Production and quality of Jiggs bermudagrass forage on Holstein cow milk production and quality parameters under an intermittent grazing system

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Production of Jiggs bermudagrass and the impact of quality milk production and quality of Holstein dairy cows under an intermittent grazing system

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Short title: Brandstetter et al. - Production and quality of Jiggs bermudagrass and milk production

ABSTRACT: Dairy production plays a fundamental role in the Brazilian economy, and high-quality forage is necessary for ruminants to produce satisfactory milk levels, so the aim of the present study was to evaluate the production and quality of Jiggs bermudagrass and its effects on the production and quality parameters of milk from Holstein cows under an intermittent grazing system throughout the year. The experiment was conducted in a randomized design with the four seasons as treatments was replicated five times. The season had a significant effect on the production and nutritional parameters of Jiggs bermudagrass with the highest total dry matter production observed during summer followed by spring and fall. The neutral detergent fiber and acid detergent fiber contents were significantly higher in winter. The In vitro dry matter digestibility was significantly higher in summer, spring and fall. Jiggs
bermudagrass is a promising forage for the enhancement of milk production under intermittent stocking. However, its effects vary seasonally that exerts a greater influence during the winter, even with irrigation, because it directly affects milk production and quality. The correlation results demonstrated the importance of better quality forage for increasing milk production without compromising the levels of milk solids.

Keywords: \([Cynodon dactylon (L.) pers.], \) forage production, irrigation, milk quality, seasons

INTRODUCTION

Well-managed tropical pastures can sustain satisfactory levels of milk production, especially during the most favorable times of the year, as they can provide the energy, protein, minerals and essential vitamins necessary for animal production (Gomide et al. 2001).

The search for alternatives intensification of the grazing system is usually associated with the advances in science and technology that have contributed to historical increases in livestock production, and indicates where potential remains, in relation to livestock genetics and breeding, greater nutrient inputs, livestock nutrition and livestock disease management (Thornton, 2010). Studies have investigated the rational use of technologies for soil, environment, plant and animal management, with a focus on the use of intermittent grazing systems, irrigation and fertilization to improve forage production (Andrade et al. 2012; Pequeno et al. 2015; Silva et al. 2015).

Forage grasses of the genus Cynodon are an option for ruminant feed and have been the focus of renewed research interest due to their versatility and the continuous release of new commercial varieties into the market (Aguiar et al. 2014; Carvalho et al. 2012). Grasses from this genus have been introduced in Brazil due to their nutritional advantages, such as...
their high protein content and more digestible fiber compared to other grasses (Burns and Fisher; Rezende et al. 2015).

Bermudagrass (*Cynodon dactylon*) is a forage grass of the genus *Cynodon*, and the Jiggs cultivar has been gaining in importance and is currently extensively used by farmers due to its high productivity and viability in poorly drained soils (Aguiar et al. 2014). Jiggs bermudagrass has a high production potential, is competitive with other forage grasses during all seasons of the year and is able to survive and produce under adverse climatic conditions (Carvalho et al. 2012).

Jiggs bermudagrass belongs to a group of sterile hybrid species, including Tifton and Coastcross, that propagate vegetatively, but its main success factor is that it can also be grown from seeds, which increases the ease and speed at which it can be established (Carvalho et al. 2012). Furthermore, the structure of its cell walls promotes digestibility as the lower concentration of fibers is more favorable for animal nutrition relative to the well-known Tifton 85 cultivar (Rezende et al. 2015).

Jiggs bermudagrass has been extensively studied due to its nutritional advantages, production potential, response to fertilization, adaptation to different environments and flexibility of use (Aguiar et al. 2014; Rezende et al. 2015; Silva et al. 2015).

Little information is available concerning the potential of Jiggs bermudagrass for milk production; thus, more detailed studies are needed. Studies should be conducted to obtain information regarding the use of intermittent grazing systems with Jiggs bermudagrass and to define recommendations for the use of this grazing system for the production of high-quality milk. The aim of the present study was to evaluate the production and quality of Jiggs bermudagrass and its effects on the production and quality parameters of milk from Holstein cows under an intermittent grazing system throughout the year.
MATERIALS AND METHODS

Description of the experimental area

The experiment was conducted on a dairy farm in the municipality of Santa Helena de Goiás, Go, Brazil, from April 2014 to March 2015. The property is part of the “Balde Cheio” project, which seeks to promote the sustainable development of dairy ranching via technology transfer to meet the extension demands of public and private entities and dairy farmers throughout Brazil.

