Agronomic performance and beef cattle grazing preference among three prairie bromegrasses

Allen Stewart Hubbard

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AGRONOMIC PERFORMANCE AND BEEF CATTLE GRAZING PREFERENCE AMONG THREE PRAIRIE BROMEGRASSES

By:

Allen Stewart Hubbard

A Thesis
Submitted to the Faculty of
Mississippi State University
in Partial Fulfillment of the Requirements
for the Degree of Master of Science
in Agriculture
in the Department of Animal and Dairy Sciences

Mississippi State, Mississippi

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2007
AGRONOMIC PERFORMANCE AND BEEF CATTLE GRAZING PREFERENCE

AMONG THREE PRAIRIE BROMEGRASSES

By

Allen Stewart Hubbard

Approved:

Jane A. Parish
Associate Extension/Research Professor of Animal and Dairy Sciences (Director of Thesis)

Bisoondat Macoon
Assistant Research Professor of Agronomy (Committee Member)

Rhonda C. Vann
Associate Research Professor of Animal and Dairy Sciences (Committee Member)

Peter L. Ryan
Associate Professor, Graduate Coordinator, Animal and Dairy Sciences

Vance H. Watson
Dean of College of Agriculture and Life Sciences
Prairie bromegrass is a cool-season perennial bunchgrass with potential as a valuable forage crop in the southeastern USA. The objective of this study was to compare dry matter production, persistence, nutritive value, and beef cattle grazing preference of two experimental lines and a commercial species (cv. Matua) of prairie bromegrass. Plots were established in a randomized complete block design with four replications. When each plot accumulated at least 20 cm of growth, plots were grazed with Hereford x Angus steers at a stocking rate of 8400 kg/ha until the first plot was grazed down to 7 cm in height. Pre- and post-grazing quadrats were taken for DM and animal preference estimation and nutrient analyses. No differences in nutritive value or grazing preference were seen among species. Treatment interactions were observed for DM production and persistence. The results suggest that there are differences in growth traits among the bromegrass species observed.
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CHAPTER I
INTRODUCTION

Producing grazable forage is an important aspect of cattle production in the southeastern USA. Especially during periods of the year when cool-season forage production is at a minimum due to climatic conditions and warm-season forages are dormant. A forage that could lengthen the grazing season in the Southeast could be very beneficial to cattle producers by decreasing stored forage or supplemental feed expenses. Prairie bromegrass (*Bromus spp.*) has the ability to extend the grazing season in the southeastern USA by producing forage later in autumn and earlier in the spring than other comparable cool-season forages (LaCasha et al., 1999).

‘Matua’ prairie bromegrass (*Bromus willdenowii* Kunth) is a cool-season perennial forage that is native to Argentina but was developed and released from New Zealand in 1973 (Rumball, 1974; LaCasha et al., 1999). Matua was also certified by the Grasslands Division, DSIR, and placed on the list of acceptable cultivars in New Zealand in 1973 (Rumball, 1974; Jung et al., 1994; Xia et al., 1994). Matua was released as a high-yielding, cool- and warm-season active, high nutritive value pasture cultivar suited to lax, infrequent grazing (Rumball, 1974; Xia et al., 1994). Matua is suited to well-drained soils with medium to high fertility and a pH of 6.0 or greater and can produce high herbage mass during drought situations (Abaye et al., 2002). Optimum growing conditions of Matua are similar to that of alfalfa (*Medicago Sativa L.*), a forage with
which Matua can also be sown to produce a forage crop with a relatively high nutritional quality (Scheneiter and Rimieri, 2001).

The life expectancy of Matua is short, usually only lasting 3 to 5 years. However, persistence of Matua relies heavily on proper management of the crop (Watkin, 1975; Baars and Cranston, 1977; Pineiro and Harris, 1978 a,b; Rys et al., 1978; Harris et al., 1980; Alexander, 1985; Bell and Ritchie, 1989). Defoliation frequency monitoring is a vital management tool for increasing the persistence and production of Matua stands (Rys et al., 1978; Harris et al., 1980; Alexander, 1985; Bell and Ritchie, 1989; Jung et al., 1994). Too frequent defoliation of Matua stands can adversely affect root growth as well as deplete energy reserves for regrowth. This can negatively affect stand viability (Stuczynska and Jakubowski, 1977; Bell and Ritchie, 1989; Guay, 2001). Too infrequent defoliation of Matua stands can also negatively affect persistence. Seedling plants are less likely to survive due to shading with less defoliation. Tiller survival can also be negatively affected by shading (Jung et al., 1994; Guay, 2001). With the proper management, Matua yields can exceed 10,000 kg ha$^{-1}$. However, Bell and Ritchie (1989) found that defoliation height is not as important as defoliation interval in the management of Matua prairie grass. Matua will also respond to N applications up to 375 kg ha$^{-1}$ yr$^{-1}$.

Cattle preference among forage species has become of increasing interest to plant breeders (Smith et al., 1997 and Smit et al., 2006). Producing a forage that is preferred by cattle over another forage could increase animal intake as well as growth in cattle and potentially impact enterprise profitability for a beef cattle producer. Cattle have shown preference among cultivars of tall fescue ($Festuca arundinacea$ Schreb.; Shewmaker et
al., 1997), annual ryegrass (*Lolium multiflorum* Lam.; Aderibigbe et al., 1982), and perennial ryegrass (*Lolium perenne* L.; O’Riordan et al., 1998; Smit et al., 2006). Several avenues have been explored to determine factors that drive animal preference in forages including amino acid concentration (Mayland et al., 2000a), TNC concentration (Mayland et al., 2000b), CP concentration (Bailey, 1995), and digestibility among forages (Smit et al., 2006). Metabolic constraints of animals on intake (Illius and Jessop, 1996) as well as morphology of sward (Shipley and Spalinger, 1992; Rook et al., 1994; Gibb et al., 1997; Barret et al., 2001) have also been evaluated as factors driving animal preference. However, the mechanisms behind this preference remain relatively unknown (Smit et al., 2006).

The objective of this study was to compare the agronomic performance as well as beef cattle grazing preference among three prairie bromegrass species; Matua, BP101 (*Bromus parody*), and BW103 (*Bromus wildenii*). Matua is a commercially available cultivar of prairie bromegrass, while BP101 and BW103 are experimental lines. In this study, cattle preference among the prairie bromegrass species as well as examine chemical composition factors that may drive this preference will be assessed.
Prairie bromegrass (*Bromus willdenowii* Kunth) is a short-lived, cool-season, perennial bunchgrass that has shown promise in extending the grazing season over other cool-season grasses. Prairie bromegrass is believed to have originated in Argentina and was introduced to the southern United States prior to the Civil War (Hoover et al., 1948; Newell, 1973; Rumball, 1974; Guay, 2001). Prairie bromegrass is suited to well-drained soils with a medium to high fertility levels and a pH of 6.0 or greater. Prairie bromegrass will not tolerate poorly-drained soils but can produce high herbage mass during drought situations (Abaye et al., 2002). Prairie bromegrass consists of annual, biennial, and perennial plants, and it is regarded as adapted to high fertility soils like those used for annual grassland crop rotations in the humid pampa region in Argentina (Bertallanez and Bertin, 1990; Scheneiter and Rimieri, 2001). This adaptation to high fertility soils has also been recognized in New Zealand (Boom and Sheath, 1990; MacFarland, 1990; Scheneiter and Rimieri, 2001). Optimum growing conditions for prairie bromegrass are similar to that of alfalfa (*Medicago sativa*) and for many years prairie bromegrass has been the major grass forage sown in association with alfalfa (Scheneiter and Rimieri, 2001).
“Grasslands Matua” is a cultivar of prairie bromegrass certified in 1973 by the Grasslands division, DSIR, New Zealand (Rumball, 1974; Jung et al., 1994). Matua was placed on the New Zealand list of acceptable herbage cultivars on January 1, 1973 and was released in New Zealand as a high-yielding, cool- and warm-season active, high nutritive value pasture cultivar suited to lax, infrequent grazing (Rumball, 1974; Xia et al., 1994). Matua is a bunch-type grass that produces highly palatable forage, including flower heads (which are produced in every crop), and is more drought tolerant than most other cool-season grasses (Jung et al., 1994). The seedheads are self-fertilizing which can help to improve uniformity in the stand if managed correctly (Rumball et al., 1972; Rumball, 1974; Guay, 2001). Stand density can be improved by allowing natural reseeding in summer months (Jung et al., 1994; Guay, 2001).

Prairie bromegrass may potentially be implemented into grazing systems in the southeastern USA. It is a high-yielding forage in the autumn and spring compared to other cool-season forages as later described in this review. The high yields of the forage may be well suited to stocker operations in the southeast USA, considering that forage quality is similar to that of annual ryegrass and tall fescue. Prairie bromegrass is also well suited to be grown in mixtures with alfalfa, which will provide a high quality pasture. Considering proper and careful management, which this forage requires, prairie bromegrass could be a viable option to improving forage systems in the southeast USA. Even though prairie bromegrass may be better suited as an annual crop, with the proper management, two years of high forage yields can be achieved.
Dry Matter Production

One of the primary factors affecting the production and persistence of prairie bromegrass is management (Watkin, 1975; Baars and Cranston, 1977; Pineiro and Harris, 1978 a,b; Rys et al., 1978; Harris et al., 1980; Alexander, 1985; Bell and Ritchie, 1989).

The results of a study conducted by Bell and Ritchie (1989) showed that prairie bromegrass yielded upwards of 16,000 kg ha\(^{-1}\) annually with a 50-day defoliation interval. The percentage of prairie bromegrass in the stand also increased as defoliation interval increased from approximately 40% with a 10-day defoliation interval to approximately 75% with a 50-day defoliation interval. Rys et al. (1978) found similar results when comparing a 46- to a 28-day grazing interval. Alexander (1985) and Harris et al. (1980) also found the DM production of prairie bromegrass under a 4- to 8-week grazing interval to be consistently higher than a 2- to 3-week grazing interval. Jung et al. (1994) showed that with the proper management (grazing interval and defoliation height), prairie bromegrass yields associated with herbage mass of greater than 4,000 kg ha\(^{-1}\) in the fall and 7,000 kg ha\(^{-1}\) in the spring could be obtained.

