and efficiently competing with cultivated perennial grasses that are more valuable and productive for cattle. Even when many invasive species have been introduced to improve primary productivity of grazinglands for cattle, in several cases these have become a problem due to their aggressiveness and in many cases lower forage value and cattle preference which make these plants very efficient competitors with desirable species.

Cattle grazing in southern Tamaulipas in Mexico consists of grazing native and introduced perennial grasses. Some of the most common introduced grasses are African stargrass (*Cynodon nlemfuencis* Vanderyst), Guineagrass (*Panicum maximum* Jacq.), signalgrass (*Brachiaria decumbens* Stapf), and pangolagrass (*Digitaria decumbens* Stent.). Even when some of these grasses are invasive species for native rangelands, they are considered desirable introduced species for cattle in this region. However, other introduced species of lower forage value that are more aggressive in nature can invade pastures reducing the productivity of these grasses. The most typical example is the group of grasses identified as "Old World Bluestems" that include Plains bluestem, [*Bothriochloa ischaemum* (L.) Keng], Kleberg bluestem [*Dicanthium annulatum* (Forsk) Stapf], Caucasian bluestem (*Bothriochloa caucasica*), and Hurricanegrass [*Bothriochloa pertusa* (L.) Camus] among others. The most common invasive species in southern Tamaulipas are Kleberg bluestem and Hurricanegrass which are locally named "carreterograss" due to the fact that most of the roads sides are covered with these species. *Bothriochloa pertusa* was initially identified in the early 1970's and it is believed it was introduced from south Europe to the Caribbean and from there it has invaded a large part of the Mexican Gulf Coast (De Alba and Gould 1977). However, most of the population currently invading native and introduced pastures in the area is Kleberg bluestem which is native to India, China, North Africa and Egypt. It grows in clumps and plants are erect and uniform with most of the leaves near the base. Numerous green slender stems 30" long become straw-colored at maturity, have white bearded nodes and seedheads with 2-10 purplish branches. It volunteers aggressively and has excellent drought tolerance and some salinity tolerance (Mutz and Drawe 1983). In general, Old World bluestems are very stemy and do not produce the quantity or quality of forage when grown in south Texas that they do when grown in areas north of this region (Ocumpaugh and Rodriguez 1999). The main dispersal mechanism of Kleberg bluestem is by seed that is moved along with animals, vehicles, air and water runoff. Old World bluestems overall are lower in quality than most native species, but because of their ability to persist under increased grazing pressure, higher temperatures and less water, they become very competitive for native and introduced desirable species.

Moderate grazing intensity is a key factor for persistence of desirable species and research has shown that primary productivity, cow herd productivity and net economic returns are maximized by moderate grazing (Falconer et al. 1999; Holocheck et

al. 1999; Ortega and Gonzalez 1992). Responses to nitrogen fertilizer differ among grass species (Petersen and Moser 1985; Jacobsen et al. 1995). For example, the pangolagrass response to nitrogen fertilizer is stronger compared to Kleberg bluestem. Berg (1990, 1993) studied the response of *Bothriochloa ischaemum* to N fertilization and spring burning and found N fertilization to substantially increase forage production resulting in an average of 66 lb of forage being produced per kg N applied. Berg and Sims (1995) found that N applied at 38 lb N/ac resulted in steer gains ranging from 5 to 9.5 lb/yr. Pangolagrass is a high quality introduced species that very readily consumed by cattle. Ortega et al. (1985) indicated that an application of 90 kg of N per ha using ammonium sulfide as a N source increased forage production by 50%.

We tested the hypothesis that moderate grazing intensity and nitrogen fertilization would increase primary productivity of the grassland and decrease the percentage Kleberg bluestem in pastures. We predicted that pangolagrass would have a stronger response to N fertilizer and moderate grazing intensity would have a positive effect on the primary productivity of pangolagrass which would contribute to the dominance of this species over the invasive Kleberg bluestem.

MATERIAL AND METHODS

Study Area

The study was conducted at Aldama Experimental Station of the National Research Institute of Crops, Forestry and Livestock (INIFAP) in Aldama, Tamaulipas, Mexico, which is located 11 miles North of Manuel, Tamaulipas (23^{o} N, 98 ^{o} W). The experimental station is about 207 ft above the sea level with a slope gradient < 1%. Soil type is considered moderately well drained clays with pH of 7.4. Climate is characterized as subtropical with hot summers and mild winters. The average annual temperature was 23.7 ^{o}C. Average annual rainfall (1990 –2000) recorded at the station was 32.6 inches per year.