The soil at the experimental site was classified as a distroferric Red Latosol (Embrapa, 2013) with 530 g kg\(^{-1}\) of clay. In May 2014, soil samples were collected from the 0-20-cm layer, and the chemical properties of the experimental site were determined as follows: pH in CaCl\(_2\): 5.8; Ca: 2.55 cmol\(c\) dm\(^{-3}\); Mg: 1.09 cmol\(c\) dm\(^{-3}\); Al: 0.06 cmol\(c\) dm\(^{-3}\); Al + H: 2.6 cmol\(c\) dm\(^{-3}\); K: 0.23 cmol\(c\) dm\(^{-3}\); cation exchange capacity (CEC): 6.47 cmol\(c\) dm\(^{-3}\); P: 5.23 mg dm\(^{-3}\); V: 58.9%; and organic matter (OM): 33.50 g dm\(^{-3}\).

Phosphorus was applied in single superphosphate form (120 kg ha\(^{-1}\) of P\(_2\)O\(_5\)), and potassium was applied as potassium chloride and fritted forms (50 and 20 kg ha\(^{-1}\) of K\(_2\)O and FTE BR 12, respectively). The fertilizers were disseminated in two applications, October 2014 and December 2014, and nitrogen fertilizer (10 kg ha\(^{-1}\) of N) was applied as urea every 19 days when the animals left the paddocks.

The pasture grass Jiggs bermudagrass was studied in a mob-stock ing (Allen et al. 2011) grazing system, in which each paddock was stocked at a high rate for one day and then allowed to rest for 19 days.

The experiment was conducted using a completely randomized design with five replicates (the number of forage cuts in each season) and the four seasons (fall, winter, spring and summer) as treatments.
During the dry period, which begins in May, a sprinkler irrigation system was used with a microsprinkler in each paddock. The irrigation regime was determined according to the needs of the plants; irrigation was conducted every four days for a total of 6.5 hours per day from May to October 2014 using a 30-mm water blade.

The dry matter (DM) production and the nutritional value of Jiggs bermudagrass were evaluated each season (summer, fall, winter and spring) for a year. The rainfall and mean monthly temperature were also monitored during this period (Figure 1).

**Forage production and quality**

The grass was evaluated under a successive-cut regimen, with cutting every 19 days at a residual height of 5 cm. Estimates of total dry matter (TDM) in kg DM ha\(^{-1}\) were obtained by collecting two forage samples (1 m\(^2\)) per paddock, according to the mass evaluation protocol, at points representative of the average sward height (Silva et al. 2013). Because of the limited areas of the paddocks, two representative points were sampled per paddock to avoid damaging the pasture structure through successive collections. Subsequently, the samples were manually separated into two fractions, leaf blade and stem + sheath.

The fresh material was immediately weighed and sent to the laboratory for further DM estimation, where it was predried in a forced air circulation oven at approximately 55°C. Next, the samples were ground with a 1-mm sieve in a Wiley-type mill and stored in plastic jars for analysis.

Chemical and bromatological analyses were performed to determine the DM (Association of Official Analytical Chemists [AOAC] Method 934.01); crude protein (CP), which was obtained through the determination of total N by the micro-Kjeldahl technique (Method 920.87; AOAC 1990) and the fixed conversion factor (6.25); neutral detergent fiber (NDF) (Mertens 2002); acid detergent fiber (ADF) (Method 973.18; AOAC 1990); and
sulfuric acid lignin (Van Soest and Robertson 1985). The total digestible nutrient (TDN) content was obtained using the equation proposed by Chandler (1990). In vitro DM digestibility (IVDMD) was determined using the Tilley and Terry (1963) technique, as adapted by Holden (1999), using a “Daisy II” automatic incubator (Ankom Technology®), and ether extract (EE) was determined gravimetrically after extraction with petroleum ether (Method 920.85; AOAC 1990).