Prairie bromegrass also responds to increasing nitrogen levels. A study conducted by Scheneiter and Rimieri (2001) in the humid Pampa region comparing prairie bromegrass and annual ryegrass as annual crops, showed that as nitrogen rates increased from 0 to 375 kg ha\(^{-1}\) yr\(^{-1}\) dry matter yields increased from 14,500 to 22,400 kg ha\(^{-1}\) in Year 1 and from 11,300 to 18,900 kg ha\(^{-1}\) in Year 2. It should be noted that the nitrogen application was in split dressings with 40% in mid winter, 30% in mid spring, and 30% in
late summer. Similar results were found by MacFarlane (1990). However, Belesky and Stout (1994) did not find increases in annual dry matter accumulation with fertilization rates above 168 kg N ha\(^{-1}\) yr\(^{-1}\). Furthermore, dry matter production of prairie bromegrass exceeded that of annual ryegrass at all times except for the first defoliation however this was probably due to the fact that prairie bromegrass continued to grow through the summer while annual ryegrass does not. The authors also concluded that the summer herbage accumulation of prairie bromegrass (2-3 t DM ha\(^{-1}\)) was high when compared to values recorded for tall fescue (1.4 ± 0.8 t DM ha\(^{-1}\)) in the humid Pampa region (Bertin and Scheneiter 1998). Winter herbage accumulation reported by the authors was also higher than values reported for tall fescue by Bertin and Rosso (1989).

The results of a study by Fulkerson et al. (2000), on the North Coast of New South Wales, Australia, showed that the DM yields of prairie bromegrass were greater than that of tall fescue and perennial ryegrass at two sites over three years. It should be noted that all of these swards were mixtures with white clover. The prairie bromegrass yields ranged from 7,784 to 13,277 kg ha\(^{-1}\) annually. Other authors have reported similar results including Vartha (1976), Simon et al., (1983), Kanno et al., (1993), and Lowe et al., (1999).

**Chemical Composition**

A study was conducted in New Zealand by Rumball et al. (1972) to evaluate the variation in chemical composition among twelve lines of prairie bromegrass. In this study analyses were conducted for K, Na, Ca, Mg, Cl, P, S, total N, nitrate N, Fe, Mn, Zn, Cu, Si, Se, and I. There was also a second part of the same study, which evaluated the
Mg concentration of 106 lines of prairie bromegrass derived from New Zealand and overseas. This portion of the study also contained 23 lines of other *Bromus* species. Rumball et al. (1972) concluded that the amounts of Fe, Mn, Cu, K, Na, Cl, and Zn, in the prairie grass lines appeared to be sufficient to meet ruminant requirements for each of these mineral elements when compared with recommendations in a report by the ARC (1966). Iodine concentrations were low compared to ARC recommendations. The authors concluded that the Na and Cl levels in prairie bromegrass were sufficient for meeting ruminant requirements but the Ca and P concentrations were very low. Furthermore, the Ca to P ratios that the authors observed in this study were generally less than 1 which is below the required Ca to P ratio for beef cattle according to the NRC (1996). The authors also concluded that Mg levels in prairie bromegrass were below adequate amounts, only yielding 0.17 percent DM in the spring. Furthermore, the authors concluded that prairie bromegrass lines should be selected for a higher Mg concentration but this could result in decreased herbage production in the spring. This would also be the case for selection of increased Ca concentration.

Turner et al. (2006) conducted a greenhouse study examining the changes in feed quality and physiology of prairie bromegrass. These authors analyzed the prairie bromegrass for water-soluble carbohydrate (WSC) concentration, P, K, Na, Mg, Ca, and N concentrations, and metabolizable energy. The results showed that WSC content increased between the 1-leaf and 6-leaf stages of regrowth with values ranging from 19.71 mg plant\(^{-1}\) to 370.45 mg plant\(^{-1}\). However, there was an initial decrease in the stubble WSC concentration between the defoliation stage (0-leaf stage) and the 1-leaf
stage. The root WSC concentration initially increased between the 1- and 2-leaf stages but then decreased between the 4- and 5-leaf stages of regrowth. Metabolizable energy concentrations did not change between the 1- and 4-leaf stages but declined between the 4- and 6-leaf stages of regrowth with values ranging from 12 to 11.5 MJ kg\(^{-1}\) DM of metabolizable energy. The results showed a general decline in CP, Ca, Mg, P, and K concentrations during regrowth after defoliation. However, values tended to plateau between the 2- or 3- and 5-leaf stages. The only exception was that Na concentrations increased between the 3- and 5-leaf stages of regrowth. Ranges in concentration values were from 141 to 375, 3.9 to 5.5, 1.4 to 2.4, 4.0 to 8.6, 1.4 to 2.3, 41.8 to 81.9, and 0.63 to 0.98 g kg\(^{-1}\) DM for CP, Ca, Mg, P, Na, K, and Ca to P ratios respectively. It should be noted that Ca to P ratios rose during regrowth but still only reached 0.98 g kg\(^{-1}\) DM.

A study by Fulkerson et al. (2000) analyzing production and forage quality of prairie bromegrass among two other grasses showed some conflicting results to the previously discussed study by Turner et al. (2006). The results of the study by Fulkerson et al. (2000) showed an increase in Ca concentrations in prairie bromegrass between the 1- and 6-leaf stages of regrowth. This also increased the Ca to P ratio above the 1.6 to 1 ratio recommended by NRC (2001) for dairy cattle. These results also showed that even though Mg concentrations were low (< 0.2% DM), they did not decrease with regrowth. Also, Na concentrations did not vary during regrowth. The WSC concentrations increased until the 3-leaf stage of regrowth and then started to decline. These results do not agree with the results found by Turner et al. (2006). However, the authors of this study accredited this decline to the onset of senescence. Metabolizable energy and K
concentrations followed the same trends as reported by Turner et al. (2006). There is a general consensus with scientific literature that prairie bromegrass pastures should be supplemented with Mg during grazing to prevent the onset of grass tetany (Rumball, 1972; Fulkerson et al., 2000; Turner et al., 2006).

LaCasha et al. (1999) conducted a forage preference study among horses using three different hays including alfalfa, bermudagrass (*Cynodon dactylon* L.), and prairie bromegrass (cv. Grasslands Matua). Mineral concentrations as well as fiber percentages were reported for all three hays. The mineral concentrations for prairie bromegrass were 0.49, 0.27, 0.18, 2.69, and 0.39% DM for Ca, Mg, P, K, and S, respectively, as well as 88, 8, 91, 76, 440, and 19 mg kg\(^{-1}\) for Al, Cu, Fe, Mn, Na, and Zn respectively. Fiber and crude protein (CP) concentrations were 13.5, 62.4, 36.1, 26.4, 27.0, 6.0, and 12% DM for CP, neutral detergent fiber (NDF), acid detergent fiber (ADF), hemicellulose, cellulose, lignin, and total nonstructural carbohydrates, respectively. Prairie bromegrass was generally less digestible than alfalfa but was more digestible than bermudagrass with DM digestibility ranging from 67, 58, and 46% for alfalfa, Matua prairie bromegrass, and Coastal bermudagrass, respectively. Crude protein levels for prairie bromegrass also fell between alfalfa and bermudagrass with concentrations ranging from 20.0, 13.5, and 11.3% for alfalfa, Matua prairie bromegrass, and Coastal bermudagrass, respectively. Crude protein, total non-structural carbohydrates (TNC), and fiber concentrations in this study were similar to concentrations reported by Missaoui (1998).
Management of Prairie Bromegrass

The recommended management practices of prairie bromegrass are to graze intensely with long rest periods (Alexander, 1985; Matthews, 1986; Xia et al., 1994) or to graze intensely only after replacement tillers have emerged at the base of the sward (Black and Chu, 1989; Xia et al., 1994). Xia et al. (1994) performed a study in New Zealand to analyze sward characteristics of prairie bromegrass between a “hard” grazing regime and a “lax” grazing regime. The “hard” grazing regime consisted of leaving a 6-cm residual stubble height with 1.5 to 2.5 t DM ha\(^{-1}\) residual herbage mass. The “lax” grazing regime consisted of leaving a 12-cm residual stubble height with 2.5 to 3.5 t DM ha\(^{-1}\) residual herbage mass. The “lax” grazing regime increased the number of live leaves per tiller, total dry weight of individual tillers prior to grazing, and post-grazing tiller population density. Tiller population density also increased with time in the “lax” grazing regime. Tiller numbers per plant were greater in the “lax” grazing regime although the difference was only significant at \(P < 0.08\). Total herbage mass and rate of herbage accumulation per day were also increased with the “lax” grazing regime.

Another study in New Zealand performed by Bell and Ritchie (1989) over a 3-year period analyzed DM production and tiller density of prairie bromegrass among five defoliation intervals (10, 20, 30, 40, and 50 days) and two defoliation heights (3 and 8 cm). The results of this study were similar to those of Xia et al. (1994). In all 3 years prairie bromegrass yields tended to increase with less frequent defoliation intervals. Also, yields were 10 to 15% greater under the 8-cm defoliation height. The 8-cm defoliation height also led to a greater proportion of prairie bromegrass in the sward. Bell
and Ritchie (1989) found that there was a linear increase in tiller numbers with lower frequency of defoliation in all 3 years. They also found that the 8-cm defoliation height produced higher tiller numbers in the first and third years of the study. Several other studies have produced similar results concerning less frequent defoliation intervals. Rys et al. (1978) saw a 17% increase in total DM and a 38% increase in the prairie bromegrass component of the sward with a 46-day compared to a 28-day defoliation interval (Bell and Ritchie 1989). Harris et al. (1980) and Alexander (1985) found that the production of prairie bromegrass was consistently higher under infrequent (4 to 8 weeks) compared with frequent grazing (2 to 3 weeks) (Bell and Ritchie, 1989). A study performed by Stuczynska and Jakubowsky (1977) indicated that frequent defoliation adversely effected root growth, which could be detrimental to the persistence of prairie bromegrass (Bell and Ritchie 1989). Even though Bell and Ritchie (1989) found that an 8-cm defoliation height could be beneficial to a prairie bromegrass stand they concluded that a less frequent defoliation interval was of great importance in the management of prairie bromegrass. 