Experimental Design

A 9.9-acre pasture of pangolagrass with an average invasion of 49 % of Kleberg bluestem was used to allocate two separate blocks consisting of 4 1.24-acres pastures. Treatments evaluated resulted from the combination of two levels of N fertilizer (0 and 45 acre^{-1}) and two levels of grazing intensity (Moderate= utilization of 50% of the available aerial biomass and High= utilization of 80% of available aerial biomass). The four treatment combinations were randomly assigned to each block. Pastures with different levels of grazing intensity were grazed with the same number of animals varying the number of grazing days to achieve the desired percentage utilization. During the rainy season (June to November), pastures were grazed every 28 days and every 56 days during the dry season (December to May). Nitrogen fertilizer was applied at the beginning of the rainy season every year.

Response Variables

The amount of Kleberg bluestem and pangolagrass was estimated based on aerial cover in pastures. Aerial cover of the two species was estimated using the line intercept method (Pieper 1973). Two permanent 16-ft transects were used per pasture and percent aerial cover per species was determined in the middle of the rainy and dry seasons every year during the three years of the study.

Response variables evaluated were forage accumulation and botanical composition in terms of percentage of Kleberg bluestem and pangolagrass. In order to calculate forage accumulation, pastures were sampled before and after grazing every cycle to determine standing biomass in each pasture. Standing biomass before and after grazing was determined using a double sampling technique (Frame 1981). Five double samples (visual estimation of standing biomass followed by clipping all herbage to ground level in a 1.64 ft^2 sampling frame) were taken in each sampling date in each pasture at sites selected to cover the variability of the pasture. Then visual estimations of standing biomass were taken at 16 randomly selected sites in each pasture. Samples from the 1.64 ft^2 were dried at 60 ^oC to obtain the actual dry weight of standing biomass. From double-sampling sites, actual values for standing biomass were regressed on visual estimations. Each year separate simple regression equations were developed for pregraze and postgraze samples. The simple regression equations possessed r^2 values higher than 0.76 in all cases. Averages of the 16 visual estimations taken per pasture were corrected using regression equations to estimate pasture values for standing biomass to be used for evaluating the effect of grazing intensity and fertilization. Forage accumulation for a given grazing cycle was considered to be the difference between standing biomass after grazing of the previous grazing cycle and standing biomass before grazing of the current cycle. Forage accumulation for the first grazing cycle was pregraze standing biomass. Data were summed over cycles to provide seasonal and annual totals.

Data Analysis

Response variables were analyzed in complete randomized block design with a 2x2 factorial arrangement of treatments replicated twice. A selected set of orthogonal linear contrast comparisons was made to quantify differences attributable to grazing intensity and fertilization. Each single degree of freedom was tested for significance with the Student's t-test. Differences were considered significant at the 0.05 level (SAS Institute, Inc., 1989).

RESULTS

Botanical composition in terms of percentage aerial cover of Kleberg bluestem and pangolagrass was analyzed only for the last year of the study to because we considered that percentages of the two species involved reflected the long term cumulative effect of the treatments. Percentage cover of Kleberg bluestem and pangolagrass at the end of the study was different ($P<0.02$) only for fertilization level (Table 1). Pangolagrass and Kleberg bluestem varied inversely in the pastures with fertilization. Fertilized pastures had 34% Kleberg bluestem cover compared to 56% for the treatments with no fertilization. Percentage aerial cover of Kleberg bluestem in pastures with fertilization was 39% lower compared to pastures with no fertilization, independently of the grazing intensity. In pastures with fertilization, percentage cover of Kleberg bluestem decreased from beginning to end of the study while pangolagrass cover increased.

As we hypothesized, pangolagrass had a stronger response to nitrogen fertilizer which allowed it to effectively compete with Kleberg bluestem. As indicated by Mutz and Drawe (1983), Kleberg bluestem response to nitrogen fertilization can be considered poor compared to the response obtained with buffelgrass (*Cenchrus ciliaris* L.), bell

rhodesgrass (*Chloris gayana* Kunth) and blue panicgrass (*Panicum antidotale* Retz.). Kleberg bluestem percent aerial cover in treatments of moderate and high grazing intensity without fertilization increased 22 and 17%, respectively, while treatments of moderate and high grazing intensity with fertilization caused Kleberg bluestem to decrease 34 and 18%, respectively.