**Milk production and quality**

There were 19 paddocks (800 m$^2$ each) on the farm, and the stocking rate was 12 animal units (AU) of Holstein cows with a mean live weight of 460 ± 36.8 kg during the rainy season and 6 AU during the dry season. The cows were allocated according to the stage of lactation.

The cows were milked twice daily to evaluate milk production and quality. The first milking started at 6:00 am, and the second began at 4:00 pm; the milk samples were collected at the first milking. Before milking, the cows were supplemented with 4 kg of energy concentrate in the form of corn grit with a mineral supplement (13 to 14% calcium and 9% phosphorus). The milking parlor was herringbone shaped (5 x 2 m) in a closed circuit and contained a high-line milk piping system, a series of feeders, a central pit, four individual milking sets and milk meters.

The milk samples were collected every 19 days on the same day as the forage production and quality evaluations. These analyses were performed throughout all of the seasons.

At milking, the first three jets were collected in a black-bottom mug to test for clinical mastitis, and milk was not collected from the animals that tested positive. Next, the udders were dipped in a 5% iodine solution (predipping), completely dried using paper towels and
then attached to a set of teat cups. After complete and uninterrupted milking, the teat cups were removed, and the udders were immersed in 5% iodine solution (postdipping) before the animals were released for grazing.

The milk samples were obtained at the end of milking using individual meters equipped with a bottom valve, which was kept in the "stir" position for five seconds to homogenize the milk sample before collection.

Milk chemical analyses

Flasks (40 mL) containing Bronopol® preservative were used for the chemical composition analyses and somatic cell counts (SCCs), and Azidiol® was used for the total bacterial counts (TBCs), which were conducted according to IDF (2006) using flow cytometry with the results expressed in SC mL⁻¹. Prior to analysis, the flasks were marked with a barcode corresponding to the number of each animal. The milk volume (M) produced by each animal was also measured.

Fat, protein, lactose, total dry extract (TDE) and nonfat dry extract (NDE) were determined according to the methodology proposed by the IDF (2000), and the results were expressed as a percentage (%). The urea (mg dL⁻¹) and casein levels (%) were determined by differential absorption using both Fourier transform infrared (FTIR) spectroscopy and LactoScope equipment (Delta Instruments).

Statistical analyses

The data for each parameter were subjected to analysis of variance using the ExpDes package (Ferreira et al. 2014) in program R (version R-3.1.1) (2014), and Tukey’s test was used to compare the means. The Pearson coefficient was estimated, and its statistical significance was validated by Student’s t-test using the color.test function of program R to
determine the associations between the variables. A probability level of 5% was considered
significant in all tests.

RESULTS AND DISCUSSION

Forage production and quality

The season had a significant effect on the production and nutritional parameters of
Jiggs bermudagrass ($P < 0.05$) with the highest TDM production observed during summer
followed by spring and fall (Table 1). The climatic conditions were better during these
seasons (Figure 1), resulting in better forage development. The forage TDM was lower in
winter than in the remaining seasons, even with irrigation; the winter TDM amounted to 49%
of the TDM observed in summer, and 33.2% of the TDM observed in spring and fall. Santos
Jr. et al. (2004) observed that the low productivity of Jiggs bermudagrass during winter, even
with adequate soil and pasture management, was associated with the environmental factors
temperature and light level, which are essential for pasture production and continuity.

Forage production was 49% higher in summer than in winter and 27% lower in fall
than in summer. Increases in grass productivity during spring and summer are related to
higher light levels, rainfall and temperature (Figure 1). Paciullo et al. (2008) reported that the
climatic conditions during the rainy season were favorable for the growth of forage species,
whereas these conditions were adverse during the dry season. Decreased rainfall and low
temperature and low light levels are the main limiting factors for the growth and development
of forage plants during winter.

A DM yield of 5877 kg ha$^{-1}$ was observed for the months of January through March
(Table 1). These values were similar to those reported by Roecker et al. (2011), who studied
Jiggs bermudagrass grown with different levels of nitrogen fertilization during summer and
observed a DM yield of 5604 kg ha$^{-1}$. 
The leaf blade/stem ratio (LB/S) was 24.03% lower during the winter than in summer, but the values were similar in winter and spring ($P > 0.05$). This phenomenon may have been due to the decrease in temperature, which started in May and reached its minimum values in winter (Figure 1). During spring, the LB/S only increased at the beginning of November, which may explain the similar LB/S values observed for winter and spring.