Jung et al. (1994) performed a study in Pennsylvania to analyze autumn and spring DM yield and sward characteristics of prairie bromegrass as a result of several fall harvest intervals and harvest dates. The results of the study indicated that if the stand was allowed to go to seed in the summer months, the seedling survival rate would increase with a harvest interval of 40 days in the fall. A residual stubble height of 7.5-cm resulted in more tillering, higher DM yield in autumn, and greater seedling survival that a residual stubble height of 12.5-cm. However, a residual stubble height of 12.5-cm after
the final harvest in autumn resulted in greater plant vigor and DM yield in the spring due to greater carbohydrate reserves in the plant needed for regrowth in the spring. When the stand was allowed to “stockpile” in autumn (80-day harvest interval) and then harvested DM yield, tiller density, and seedling survival tended to decrease in the following spring. Single late autumn harvest decreased spring yields by greater than 50%. Winter survival, spring yield, and plant vigor were improved by harvesting early rather than late autumn, leaving higher stubble, or taking multiple harvests in autumn.

The authors of this study indicated that prairie bromegrass potentially could acquire DM yields of 4,000 kg ha\(^{-1}\) in the autumn and spring if properly managed.

**Animal Preference**

Animal preference among different forage species is a subject that has become of increasing interest to plant breeders (Smith et al., 1997; Smit et al., 2006). Cattle have shown preference among cultivars of tall fescue (*Festuca arundinacea* Schreb.) (Shewmaker et al., 1997), annual ryegrass (*Lolium multiflorum* Lam.) (Aderibigbe et al., 1982), and perennial ryegrass (*Lolium perenne* L.) (O’Riordan et al., 1998) (Smit et al., 2006). The mechanisms behind this preference are relatively unknown (Smit et al., 2006). Researchers have explored several different avenues concerning chemical composition of forages to determine what factors may drive animal preference. Some of these avenues include amino acid concentration of different varieties of tall fescue (Mayland et al., 2000a), TNC concentration of different varieties of tall fescue (Mayland et al., 2000b), CP concentration of different forages (Bailey, 1995), and digestibility of different varieties of perennial ryegrass (Smit et al., 2006). Illius and Jessop (1996) have
also looked at metabolic constraints of animals effecting voluntary intake of feeds. Researchers have examined sward surface height (SSH) of forages as well as botanical composition of a paddock as being negatively or positively correlated to animal preference (Shipley and Spalinger, 1992; Rook et al., 1994; Gibb et al., 1997; Barret et al., 2001). For the purpose of this review, the focus is placed on the chemical composition among forages and cultivars of specific forages as driving factors for animal preference.

**Crude Protein**

Bailey (1995) conducted a study in Oklahoma evaluating cattle preference and grazing patterns between pastures of homogenous species and heterogeneous species. Researchers have shown that relative preference for plant communities by cattle were proportional to relative differences in quality and quantity of preferred forage (Senft et al., 1985; Senft, 1986). The basic hypothesis of this study was that cattle in heterogeneous areas return to patches containing higher forage quality and quantity more frequently than patches with lower forage quality and quantity. Forage quality was determined by CP concentration of the forage in this study. The results of this study showed that cattle preferred patches with higher CP in a heterogeneous situation. Even though this was the case, nutritional factors other than CP could have affected forage quality and animal preference (Bailey, 1995). The results of this study supported the hypothesis of Senft et al. (1987) that animals respond to landscape scale heterogeneity on daily temporal scales and that animals may return to areas with more resources more frequently than areas with less resources (Bailey et al., 1989a,b).
Non-Structural Carbohydrates

Readily fermentable carbohydrates in forages provide energy to grazing animals and may be one of the cues used when selecting which forage plants to eat according to Fisher et al., (1999) and Mayland et al., (2000b). Many researches have investigated this concept and shown varying results. Tava et al. (1995) reported that three tall fescue cultivars having higher water soluble carbohydrates (WSC) were considered more palatable to cattle than three other tall fescue cultivars having lower WSC. Total non-structural carbohydrates (TNC), which include WSC, serve as an energy source to ruminants. It has been shown that hungry animals display a rapid response to energy dense diets (Provenza, 1995; Baumont, 1996). Thus, animal grazing behavior may be conditioned to TNC concentrations in forage (Mayland et al., 2000b). The TNC influence the amount and ratio of volatile fatty acids produced in the rumen (Bowden et al., 1968), which effects the efficiency of forage utilization (Mayland et al., 2000b).

Researchers have shown that the palatability of forage increases with increasing WSC concentrations (Reid et al., 1966; Tava et al., 1995). Krueger et al. (1974) hypothesized that taste may be the primary sense used by ruminants to discriminate among forages while Nombekela et al. (1994) showed that large animals prefer sweet flavors over other primary tastes such as sour, salty, or bitter. However, the preference for sweeter-tasting diets may be driven by the energy that these sugars contribute to the diet. Provenza (1995) showed that hungry animals prefer energy-dense diets and will identify such feeds within minutes after initial ingestion.
Mayland et al. (2000b) conducted a study in Idaho that resulted in a positive correlation between TNC concentrations and animal preference. At the time of this publication, there were no other publications that showed these same results to the knowledge of the authors. The study was conducted using eight cultivars of endophyte-free tall fescue and data were collected over two years. In this study, no forage cultivar was greater in TNC than the Kenhy cultivar or lower in TNC than the Mozark cultivar. For both years, the animals preferred Kenhy the most and Mozark the least resulting in preference and TNC concentrations among the cultivars being positively related. The TNC concentrations in forages have been identified as the third most important characteristic requiring the attention of forage breeders (Wheeler and Corbett, 1989). Mayland et al. (2000b) suggested that plant breeding programs and harvest management strategies should be directed toward increasing the TNC in forages.

Soluble carbohydrate (SC) levels between morning and evening have been investigated to determine correlations with preference and intake. In temperate climates, herbage SC concentrations are generally highest in the evening and lowest in the morning (Holt and Hilst, 1969; Orr et al., 1997; Barret et al., 2001). These SC concentrations also vary seasonally with higher SC levels in the spring and lower SC levels in the summer or autumn (Dent and Aldrich, 1963; Deinum et al., 1968; Delagarde et al., 2000). Herbage digestibility and SC levels also vary among genotypes (Dent and Aldrich, 1963; Wilson and Ford, 1973; Jung et al., 1976), growth stages (Jung et al., 1976; Fulkerson et al., 1998; Delagarde et al., 2000), plant parts (Terry and Tilley, 1964; Lechtenberg et al., 1971), and vertical horizons (Buxton and Martin, 1989; Delagarde et al., 2000) within
cool-season grass and legume swards (Griggs et al., 2005). Experimental shading treatments and sampling across times of day, genotypes, stages of growth, and environmental conditions have shown positive associations between levels of herbage SC and feed preference (Fisher et al., 1999, 2002; Ciavarella et al., 2000; Mayland et al., 2000b) and energy intake and livestock performance (Mitchell, 1973; Lee et al., 2000; Miller et al., 2001). Researchers have interpreted these temporal SC patterns as suggesting that animal performance may be higher under afternoon or evening allocation of daily pasture area (Lechtenberg et al., 1971; Delagarde et al., 2000; Orr et al., 2001). Researchers have also shown that dietary preference, intake, and performance improvements have been shown for relatively small increases in herbage SC levels associated with genotype, environment, and management (Fisher et al., 1999; 2002; Ciavarella et al., 2000; Orr et al., 2001). However, Griggs et al. (2005) conducted a study analyzing SC and TNC levels in orchardgrass between the mornings and evening in which no relation between higher daily energy intake and increasing TNC values were detected. Nevertheless, TNC values in this study were similar to that of previous studies being higher in the morning than in the evening allocations.

**Organic Acids**

Genetic differences in concentration of organic acids such as malate or citrate among different forage cultivars could effect animal preference and forage palatability (Jones and Barnes, 1967). Malate and citrate are fundamental to photosynthesis and concentrations of these likely differ among plant species (Dijkshoorn, 1973). Differences in genotype, soil fertility, temperature, and maturity affect organic acid concentrations in
grasses (Burns et al., 1968; Barta, 1973; Mayland et al., 2000a). Gilbertson et al. (1997) found that malate and citrate increase salivary flow and intensify sweet flavors in non-ruminants. Mayland et al. (2000a) hypothesized that a similar effect may be seen in ruminants, which could increase animal preference and alter dry matter intake and digestion of a forage. Researchers have found that increasing the malate content of a diet stimulates lactate utilization and propionate production by the ruminal bacterium *Selenomonas ruminantium* (Martin and Streeter, 1995; Callaway and Martin, 1996) which could reduce the severity of acidosis of ruminants consuming a diet high in readily fermentable carbohydrates (Martin, 1998). Mayland et al. (2000a) also hypothesized that this effect could improve ruminal fermentation of grazing animals. Nevertheless, Mayland et al. (2000a) conducted a study comparing animal preference scores against malate, citrate, and amino acid concentrations among eight cultivars of tall fescue and did not find any correlations with any of these factors.

**Animal Preference Among Plant Species**

Newman et al. (1995) stated that although cattle are often considered to be indiscriminate grazers, they are still known to select if given the opportunity (Smit et al., 2006). This concept has been studied by several researchers (Heady, 1964; Stephens and Krebs, 1986; Provenza et al., 1996) and has been given more attention by plant breeders (Smith et al., 1997). Cattle have shown preference among cultivars of tall fescue (Shewmaker et al., 1997), annual ryegrass (Aderibigbe et al., 1982), and perennial ryegrass (O’Riordan et al., 1998); (Smit et al., 2006). Several factors have been studied, including the factors previously discussed, to try to determine reasons behind animal
preference but the mechanisms behind preference are still relatively unknown (Smit et al., 2006). Sward surface height (SSH) of a forage has been deemed a key parameter in determining animal behavior (Griffiths et al., 2003), but other results have proven SSH not to be a key factor correlated with animal behavior (Gibb et al., 1997; Smit et al., 2006).