Table 1. Effect of grazing intensity and nitrogen fertilization on botanical composition (Percent aerial cover) of a pangolagrass pasture invaded with Kleberg bluestem.

Treatment			
Grazing Intensity	**N Fertilization (lb acre^{-1})**	**Pangolagrass (%)**	**Kleberg bluestem (%)**
High	0	45 b*	55 a
High	56	63 a	37 b
Moderate	0	44 b	56 a
Moderate	56	70 a	30 b

* Different letters within a column indicate statistically different means (P=0.05).

Forage accumulation was analyzed by season of the year (dry and rainy) averaged over the three years of the study (Table 2). Results for the dry seasons did not differ (P>0.05) among treatment combinations with an average forage production of 1773 lb acre^{-1}.

Table 2. Effect of grazing intensity and nitrogen fertilization on annual and seasonal primary productivity of a pangolagrass pasture invaded with Kleberg bluestem .

Treatment		**Average Forage Accumulation (lb acre^{-1})**		
Grazing Intensity	**N Fertilization (lb acre^{-1})**	**Dry Season**	**Rainy Season**	**Annual**
High	0	1978 a*	2605 c	4581 b
High	56	2112 a	3710 b	5822 b
Moderate	0	2399 a	2615 c	5015 b
Moderate	56	2520 a	4694 a	7213 a

* Different letters within a column indicate statistically different means (P=0.05).

In this region, moisture availability as well as low temperatures during the months of December and January limit growth of grasses. Precipitation during February, March and April during the study was lower than 0.76 inches, and average minimum temperature from November to March was lower than 16^{o}C which likely limited forage production. Pangolagrass and Kleberg bluestem are C4 grasses that require higher temperature for optimum growth as indicated by Coyne et al. (1995).

Forage accumulation during the rainy season was different for grazing intensity (P<0.001), fertilization (P<0.003) and the interaction between the two factors (P<0.003) (Table 2). Forage accumulation was higher in pastures that received the treatment combination of moderate grazing intensity with fertilization with 4694 lb acre^{-1} compared to the treatments of high grazing intensity with fertilization and moderate and high grazing intensity without fertilization that produced 3710, 2615, and 2605 lb acre^{-1},

respectively. The results indicate that moderate levels of grazing intensity and nitrogen fertilization increased productivity of pangolagrass probably because enough leaf area remained in the plants after grazing for the plants to initiate regrowth, and nitrogen availability was sufficient to allow the plant to maximize growth potential. Increased production of forage occurs when moderate levels of defoliation by grazing animals are applied (Ortega et al. 1992). Canudas (1988) reported increased forage production of pangolagrass when residual dry matter after grazing was intermediate. Differential response of warm season grasses to nitrogen fertilizers have been documented by Mutz and Drawe (1983) and the results of this study agree with the positive effect of moderate levels of defoliation on primary productivity reported by Holocheck et al. (1999) and Ortega and Gonzalez (1992).

Annual forage accumulation (sum of dry and rainy season forage accumulation) (Table 2) differed only for fertilization ($P < 0.01$). Treatments with fertilization yielded 26% more forage than treatments without fertilization.

Considering that percentage cover of Kleberg bluestem was 39% lower in treatments with fertilization, 65% of the forage accumulation was produced during the rainy season, and the highest forage accumulation was obtained in pastures that received the treatment combination of moderate grazing intensity with nitrogen fertilization, we conclude that fertilization and moderate grazing intensity effectively limited the invasion of Kleberg bluestem in pangolagrass pastures and increased primary productivity of pastures. The significant interaction detected between fertilization and grazing intensity during the rainy season for forage accumulation and the decreasing trend of the percentage Kleberg bluestem from the beginning to the end of the study in treatments with fertilization indicate that moderate grazing intensity in combination with nitrogen fertilization during the rainy season could have potential to keep pangolagrass pastures from Kleberg bluestem invasion. The response of pangolagrass to grazing intensity and fertilization may become stronger, increasing forage accumulation, as Kleberg bluestem percentage in pastures decreases, allowing pangolagrass to become more productive and competitive.

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