The lower LB/S observed in winter (Table 1) was also related to stem elongation. During winter, the LB/S rapidly decreases as a result of the higher stem growth and decreased leaf emergence (essential for DM production) due to the lower quantity and quality of light that reaches inside the canopy.

This decrease indicates a negative effect on the quality and use of the forage produced during the dry season, even with the use of irrigation. The quantity and quality of the forage produced is not only associated with moisture but with other factors affecting and limiting plant vegetative growth and maturation, such as light and temperature (Rodrigues et al. 2006).

### Chemical composition of forage

Regarding the nutritional value of the Jiggs bermudagrass, the CP contents did not differ significantly among fall, spring and summer, but they were significantly lower in winter (162.7 g kg$^{-1}$) ($P > 0.05$; Table 1). The results for CP finding occurred due to the better climatic conditions observed for fall, spring and summer, which resulted in higher leaf and stem development due to the higher light incidence.

Aguiar et al. (2014) evaluated the performance of heifers raised at different stocking rates on Jiggs bermudagrass pastures and observed CP contents of 158, 165, 161 and 150 g kg$^{-1}$ for May, June, July and August, respectively. These values were very close to those observed in the present study in winter. Silva et al. (2011) evaluated Jiggs bermudagrass at different heights (20 to 35 cm) and cutting times (19, 28 and 60 days) and observed a CP
value of 205 g kg\(^{-1}\) when cutting at 19 days to a height of 20 cm. This previous finding is consistent with the 200.4 g kg\(^{-1}\) CP observed in the present study for the same cutting time during summer.

The NDF and ADF contents were significantly higher in winter and were not significantly different between fall, spring and summer \((P > 0.05; \text{Table } 1)\). This result was a result of the lower tillering and emergence of new leaves during winter due to the lower temperatures (Figure 1), leading to lower LB/S values, higher fiber fractions, lower percentages of digestible nutrients (soluble carbohydrates, proteins, minerals and vitamins) and, therefore, lower pasture quality (Velásquez et al. 2010).

Oliveira et al. (2014) studied Jiggs bermudagrass at different cutting times and observed mean values of 762.7 g kg\(^{-1}\) NDF and 348.6 g kg\(^{-1}\) ADF. These values are similar to the ADF values found in the present study.

A significant effect of the season was observed on the IVDMD of Jiggs bermudagrass. The IVDMD was significantly higher in summer, spring and fall than in winter \((P < 0.05)\). In summer, spring and fall, the more favorable climatic conditions for forage production resulted in higher leaf production, with a higher CP and lower fiber contents. The digestibility of tropical grasses gradually decreases during winter due to increased structural carbohydrates and lignin contents, resulting in lower forage digestibility (Cedeño et al. 2003).

It should be highlighted that a mob grazing system was adopted in the present study, with high stocking rates for short periods of time. This system promoted pasture quality because mob grazing results in higher pseudostem removal. As a consequence, the pseudostems present in the forage mass are younger and consequently possess higher CP and lower fiber contents (Cecato et al. 1985).

The ethereal extract (EE) was significantly lower in winter than in the remaining seasons \((P < 0.05; \text{Table } 1)\). The TDN contents were similar in summer and fall. This finding
may be explained by the grass having maintained its nutritional quality during spring, summer and fall. The EE content in Jiggs bermudagrass was higher during these seasons because it was influenced by the higher TDN for the same period. This phenomenon occurred because fat supplies 2.25 times more energy than carbohydrates. The TDN content is important because energy and protein are frequently the most limiting factors for ruminants (Oliveira et al. 2010). Therefore, higher EE and TDN contents in seasons with better climatic conditions may result in better forage use by the animals, leading to higher energy consumption and consequently better performance of dairy cows.

Milk production and quality

The season significantly influenced milk production, milk fat, protein, lactose, the urea and casein contents and the SCC ($P < 0.05$) but not the TDE or defatted dry extract (DDE).