Smit et al. (2006) conducted a study analyzing cattle preference among six diploid cultivars of perennial ryegrass and found that cattle did prefer specific cultivars to others. Cattle preference was correlated to four parameters in the study: negatively with ash and NDF and positively with WSC and digestible organic matter (DOM). Results of the study concluded that morphology of the sward along with sward surface height did not have an effect on animal preference although leaf blade, stem, and pseudostem proportions of the sward had large effects on NDF concentrations. Ash concentrations or minerals usually show a positive relationship with preference (Westoby, 1974; Belovsky, 1978) but in this study a negative relation was found between ash content and animal preference. The authors suspect this occurrence to be explained by the highest preferred cultivar ‘Abergold’ having the highest WSC concentrations and the lowest ash concentrations as well. Other authors support the theory of positive correlations between high WSC concentrations and animal preference (Heady, 1964; Reid et al., 1966; Tava et al., 1995; Ciavarella et al., 2000; Mayland et al., 2000b). It should also be noted that tetraploid cultivars of perennial ryegrass have a larger cell content than diploids resulting in higher digestibility, CP, and WSC concentration (Smith et al., 2001).
In the conclusions of the study conducted by Smit et al. (2006) the author states, “a higher preference for certain cultivar will not directly increase herbage intake of dairy cows if these cultivars are fed alone, and caution should be taken with interpretation of these results.” This statement poses the question of the reasons behind the research. Factors determining animal preference need further research before any associated conclusions can be determined regarding herbage intake by cattle.

**Metabolic Constraints on Intake**

Having stated all the previous possibilities, mainly related to forage characteristics, for determining animal preference, there is another factor that could play a large role in determining the amount of intake by an animal. Animal preference may be determined by the amount of intake of a particular feed due to metabolic constraints of an animal factor. Illius and Gordon (1991; 1992) concluded that forages of low digestibility are thought to place constraints on intake because of their slow passage through the rumen and gastrointestinal tract. Feeds of higher digestibility can be eaten in greater quantities before the physical constraints of the rumen apply. Then voluntary intake will be more related to the animal’s ability to utilize the nutrients absorbed. Voluntary intake by animals has been deemed a natural phenomenon, which involves the neural integration of many signals and is subject to psychological phenomena such as perceptual constraints and learning (Illius and Gordon, 1993; Provenza, 1995; Illius and Jessop, 1996). However, the theory that physical distention in the gastrointestinal tract will limit voluntary dry matter intake (VDMI) has been widely accepted (Campling, 1970; Baile and Forbes, 1974; Grovum, 1987; Forbes, 1995; Allen, 1996). Physical distention in the
gastrointestinal tract is thought to limit VDMI of low quality feeds. Although, physical
distention is presumed to decrease as digestibility increases (Allen, 1996). It has been
suggested that there is a breakpoint in digestibility at which limitation of VDMI by
physical fill in the gastrointestinal tract is replaced by limitation by satisfaction of energy
demand (Conrad et al., 1964; Allen, 1996).

Nutrient imbalances have also been presumed to constrain intake, because this can
cause a build-up of excess metabolites (Illius and Jessop, 1996). For example, acetate
clearance in adipose tissue is dependent on a supply of glucose to balance the NADPH
and ATP requirements for triglyceride formation with the supply of these from acetate
catabolism. Without adequate glucose, blood acetate rises and the resulting metabolic
feedback would presumably cause intake to be reduced (Illius and Jessop, 1996).
Sensations of discomfort or malaise are correlated with an animal’s sensory element
regarding nutrient imbalances, which will cause reduced intake or avoidance (Provenza,
1995). Animals can use these sensations as well as others to correct nutrient imbalances
and may choose accordingly to modify their nutrient uptake if given the opportunity
(Burritt and Provenza, 1992; Provenza et al., 1994).

Dietary selection has also been attributed to the animal’s physiological state or
growth stage. Research has shown that chickens, pigs, and sheep, if given an appropriate
choice of feeds, will select nutrient ratios that match their requirements. It has also been
shown that an initial period of learning will improve the performance of the animal in
these trials suggesting that the animals are capable of learning the metabolic
consequences of their selection (Kyriazakis et al., 1990). In the Kyriazakis et al. (1990)
study, as pigs increased in size they chose a combination of feeds that met their declining requirements for protein deposition when offered isocaloric feeds differing in protein concentration. This research also showed that when pigs were offered two feeds, neither of which met the protein requirements of the pigs, the pigs chose the feed that had highest protein concentration and vice-versa. This evidence shows that some animals are capable of selecting feeds to meet their nutritional requirements. Similar results have also been shown in ruminant animals. Cropper (1987) and Hou (1991) showed that sheep will select a diet with a protein concentration that varies consistently with their degree of maturity. Kyriazakis et al. (1994; 1996) also showed that sheep infected with intestinal nematode larvae, without increasing feed intake, would select a diet with a higher protein concentration. This infection is associated with endogenous protein loss from the mucosa and from invocation and maintenance of the immune response (Poppi et al., 1986; Kimambo et al., 1988).

Research has also shown that the intake of poor quality forages can be improved by increasing the supply of protein relative to energy in the absorbed nutrients (Egan, 1977). Egan (1977) saw an increase in intake when protein was supplied post-ruminally and the digestibility of the forage did not change. This is evidence that a balance of absorbed nutrients can increase the intake of poor quality forages. Leng (1990) saw a similar increase in intake when he supplemented a poor quality forage with ruminally available nitrogen. Leng (1990) also showed that if the supply of ruminally available nitrogen relative to energy is limited then microbial growth in the rumen will decline and ultimately digestion of feeds will follow.
The rate and amount of intake by animals has been researched from the plant and animal’s perspectives extensively and needs to be further studied before a definite answer on what controls intake and preference among animals can be determined. Evidence has shown that animals have the ability to select feeds based on their nutritional requirements as well as selecting forages that meet these requirements. Matching these requirements with appropriate feeds or forages should improve studies, efficiency, and productivity of grazing animals and pastoral forage systems alike.
CHAPTER III
MATERIALS AND METHODS

Site Description and Trial Preparation

This experiment was conducted at the Mississippi Agricultural and Forestry Experiment Station, Leveck Animal Research Center Forage Unit, Mississippi State, MS (33° 25' N, 88° 47' W; 98.8 m above sea level). The soil type at this site is a Marietta fine sandy loam (fine-loamy, siliceous, thermic Fluvaquentic Eutrochrept). In autumn of 2005, three prairie bromegrass species, Matua (B. willdenowii), BP101 (B. parody), and BW103 (B. wildenoiiti), were established in 9 m x 9 m plots in a randomized complete block design with four replications. Matua (Barenbrug USA, Oregon, USA) is a commercially available prairie bromegrass cultivar. BP101 and BW103 are both experimental lines of prairie bromegrass. Prior to planting, the experiment site was sprayed with Gramoxone™ (1.17 L ha⁻¹ 45% paraquat) (Syngenta, USA) and tilled with disk harrows. Seeds were drilled into a prepared seedbed with a precision cone seeder (Almaco, Nevada, Iowa) at a seeding rate of 28 kg ha⁻¹. Lime, P, and K were applied prior to planting according to soil test recommendations (Mississippi State University Soil Test Laboratory, Mississippi State, MS). Nitrogen fertilizer (37 kg N ha⁻¹) was applied one month after planting as ammonium nitrate (NH₄NO₃). Additional Lime, P, and K were applied according to annual soil test recommendations. Nitrogen fertilizer (56
kg N ha\(^{-1}\)) was applied after each grazing period. Applications of 2,4-D\(^{TM}\) (2.40 L ha\(^{-1}\)) were used as needed to control broadleaf weeds. Applications of 2,4-D\(^{TM}\) (2.40 L ha\(^{-1}\)) were used as needed to control broadleaf weeds.

**Data Collection**

*DM estimation, Nutritional Analyses, Persistence, and Animal Preference*

Plots were grazed on April 4, May 2, and May 30 of 2006 and January 24 and April 25 of 2007. Grazing dates were referred to as grazing periods in numerical sequence by chronological order for each year (Table 3.1). Before all grazing periods, when each plot had accumulated at least 20 cm of growth, five quadrats (0.13 m\(^2\)) were clipped to a 7-cm stubble height to estimate pre-grazing herbage mass. A growing period of 30 days after N fertilization was usually sufficient to acquire 20-cm of growth. For DM determination, samples were dried in a forced-air oven at 55°C until constant weight was achieved. Samples were then ground to pass a 1-mm screen using a Wiley Mill (Thomas Scientific, Swedesboro, NJ). All ground samples were analyzed for dry matter (DM), ash, total N (AOAC, 1990), in vitro dry matter digestibility (IVDMD) (Cherney et al., 1997), and neutral detergent fiber (NDF), and acid detergent fiber (ADF) (Van Soest et al., 1991). Crude protein concentration was determined by multiplying total N concentration by 6.25.
Table 3.1. Table of planting date and grazing periods.

<table>
<thead>
<tr>
<th>Date</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/1/2005</td>
<td>Planting date</td>
</tr>
</tbody>
</table>

**Year 1**
- 4/4/2006   Grazing Period 1
- 5/2/2006   Grazing Period 2
- 5/30/2006  Grazing Period 3

**Year 2**
- 1/24/2007  Grazing Period 1
- 4/25/2007  Grazing Period 2

Exclusion cages (1 m²) were placed at random sites in each plot prior to grazing. Plots were then grazed with Hereford X Angus steers (BW = 227 kg) at a stocking density of 8399 kg/ha until the first plot was grazed down to a 7-cm residual stubble height. Typically, animals remained on plots for five 24-hr days for the target stubble height to be reached. Steers were contained in the plot area with access to only the plots, a lane (consisting of various grass species with annual ryegrass predominating), and ad libitum water and mineral supplement (Multi-Kare, Inc., Tifton, GA, 12% Ca, 6% P, 16% NaCl, 8% Mg, 1% K, 1.2% S, 3000 PPM Mn, 4000 PPM Zn, 1500 PPM Cu, 60 PPM Co, 70 PPM I, 26.5 PPM Se, 220,000 IU/LB Vit. A, 45,000 IU/LB Vit. D-3, 220 IU/LB Vit. E). Five quadrats (0.13 m²) were clipped after grazing to a 7-cm stubble height to estimate post-grazing herbage mass. One quadrat (0.13 m²) was clipped from each exclusionary cage to account for forage growth during grazing. Post-grazing and
exclusion cage samples were dried in a forced-air oven at 55°C until dried to a constant weight. Animal preference was determined by using the following equation.

Available Herbage Mass (HM) – Post-grazing HM = Herbage Disappearance (HD)

Where Available HM = Pre-grazing HM + Herbage Accumulation.

Equation 1.

(Arizona Game and Fish Department, 2005; Mousel and Smart).

After grazing, all plots were then clipped to a 7-cm stubble height with a flail harvester and fertilized with N (56 kg N ha\(^{-1}\)) as ammonium nitrate. Percent stand of each plot was estimated visually as described by Vincelli et al. (2000) after Grazing Periods 1 and 2 of Year 2.

**Plant Physiology**

Prior to and after each grazing 100 tillers (in 2006) or 50 tillers (in 2007) were taken randomly from each plot for leaf and sheath separation. Each tiller was dissected into leaf blade and leaf sheath of different age (1= oldest – 5= youngest), and reproductive material. The length of each pre- and post-grazing component was measured (cm) and then pooled within leaf age. Tillers that were not prairie bromegrass were also pooled within each treatment. The pooled samples were then dried in a forced-air oven at 55°C until a constant weight was achieved and then weighed to determine pre- and post-grazing dry weight of each component. The post-grazing weight was then subtracted from the pre-grazing weight to determine the quantity of each component that was removed by the cattle as described by Watson (2000). The mean post-grazing length
was also subtracted from the mean pre-grazing length of each component to determine how much was removed by the cattle. The differences were then converted to percentages of each component that were removed.

Grazing Preference Observations

Animal measurements were collected in accordance with an approved Mississippi State University Institutional Animal Care and Use Committee protocol (IACUC # 06-026). Cattle were adapted to the experiment site prior to data collection. During the first 24 h of each grazing period in 2007, all of the cattle were observed and their actions were recorded on 5-min intervals. Actions recorded at the beginning of each interval were assumed to continue until the beginning of the next interval. During the first grazing period four steers were observed. During the second grazing period six steers were observed. Actions recorded by plot number (1-12) or out of plot area (out) were grazing, ruminating, or idling; and standing or lying as similarly described by Howard et al. (1992). Animal grazing minutes were then totaled for each 24-h period within each plot to determine animal preference among species.

Statistical Analyses

All data were analyzed using the PROC MIXED procedures of SAS (SAS Inst., 1998). Herbage mass, CP, NDF, ADF, IVDMD, IVTD, tiller length, and persistence data were all compared using the main effects of grazing period, treatment, and grazing period x treatment in the model. Replication was random.
Least square means were separated using pair-wise comparisons and considered to be significant if $P < 0.05$ when comparing HM, forage nutritive value, observation, and persistence data. Differences were considered to be significant if $P < 0.10$ when comparing tiller length and tiller weight data.
CHAPTER IV
RESULTS AND DISCUSSION

Weather Data

The mean air temperatures for both growing seasons in this study (spring of 2006 and 2007) were approximately 1° C higher than the 30-yr average as reported by the Mississippi State University Geosciences Department and were relatively evenly distributed (Table 4.1). However, rainfall averages were low in 2006 and 2007 and conditions were considered very dry during the spring of both years. During the spring of 2006, rainfall was below the 30-yr average by 13% (Table 4.1). During the spring of 2007, average rainfall was 63% below the 30-yr average (Table 4.1).
Table 4.1

Mean monthly air temperature and precipitation at Mississippi State, MS (2005-2007).

<table>
<thead>
<tr>
<th>Month</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>30-yr avg. †</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>30-yr avg.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>°C</td>
<td></td>
<td></td>
<td></td>
<td>mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan.</td>
<td>6.7</td>
<td>10</td>
<td>7.1</td>
<td>5.3</td>
<td>140</td>
<td>170</td>
<td>86</td>
<td>135</td>
</tr>
<tr>
<td>Feb.</td>
<td>9.1</td>
<td>6</td>
<td>6.3</td>
<td>4.9</td>
<td>153</td>
<td>265</td>
<td>78</td>
<td>125</td>
</tr>
<tr>
<td>Mar.</td>
<td>10.5</td>
<td>13.3</td>
<td>16</td>
<td>12.2</td>
<td>77</td>
<td>98</td>
<td>15</td>
<td>152</td>
</tr>
<tr>
<td>Apr.</td>
<td>16.9</td>
<td>20.3</td>
<td>15.7</td>
<td>17.2</td>
<td>204</td>
<td>77</td>
<td>53</td>
<td>145</td>
</tr>
<tr>
<td>May</td>
<td>20.4</td>
<td>21.3</td>
<td>22.5</td>
<td>21.7</td>
<td>74</td>
<td>60</td>
<td>17</td>
<td>117</td>
</tr>
<tr>
<td>June</td>
<td>24.9</td>
<td>25.2</td>
<td>26.6</td>
<td>25.6</td>
<td>133</td>
<td>55</td>
<td>72</td>
<td>97</td>
</tr>
<tr>
<td>July</td>
<td>26.9</td>
<td>27.9</td>
<td>26.6</td>
<td>27.2</td>
<td>251</td>
<td>57</td>
<td>140</td>
<td>124</td>
</tr>
<tr>
<td>Aug.</td>
<td>27.6</td>
<td>28.3</td>
<td>29.9</td>
<td>26.7</td>
<td>143</td>
<td>98</td>
<td>42</td>
<td>86</td>
</tr>
<tr>
<td>Sept.</td>
<td>24.6</td>
<td>21.3</td>
<td>-</td>
<td>23.3</td>
<td>96</td>
<td>99</td>
<td>-</td>
<td>97</td>
</tr>
<tr>
<td>Oct.</td>
<td>17</td>
<td>15.2</td>
<td>-</td>
<td>17.2</td>
<td>3</td>
<td>266</td>
<td>-</td>
<td>84</td>
</tr>
<tr>
<td>Nov.</td>
<td>12.8</td>
<td>9.8</td>
<td>-</td>
<td>12.2</td>
<td>71</td>
<td>56</td>
<td>-</td>
<td>109</td>
</tr>
<tr>
<td>Dec.</td>
<td>5.4</td>
<td>8.8</td>
<td>-</td>
<td>5.9</td>
<td>102</td>
<td>120</td>
<td>-</td>
<td>150</td>
</tr>
</tbody>
</table>

† Data from Geosciences Department, Mississippi State, MS (33.47° N, 88.78° W, Elevation = 185 ft.).
Dry Matter Yield

BP101 had the least pre-grazing herbage mass (HM) among the three species in the first grazing period in Year 1 (P < 0.05) (Table 4.2). Pre-grazing HM were similar among species in Year 2 within grazing period, however, HM of Matua and BW103 were greater in the second grazing period than the first grazing period (P < 0.05). During Year 1, BP101 proved to be slower growing and therefore generally producing less forage when compared to Matua and BW103. Mean spring HM per grazing period during Year 1 for Matua, BP101, and BW103 were 4,000, 2,750, and 3,800 kg ha\(^{-1}\), respectively. However, longer rest intervals between grazing as well as lack of rainfall may have allowed BP101 to accumulate enough forage to be similar to Matua and BW103 in Year 2 with mean HM yields totaling 4,500, 4,900, and 4,200 kg ha\(^{-1}\) for Matua, BP101, and BW103, respectively. Spring HM in Year 2 exceeded yields found by Lang (2006, Personal Communication). However, fertilizer regimes were different between studies. There was less pre-grazing HM (P < 0.05) for all species in Grazing Periods 2 and 3 than in Grazing Period 1 during Year 1, which was possibly the result of a shorter regrowth period before these grazing periods. Matua and BW103 pre-grazing HM in Year 2 increased (P < 0.05) from the first grazing period to the second, which is probably the result of greater stem and reproductive material production (Table 4.6). Pre-grazing HM of BP101 was similar (P > 0.05) in both grazing periods in Year 2.
Table 4.2

Pregrazing and postgrazing herbage mass and herbage disappearance of three prairie bromegrass species at Mississippi State, MS (2006 – 2007).