Milk production was higher in fall, spring and summer than in winter (Table 2). This finding indicates that the favorable climatic conditions during spring, summer and fall increase forage DM production, CP content and digestibility and, therefore, forage quality (Table 1). Lopes et al. (2015), observed a direct relationship between forage quality and milk production (Table 3) animals with access to better quality pastures produced more milk per day milk with greater milk solids.

Although milk production was lower during winter, the use of irrigation during this season had a positive effect on milk production, and an average milk production of 15.3 kg cow day$^{-1}$ was observed in the winter. During this period, there is a seasonality of forage production in many tropical and subtropical regions that is directly reflected in lower milk production. The present results are in agreement with Teixeira et al. (2013), who observed an average milk production of 15.0 kg milk cow day$^{-1}$ for cows raised on Tifton 85 grass pastures with irrigation.
According to Cardoso et al. (2009), the pasture must be the main source of nutrients for the animal, but it is necessary to be well handled and formed by species with elevated nutritional and productive potentials. This study, was observed an imbalance in the relation energy/protein in the winter season, maybe causing a excessive concentration of fermented protein in the rumen.

Overall, the energy ingestion is a limiting factor in milk production in tropical pastures, especially in the initial third part of lactation, because of the inability of cows to consume energy in sufficient quantity to sustain high levels of milk production (Vilela et al., 2002).

Significant differences in milk fat contents were observed between the different seasons. The milk fat contents were not significantly different in spring, summer and fall, but they were significantly lower in winter (33.5 g kg$^{-1}$; $P < 0.05$).

The average milk fat content observed in the present study was higher than that observed by Mota et al. (2008), who studied the productive performance and milk composition of Holstein cows at the end of lactation. The cows in the previous study were raised on Coastcross bermudagrass pastures and received different levels of concentrated supplement. The authors observed an average milk fat content of 34.2 g kg$^{-1}$ in summer, which was lower than that in the present study for the same period (44.7 g kg$^{-1}$), and was probably associated with the increase in energy concentrate supplementation and the supply of starch sources for more rapid ruminal fermentation.

The higher milk fat contents observed in spring, summer and fall were also associated with the more favorable climatic conditions (Figure 1), which resulted in forage with higher CP and EE but lower NDF and ADF contents (Table 1); more forage with better quality fibers was available during these seasons. Van Soest (1994) showed that low levels of NDF in forage crops were associated with higher DM intake. Furthermore, fiber degradation produces
acetate, which is a primary precursor of milk fat synthesis (Bargo et al. 2003; Porto et al. 2009).

According to the results obtained in the study, no direct relationship between fat content in milk and fiber content, was observed indicating that the digestibility of DM should also be considered in the production of acetate, a fact that corroborated by the estimate of positive correlation in high magnitude observed between fat content and digestibility (Table 3). Therefore, during the summer period, the bromatological composition of the forage has high nutritional contents and digestibility, favoring the ideal ruminal fermentation for the acetate production, and as a consequence the highest milk fat contents were observed to winter.

Fat is the largest variability component of milk, which can range from 20 to 40 g kg\(^{-1}\), being influenced by genetics, nutritional and environmental factors. The present study was carried out in tropical conditions, where a lower forage availability was observed in the winter season (Table 1), in fact that affect the fat content (Dewhurst et al., 2003).

Significant differences in milk protein contents were observed among seasons \((P < 0.05)\). The milk protein contents were 23% higher for spring and summer than for winter and were not significantly different between fall and winter. The finding that the CP was higher during spring, summer and fall (Table 1) explained the higher milk protein contents observed for these periods. Thus, the presence of non-fibrous carbohydrates in forage results in higher synthesis of microbial proteins in the rumen, which supply 400 to 720 g kg\(^{-1}\) of the protein required by the mammary glands (Stelzer et al. 2009). In addition to feeding, inherent qualities of the animals, such as breed, age, weight, body size and lactation stage, as well as external environmental factors, may affect the chemical composition of milk (Bencini and Pulina 1997; Hübner et al. 2007).
The milk lactose contents varied significantly with the season \((P < 0.05)\) and were lower in winter than in summer. However, the mean values observed in the winter, fall and spring were not significantly different (Table 2). Rosa et al. (2012) reported that lactose was related to the regulation of osmotic pressure at the mammary gland, with higher lactose production resulting in higher milk production. The higher protein levels in the forage may have stimulated microbial growth, thereby increasing the supply of metabolizable protein in the small intestine. A portion of the amino acids absorbed in the small intestine that originate from protein degradation are precursors of glucose synthesis in the liver. Higher protein ingestion may lead to increased lactose production in the mammary gland and consequently to higher milk lactose contents (Cardoso et al., 2008; Silva et al., 2009).