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Species</th>
<th>Pregrazing HM</th>
<th>Postgrazing HM</th>
<th>Herbage Disappearance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grazing Period 1</strong></td>
<td>Matua_a</td>
<td>6179.74 Aa</td>
<td>3790.77 Ba</td>
<td>2653.54 Aa</td>
</tr>
<tr>
<td></td>
<td>BP101_a</td>
<td>3790.77 Ba</td>
<td>1816.41 Ca</td>
<td>1974.36 ABa</td>
</tr>
<tr>
<td></td>
<td>BW103_a</td>
<td>5626.92 Aa</td>
<td>4422.56 Aa</td>
<td>1204.36 Ba</td>
</tr>
<tr>
<td></td>
<td>SE</td>
<td>625</td>
<td>402</td>
<td>664</td>
</tr>
<tr>
<td><strong>Grazing Period 2</strong></td>
<td>Matua_a</td>
<td>2665.38 Ab</td>
<td>2428.46 Ab</td>
<td>730.51 Ab</td>
</tr>
<tr>
<td></td>
<td>BP101_a</td>
<td>2961.54 Ab</td>
<td>2696.97 Aa</td>
<td>1125.38 Aa</td>
</tr>
<tr>
<td></td>
<td>BW103_a</td>
<td>1816.41 Ca</td>
<td>1682.15 Aa</td>
<td>746.31 Aab</td>
</tr>
<tr>
<td></td>
<td>SE</td>
<td>625</td>
<td>434</td>
<td>664</td>
</tr>
<tr>
<td><strong>Grazing Period 3</strong></td>
<td>Matua_a</td>
<td>2882.56 Ab</td>
<td>2053.33 Ab</td>
<td>1074.05 Ab</td>
</tr>
<tr>
<td></td>
<td>BP101_a</td>
<td>2902.31 Ab</td>
<td>1543.95 Aa</td>
<td>509.38 Ab</td>
</tr>
<tr>
<td></td>
<td>BW103_a</td>
<td>3415.64 Ab</td>
<td>1808.51 Ab</td>
<td>1093.79 Aa</td>
</tr>
<tr>
<td></td>
<td>SE</td>
<td>675</td>
<td>434</td>
<td>664</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year 2</th>
<th>Species</th>
<th>Pregrazing HM</th>
<th>Postgrazing HM</th>
<th>Herbage Disappearance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grazing Period 1</strong></td>
<td>Matua_a</td>
<td>3376.15 Ab</td>
<td>4363.94 Aa</td>
<td>1074.05 Ab</td>
</tr>
<tr>
<td></td>
<td>BP101_a</td>
<td>4363.94 Aa</td>
<td>3242.89 Aa</td>
<td>509.38 Ab</td>
</tr>
<tr>
<td></td>
<td>BW103_a</td>
<td>3415.64 Ab</td>
<td>1915.13 Aa</td>
<td>1093.79 Aa</td>
</tr>
<tr>
<td></td>
<td>SE</td>
<td>675</td>
<td>717</td>
<td>664</td>
</tr>
<tr>
<td><strong>Grazing Period 2</strong></td>
<td>Matua_a</td>
<td>5646.67 Aa</td>
<td>5395.90 Aa</td>
<td>2949.69 Aa</td>
</tr>
<tr>
<td></td>
<td>BP101_a</td>
<td>4995.13 Aa</td>
<td>2921.57 Aa</td>
<td>2921.57 Aa</td>
</tr>
<tr>
<td></td>
<td>BW103_a</td>
<td>2673.28 Aa</td>
<td>2673.28 Aa</td>
<td>2673.28 Aa</td>
</tr>
<tr>
<td></td>
<td>SE</td>
<td>675</td>
<td>434</td>
<td>717</td>
</tr>
</tbody>
</table>

† Within rows, means followed by the same upper case letter or within columns (for the same parameters within year), followed by the same lower case letter are not different (P < 0.05) using probability of difference for pair-wise comparisons.

Post-grazing HM was similar (P > 0.05) among species during all grazing periods except Grazing Period 1 in Year 1 (Table 4.2). However, during Grazing Period 1 in
Year 1, all three species differed (P < 0.05) in post-grazing HM (Table 4.2). This was likely due to the amount of available forage of each species at the beginning of this grazing period. Post-grazing HM was less in Grazing Periods 2 and 3 in Year 1 for Matua and BW103 (P < 0.05). However, post-grazing HM for BP101 was consistent across all grazing periods in Year 1. Post-grazing HM increased from the 1\textsuperscript{st} to the 2\textsuperscript{nd} grazing period for all species in Year 2 (P < 0.05). This effect can probably be attributed to the time of the growing season in which the grazing periods occurred. All stands consisted of more stem and reproductive material in the second grazing period in Year 2.

Herbage disappearance (HD), used to quantify animal preference, was similar (P > 0.05) among prairie bromegrass species during all grazing periods except Grazing Period 1 in Year 1 in which Matua was preferred the most, BW103 was preferred the least, and BP101 was intermediate. During this grazing period, BP101 pre-grazing HM was less than the other species (P < 0.05) (Table 4.2). Post-grazing HM also differed (P < 0.05) with BW103 having the most, BP101 having the least, and Matua ranking in between the other species (Table 4.2). Examination of the tiller length data (Table 4.6) indicates that post-grazing residual HM is linked to sheath length as during this grazing period BW103 produced the longest sheath and BP101 produced the shortest sheath (Leaves 3 – 5) (P < 0.10). These data indicate that the cattle grazed each species until reaching the seemingly less preferable sheath material. Herbage disappearance was less in Grazing Periods 2 and 3 during Year 1 for Matua and BP101 (P < 0.05). Although, pre-grazing HM was also less (P < 0.05) during these grazing periods. Herbage disappearance was consistent (P > 0.05) across all grazing periods for BW103 in Year 1.
In Year 2, herbage disappearance was consistent across both grazing periods for all species (P > 0.05). In all grazing periods except Grazing Period 1 in Year 1, herbage disappearance and post-grazing HM values were similar (P > 0.05). Because the cattle were forced to graze until at least one plot reached a 7.5-cm stubble height, these data indicate that there is no animal preference among the three species of prairie bromegrass.

Both Matua and BW103 persisted well, maintaining approximately 80% and 83% stands after two grazing seasons. However, BP101 did not persist as well, maintaining only approximately a 30% stand. It should be noted that one replicate of BP101 had to be dropped from the study in the second year due to poor persistence. The poor persistence of BP101 can probably be linked to grazing pressure, because all three of these species have shown to persist well under mechanical harvest. Lang (2006, Personal Communication) observed all three species retain at least 69% of their stand under mechanical harvest for two spring seasons after planting in Mississippi. Also, the canopy of the stand did not open in the summer or fall of each year due to lack of rainfall. This likely reduced the amount of natural reseeding to a minimum level (Guay, 2001; Jung et al., 1994).
Table 4.3

Stand Density of three prairie bromegrass species at Mississippi State, MS.

<table>
<thead>
<tr>
<th></th>
<th>Matua</th>
<th>BP101</th>
<th>BW103</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2/1/2007</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stand Density %</td>
<td>80.63 Aa†</td>
<td>40.63 Ba</td>
<td>85.63 Aa</td>
</tr>
<tr>
<td><strong>4/1/2007</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stand Density %</td>
<td>81.25 Aa</td>
<td>36.25 Ba</td>
<td>82.50 Aa</td>
</tr>
<tr>
<td><strong>5/1/2007</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stand Density %</td>
<td>80.00 Aa</td>
<td>27.50 Ba</td>
<td>83.75 Aa</td>
</tr>
</tbody>
</table>

† Within rows, means followed by the same upper case letter or within columns, followed by the same lower case letter are not significant (P < 0.05) using probability of difference for pair-wise comparisons.

**Nutritive Value**

**Crude Protein**

In Year 1, CP concentration only varied by species during the first grazing period (P < 0.05). Values ranged from 96 to 113 g kg\(^{-1}\) DM with BP101 being the highest (Table 3.4). Similar CP levels in prairie bromegrass were seen by Lacasha et al. (1999) and Missaoui (1998). This difference among species could be due to the variation in growth habits. In Year 1, as stated earlier, BP101 proved to be a slower growing and therefore less productive forage when compared to the other two species in the study. The time period between N application and grazing was much longer before the first grazing period than the following two grazing periods in Year 1. This length of time may have allowed the more productive species to produce enough forage mass to dilute the N concentration in the plant resulting in a lower CP value.
Turner et al. (2006) also saw a decline in CP during regrowth. These time periods between fertilizer application and grazing may have also been the reason for greater CP levels in all species in Grazing Periods 2 and 3 in Year 1.
Table 4.4

Nutritional quality of three prairie bromegrass species at Mississippi State, MS (2006-2007).

<table>
<thead>
<tr>
<th>Year</th>
<th>Grazing Period 1</th>
<th>IVDMD</th>
<th>IVTD</th>
<th>NDF</th>
<th>ADF</th>
<th>CP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matua</td>
<td>735 Aa†</td>
<td>865 Aa</td>
<td>530 Ab</td>
<td>285 Ab</td>
<td>100 ABb</td>
<td></td>
</tr>
<tr>
<td>BP101</td>
<td>728 Aa</td>
<td>861 Aa</td>
<td>507 Ab</td>
<td>274 Ab</td>
<td>113 Ab</td>
<td></td>
</tr>
<tr>
<td>BW103</td>
<td>715 Aa</td>
<td>851 Aa</td>
<td>540 Ab</td>
<td>295 Ab</td>
<td>96 Bb</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grazing Period 2</th>
<th>Matua</th>
<th>628 Ab</th>
<th>801 Ab</th>
<th>613 Aa</th>
<th>341 Aa</th>
<th>140 Aa</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP101</td>
<td>635 Ab</td>
<td>794 Ab</td>
<td>620 Aa</td>
<td>327 Aa</td>
<td>153 Aa</td>
<td></td>
</tr>
<tr>
<td>BW103</td>
<td>631 Ab</td>
<td>803 Ab</td>
<td>626 Aa</td>
<td>345 Aa</td>
<td>142 Aa</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grazing Period 3</th>
<th>Matua</th>
<th>596 ABb</th>
<th>778 Ab</th>
<th>618 Aa</th>
<th>343 Aa</th>
<th>141 Aa</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP101</td>
<td>562 Bc</td>
<td>745 Bc</td>
<td>615 Aa</td>
<td>347 Aa</td>
<td>151 Aa</td>
<td></td>
</tr>
<tr>
<td>BW103</td>
<td>608 Ab</td>
<td>771 ABc</td>
<td>617 Aa</td>
<td>340 Aa</td>
<td>142 Aa</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Grazing Period 1</th>
<th>Matua</th>
<th>705 Aa</th>
<th>856 Aa</th>
<th>520 ABb</th>
<th>259 Ab</th>
<th>154 Aa</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP101</td>
<td>686 ABa</td>
<td>843 ABa</td>
<td>503 Bb</td>
<td>255 Ab</td>
<td>159 Aa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BW103</td>
<td>652 Ba</td>
<td>822 Ba</td>
<td>551 Ab</td>
<td>277 Ab</td>
<td>142 Aa</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grazing Period 2</th>
<th>Matua</th>
<th>576 Bb</th>
<th>700 Bb</th>
<th>678 Aa</th>
<th>366 Aa</th>
<th>95 Ab</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP101</td>
<td>618 Ab</td>
<td>761 Ab</td>
<td>664 Aa</td>
<td>360 Aa</td>
<td>94 Ab</td>
<td></td>
</tr>
<tr>
<td>BW103</td>
<td>580 ABb</td>
<td>726 Bb</td>
<td>659 Aa</td>
<td>358 Aa</td>
<td>96 Ab</td>
<td></td>
</tr>
</tbody>
</table>

† Within rows, means followed by the same upper case letter or within columns (within year), followed by the same lower case letter are not significant (P < 0.05) using probability of difference for pair-wise comparisons.

In Year 2, CP levels were not different (P > 0.05) among species in either grazing period. However, CP levels were greater (P < 0.05) in Grazing Period 1 compared to 2. This effect can be attributed to climatic conditions and growth stages of the plant. In the
“Deep South USA”, the region in which the present experiment was conducted, most cool-season plants reach maturity in late spring or early summer. Therefore, at the beginning of the second grazing period in Year 2 the plants were reaching maturity and producing more reproductive material than in the first grazing period. To add to this, during Year 2, there was a lack of rainfall which will speed up the maturation process in the plant. As the plants reach maturity, CP levels will tend to decline.

**Fiber Concentration**

There were no differences in ADF (P > 0.05) among species throughout the study. However, as plants got closer to maturity with progressing grazing periods, ADF values increased with values ranging from 255 to 366 g kg\(^{-1}\) DM. During Year 1, NDF values were not different among species (P > 0.05). However, NDF values were also higher (P < 0.05) in Grazing Periods 2 and 3 than in Grazing Period 1, because the plants were getting closer to maturity at this time. In Year 2, NDF values did vary among species during Grazing Period 1. Since this grazing period was at a time in the season when the plants were producing mostly vegetative growth, this effect could probably be linked to physiological differences among the species. Proportion of stem and / or reproductive material production may vary among species during times of mainly vegetative growth. Sheath production values seem to be linked to NDF values during this grazing period. During the second grazing period in Year 2 when the plants were closer to maturity, there were no differences (P > 0.05) in NDF among species. Similar values for ADF and NDF were reported by LaCasha et al. (1999) and Missaoui (2000).
**Digestibility**

As expected, digestibility values followed similar trends as fiber concentration values. In Year 1, there were no differences (P > 0.05) in IVTD or IVDMD among species during the first two grazing periods. However, digestibility decreased as plants reached maturity as the season progressed in both years. During the third grazing period of Year 1, IVTD and IVDMD of BP101 were lesser than for the other species (P < 0.05).

In Year 2, there was a species x grazing period interaction on IVTD (P < 0.05) and IVDMD (P < 0.05). These differences may be related to physiological differences among species. During the first grazing period when the plants were in a vegetative stage, it appears that Matua had the highest digestibility values. However, during the second grazing period, BP101 appeared to have the highest digestibility values while Matua and BW103 appeared to have the lowest digestibility values. There was a severe lack of rainfall between Grazing Period 1 and Grazing Period 2 in Year 2 (Table 4.1). These data could lend support to the hypothesis that BP101 is less susceptible to drought stress than Matua or BW103. Digestibility values also decreased (P < 0.05) for all species during the second grazing period as all plants were closer to maturity.

**Animal Preference Related to Tiller Data**

During all grazing periods in both years cattle removed more leaf material from the plant than sheath material (P < 0.05). However, the tiller herbage disappearance % (HD %) data seemed to follow the DM herbage disappearance trends closely. Differences in tiller length seemed to affect tiller HD %. It follows that if the tiller leaf
length was greater, then the leaf HD % would also be greater, and vice-versa. These data indicate that the cattle selectively grazed more leaf than sheath but simply by harvesting an upper portion of the tiller. These data show that leaf length seems to spike at the 2nd or 3rd oldest leaf (Table 4.6). The tiller HD% data follows the same trend closely (Table 4.5). Examination of the physiological characteristics of the prairiegrass plant perhaps explains how these HD % could occur. During the grazing periods, the 2nd or 3rd leaf would be the longest leaf growing above the 3rd or 4th leaf in total height and also curl downward to give the appearance of an equal leaf height among leaves. At the same time, the overall heights of all the leaf sheaths were in a closer range. If cattle harvested an upper portion of the tiller, then naturally the longest leaf would show more disappearance compared to the others. In Year 1, cattle removed more reproductive material for BP101 and BW103 than Matua in Grazing Period 3. This data appear to indicate that as the plants mature, Matua may be less preferable than BP101 or BW103. This conclusion seems to link well with the nutritional quality data taken from Year 2 (Table 4.4). However, during Year 2 as the plants matured, cattle seemed to remove more sheath material from Matua. Again, this data could indicate that Matua is a faster maturing species under drought stress and average sheath length was greater than the other species, thus there was more to be removed at this time.
Table 4.5
Proportion of leaf sheath and leaf blade herbage disappearance for leaf ages 1 – 5
(L1 = oldest leaf – L5 = youngest leaf) of prairie bromegrass tillers.

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Grazing Period</th>
<th>Species</th>
<th>L1 S</th>
<th>L1 B</th>
<th>L2 S</th>
<th>L2 B</th>
<th>L3 S</th>
<th>L3 B</th>
<th>L4 S</th>
<th>L4 B</th>
<th>L5 S</th>
<th>L5 B</th>
<th>Repro</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Matua</td>
<td>-18 Aab</td>
<td>10 Bb</td>
<td>-10 Aab</td>
<td>25 Bb</td>
<td>-2 Aab</td>
<td>38 Bb</td>
<td>-6 Aa</td>
<td>43 Ba</td>
<td>-18 Ab</td>
<td>40 Bb</td>
<td>-7 Aa</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>BP101</td>
<td>-7 Aa</td>
<td>36 Aa</td>
<td>-4 Ab</td>
<td>61 Aa</td>
<td>10 Ab</td>
<td>69 Aa</td>
<td>0.5 Ab</td>
<td>71 Aa</td>
<td>-37 Ab</td>
<td>64 Aa</td>
<td>13 Ab</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>BW103</td>
<td>-10 Aa</td>
<td>3 Bc</td>
<td>2 Aa</td>
<td>14 Bc</td>
<td>4 Aa</td>
<td>34 Bb</td>
<td>4 Aa</td>
<td>45 Ba</td>
<td>-9 Aa</td>
<td>46 ABa</td>
<td>2 Ab</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Species</th>
<th>2</th>
<th>Matua</th>
<th>3 Aa</th>
<th>36 Aa</th>
<th>1 Aa</th>
<th>47 Aa</th>
<th>6 Aa</th>
<th>36 Ab</th>
<th>8 Aa</th>
<th>23 Ab</th>
<th>55 Aa</th>
<th>10 Bc</th>
<th>11 ABa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>BP101</td>
<td>1 Aa</td>
<td>21 Bb</td>
<td>-5 Ab</td>
<td>32 Ab</td>
<td>-1 Ab</td>
<td>22 Ac</td>
<td>-9 Ab</td>
<td>19 Ac</td>
<td>11 ABab</td>
<td>12 Bb</td>
<td>-19 Bb</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>BW103</td>
<td>-1 Aa</td>
<td>39 Ab</td>
<td>-10 Aa</td>
<td>52 Ab</td>
<td>4 Aa</td>
<td>36 Ab</td>
<td>16 Aa</td>
<td>21 Ab</td>
<td>-3 Ba</td>
<td>36 Aa</td>
<td>24 Ab</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Species</th>
<th>3</th>
<th>Matua</th>
<th>-25 Bb</th>
<th>45 Aa</th>
<th>-20 Bb</th>
<th>45 Ba</th>
<th>-14 Bb</th>
<th>55 Aa</th>
<th>-3 Ba</th>
<th>43 Aa</th>
<th>50 Aa</th>
<th>67 Aa</th>
<th>16 Ba</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
<td>BP101</td>
<td>7 Aa</td>
<td>49 Aa</td>
<td>21 Aa</td>
<td>63 ABa</td>
<td>35 Aa</td>
<td>53 Ab</td>
<td>36 Aa</td>
<td>48 Ab</td>
<td>52 Aa</td>
<td>46 ABa</td>
<td>50 Aa</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>BW103</td>
<td>-12 ABa</td>
<td>55 Aa</td>
<td>3 Aa</td>
<td>71 Aa</td>
<td>20 Aa</td>
<td>54 Aa</td>
<td>27 ABa</td>
<td>45 Aa</td>
<td>-16 Ba</td>
<td>36 Ba</td>
<td>76 Aa</td>
</tr>
</tbody>
</table>

† Within rows, means followed by the same upper case letter or within columns (within year), followed by the same lower case letter are not different (P < 0.10) using probability of difference for pair wise comparisons.

aL1 S = Leaf 1 Sheath  cL3 S = Leaf 3 Sheath  iL5 S = Leaf 5 Sheath
bL1 B = Leaf 1 Blade   dL2 B = Leaf 2 Blade   fL4 S = Leaf 4 Sheath
L2 S = Leaf 2 Sheath   L4 B = Leaf 4 Blade   kRepro = Reproductive Stem
L5 S = Leaf 5 Sheath
Table 4.5 (Continued).

<table>
<thead>
<tr>
<th>Period</th>
<th>Species</th>
<th>L1 S</th>
<th>L1 B</th>
<th>L2 S</th>
<th>L2 B</th>
<th>L3 S</th>
<th>L3 B</th>
<th>L4 S</th>
<th>L4 B</th>
<th>L5 S</th>
<th>L5 B</th>
<th>Repro</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Matua</td>
<td>4 Aa</td>
<td>64 Aa</td>
<td>5 Aa</td>
<td>66 Aa</td>
<td>-9 Ab</td>
<td>63 Aa</td>
<td>-73 Ab</td>
<td>61 Aa</td>
<td>-102 Bb</td>
<td>38 Ab</td>
<td>100 Aa</td>
</tr>
<tr>
<td>1</td>
<td>BP101</td>
<td>20 Aa</td>
<td>57 Aa</td>
<td>20 Aa</td>
<td>58 Aa</td>
<td>4 Aa</td>
<td>59 Aa</td>
<td>-8 Ba</td>
<td>47 Aa</td>
<td>-100 Bb</td>
<td>30 Ab</td>
<td>.</td>
</tr>
<tr>
<td>1</td>
<td>BW103</td>
<td>4 Aa</td>
<td>63 Aa</td>
<td>4 Aa</td>
<td>65 Aa</td>
<td>-5 Aa</td>
<td>63 Aa</td>
<td>-90 Ab</td>
<td>48 Aa</td>
<td>0 Aa</td>
<td>30 Ab</td>
<td>.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Species</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Matua</td>
<td>-36 Ab</td>
<td>47 Ab</td>
<td>-2 Aa</td>
<td>43 Ab</td>
<td>10 Aa</td>
<td>41 ABb</td>
<td>13 Aa</td>
<td>42 ABb</td>
<td>-15 Aa</td>
<td>62 Aa</td>
<td>29 Ab</td>
</tr>
<tr>
<td>2</td>
<td>BP101</td>
<td>-25 Ab</td>
<td>46 Aa</td>
<td>-8 Ab</td>
<td>47 Aa</td>
<td>-5 Aa</td>
<td>54 Aa</td>
<td>2 Aa</td>
<td>56 Aa</td>
<td>-1 Aa</td>
<td>72 Aa</td>
<td>18 A</td>
</tr>
<tr>
<td>2</td>
<td>BW103</td>
<td>-35 Ab</td>
<td>46 Ab</td>
<td>-9 Aa</td>
<td>37 Ab</td>
<td>-3 Aa</td>
<td>29 Bb</td>
<td>-1 Aa</td>
<td>40 Ba</td>
<td>8 Aa</td>
<td>67 Aa</td>
<td>21 A</td>
</tr>
</tbody>
</table>

† Within rows, means followed by the same upper case letter or within columns (within year), followed by the same lower case letter are not different (P < 0.10) using probability of difference for pair wise comparison.

- L1 S = Leaf 1 Sheath
- L1 B = Leaf 1 Blade
- L2 S = Leaf 2 Sheath
- L2 B = Leaf 2 Blade
- L3 S = Leaf 3 Sheath
- L3 B = Leaf 3 Blade
- L4 S = Leaf 4 Sheath
- L4 B = Leaf 4 Blade
- L5 S = Leaf 5 Sheath
- L5 B = Leaf 5 Blade
- Repro = Reproductive Stem
Cattle also appeared to prefer BP101 leaf blade material to that of BW103 and Matua in Grazing Period 1 of Year 1. However, this is probably due to the fact that BP101 produced a longer leaf than BW103 and Matua during this grazing period although not statistically significant \((P > 0.10)\) (Table 4.6). As previously stated and as shown by the data (Table 4.6), during the first grazing period in Year 2, the plants were in a vegetative state. The lack of reproductive stems and L5 sheath material is an indicator of this condition.
Table 4.6

Length of leaf blade and leaf sheath for leaf ages 1 - 5 (L1 = oldest leaf – L5 = youngest leaf) of prairie bromegrass tillers.

<table>
<thead>
<tr>
<th>Species</th>
<th>L1 S</th>
<th>L1 B</th>
<th>L2 S</th>
<th>L2 B</th>
<th>L3 S</th>
<th>L3 B</th>
<th>L4 S</th>
<th>L4 B</th>
<th>L5 S</th>
<th>L5 B</th>
<th>Repro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matua</td>
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† Within rows, means followed by the same upper case letter or within columns (within year), followed by the same lower case letter are not different (P < 0.10) using probability of difference for pair wise comparisons.

aL1 S = Leaf 1 Sheath  
bL1 B = Leaf 1 Blade  
cL2 S = Leaf 2 Sheath  
dL2B = Leaf 2 Blade  
eL3 S = Leaf 3 Sheath  
fL3 B = Leaf 3 Blade  
gL4 S = Leaf 4 Sheath  
hL4 B = Leaf 4 Blade  
iL5 S = Leaf 5 Sheath  
jL5 B = Leaf 5 Blade  
kRepro = Reproductive Stem
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Species

2     | Matua   | 5 Ab | 17.5 Ab | 9 Aa | 17.5 Ab | 11 Aa | 17 Ab | 12 Ab | 16 Ab | 12.5 Aa | 15 Ab | 27.5 Aa |
2     | BP101   | 4.5 Aa | 15.5 Ab | 7.5 Aa | 16.5 Ab | 8.5 Ba | 17 Ab | 9 Ba | 16 Ab | 9.5 B | 14.5 Ab | 22 B  |
2     | BW103   | 5 Ab | 17.5 Ab | 9 Aa | 17.5 Ab | 10.5 Aa | 16.5 Ab | 11 Aa | 15 Ab | 12 Aa | 14 Ab | 27.55 A |
|       | SE      | 0.6 | 1.95 | 0.8 | 2.34 | 0.84 | 2.06 | 0.91 | 1.84 | 1.31 | 1.84 | 2.43 |

† Within rows, means followed by the same upper case letter or within columns (within year), followed by the same lower case letter are not different (P < 0.10) using probability of difference for pair wise comparisons.

aL1 S = Leaf 1 Sheath    cL3 S = Leaf 3 Sheath    iL5 S = Leaf 5 Sheath
bL1 B = Leaf 1 Blade    fL3 B = Leaf 3 Blade    jL5 B = Leaf 5 Blade
cL2 S = Leaf 2 Sheath    gL4 S = Leaf 4 Sheath    kRepro = Reproductive Stem
dL2B = Leaf 2 Blade     hL4 B = Leaf 4 Blade
If the leaf and sheath lengths between Grazing Periods 1 and 2 of Year 2 are compared, the impact of a lack of moisture on plant growth is revealed. As the data show in Grazing Period 2 of Year 2 (Table 4.5), there tended to be more sheath removal and less leaf removal than Grazing Period 1. After the vegetative plants of Grazing Period 1 were grazed and clipped, the stand was fertilized and left to regrow. However, there was a severe lack of rainfall during the time period between Grazing Period 1 and Grazing Period 2 in Year 2 (refer to table 4.1), which likely caused the plants to mature at a faster than normal rate. As the stands reached maturity the stems elongated and produced reproductive material (seedheads and stem). This process in turn produced more sheath material which is probably the reason for greater sheath removal during Grazing Period 2. The faster rate of maturity also could have affected leaf growth which can explain shorter leaf lengths in Grazing Period 2.

No differences in HD % could be linked to animal preference among species. Although, HD % seems to be linked to the amount of pre-grazing leaf or sheath material that was present. This means that generally, if there was more material present to be removed, then the HD % values were higher and vice-versa. Therefore, it can be concluded that there is no animal preference among Matua, BP101, and BW103 prairie bromegrasses.

**Grazing Behavior Observations**

There were no differences in time spent grazing by animals among species in either observation period in Year 2 (P > 0.05). Mean animal grazing minutes ranged among species from 41 to 45 in Grazing Period 1 and from 14 to 19 in Grazing Period 2.
The differences in grazing time between the two grazing periods was likely due to the
difference in amount of available forage at the beginning of the grazing periods as well as
the differences in maturity of the forages between grazing periods. More available forage
in Grazing Period 2 (refer to table 4.2) should allow the cattle to realize gut fill in a
shorter length of time than Grazing Period 1. Also, the nutritional data indicates that
digestibility of all species was poorer in Grazing Period 2 (P < 0.05) (Table 4.4). Poorer
digestibility could in turn produce longer digestion periods due to slower rate of passage
and, in turn, reduce grazing time in a 24-h period.

Conclusion

From an agronomic standpoint, prairie bromegrass is a forage that is capable of
producing acceptable amounts of good quality forage. Researchers have shown that
prairie bromegrass is capable of producing upwards of 10,000 kg ha\(^{-1}\) (Bell and Ritchie,
1989; Jung et al., 1994). However, an appropriate management plan would have to be
implemented in order to achieve high herbage production. The data collected in this
study indicate that BP101 is a slower growing and lesser producing forage than Matua or
BW103. The persistence of BP101 was inferior to the other species, which could be due
to grazing pressure as research has shown that it will persist under mechanical harvest
(Lang, 2006, Personal Communication). It should be noted that to the knowledge of the
authors, no grazing research has been conducted using the BP101 or BW103 species in
the USA at present. Therefore, comparisons among studies are based solely on the Matua
species. The nutritional quality of prairie bromegrass is similar to other commonly
grown cool-season forages in the southeast USA including annual ryegrass and tall fescue
(Ball et al., 2002). No consistent differences among species were found pertaining to forage quality during the course of this study ($P > 0.05$).

The cattle in this study did not show any preference for one species over another. Herbage disappearance correlated very strongly with the amount of available forage at the beginning of grazing periods. Cattle were left to graze the plots until the first plot was grazed to approximately 7-cm. This process resulted in cattle removing more plant material if there was more plant material to be removed. For example, as plants reach maturity with the progressing grazing periods within a year, there will be more sheath material production in the stand. If cattle are forced to graze the stand down to the same height in each grazing period then there will be more sheath removal as the stand reaches maturity. However, these results are based on the fact that there was no animal preference among species, as was the case in this study.

The tiller data did show that BP101 consistently produced the least sheath and reproductive material although it was not always significant ($P > 0.05$). However, in Grazing Period 1 of Year 1 and in Grazing Period 2 of Year 2, BP101 produced significantly less sheath (leaves 3 to 5) and reproductive material and also had greater digestibility values in Year 2 ($P < 0.05$). These data could indicate a correlation between sheath and reproductive material and digestibility. The grazing behavior observations showed similar results. Based on time spent grazing, cattle showed no preference among species. Mean grazing time declined from Grazing Period 1 to Grazing Period 2, however, values were not significantly different ($P > 0.05$). These data indicate that the greater amount of available forage in Grazing Period 2 allowed the cattle to obtain gut fill
to the point where the grazing bout ceased in less grazing time. Also, digestibility was poorer in the second grazing period which could lead to longer digestion periods for the cattle resulting in less grazing time in a 24-h period.

The results of this study indicate there could be differences in growth traits among the three species of prairie bromegrass observed. This information could be of interest to plant breeders if breeding for an improved variety of prairie bromegrass. It is the conclusion of the authors that large scale grazing research as well as economic analyses may be needed to before any conclusions about the viability of prairie bromegrass as an alternative forage crop in the southeastern USA can be made.
LITERATURE CITED


Arizona Game and Fish Department. *Are there too many elk?* 2005. [www.azdfg.gov/focuswild](http://www.azdfg.gov/focuswild).