The milk lactose and protein contents observed in the summer were higher than those reported by Mota et al. (2008), who observed means of 43 g kg\(^{-1}\) lactose and 30 g kg\(^{-1}\) protein in the milk of Holstein cows raised on Coastercross bermudagrass pastures during summer.

No differences in the TDE and NDE were observed between seasons \((P > 0.05)\), and the values of both met the quality standards established by Brazilian legislation (Normative Ruling n°. 62 of 29 December 2011; Brasil, 2011). These results are in agreement with Gonzalez et al. (2004), who observed no significant differences in TDE but did observe significant differences in NDE between different seasons.

The milk SCC was significantly higher in spring and summer followed by fall and winter \((P < 0.05; \) Table 2). The higher SCC observed in spring and summer was due to the higher temperatures and humidity (Figure 1), which promoted the development of mastitis-causing microorganisms (Gonzalez et al. 2004).

The SCC values observed in the present study were in agreement with Henrichs et al. (2014), who reported that the milk SCC was affected by seasonal variations and was higher during summer when the milk exhibited the lowest quality. Similar results were also observed.
by Paula et al. (2004), who analyzed milk samples collected between January and November from the Brazilian states of Santa Catarina, Paraná and São Paulo; these authors observed the highest average SCCs in January and the lowest in September.

The average SCC observed in the present study (Table 2) met the quality standards established by Brazilian legislation (Normative Ruling no. 62), which allowed a maximum value of 500,000 SC mL$^{-1}$. Higher SCC values indicate the prevalence of clinical and subclinical mastitis in herds (Brasil, 2011).

In seasons with high rainfall and temperature, a good milking technique, pre- and post-milking tit disinfection, adequate dry cow treatment, antibiotic treatment of clinical mastitis and attention to hygiene are recommended to avoid mastitis and consequently decrease the milk SCC (Barkema et al. 1998; Barbosa et al. 2002).

The milk urea nitrogen (MUN) contents were significantly higher in spring, summer and fall than in winter ($P < 0.05$; Table 2), and those observed for spring, summer and fall indicated that the diet met the protein and nitrogen demands of the animals for the level of milk production. The lower MUN contents observed in winter may have been due to the lower quality of forage, which directly resulted in decreased milk protein contents (Table 1). The MUN contents may vary between 10 and 16 mg/dL depending on the milk production level (Jonker et al. 1999).

The MUN indicates the adequacy or excess of rumen ammonia relative to the energy available for rumen microbial growth. High protein availability in the rumen relative to the amount of carbohydrates results in a high level of urea nitrogen (Rajala-Schultz et al. 2001).

The milk casein contents exhibited a pattern similar to that observed for MUN. Variations in temperature and humidity between different seasons resulted in higher casein contents during the spring and summer. The period of lowest protein synthesis (observed in winter) corresponded to the period with lower forage offer and availability (Table 2). Similar
results were reported by Gonzales et al. (2004), who observed higher casein contents in October, November, March and April and lower contents in June and July. Therefore, casein exhibited a pattern opposite to that of milk production along with lactation, which did not support the hypothesis that the milk component contents increased with decreased milk production.

**Correlation between forage production and quality and milk production and quality**

Pasture quality was directly reflected by the milk production and quality. The forage TDM production, LB/S, CP, IVDMD and TDN were positively correlated with the concentrations of milk solid components (Table 3).

Regarding milk production, this showed a significant correlation with all forage variables evaluated, highlighting a greater magnitude of association with IVDMD. The negative correlations presented with fiber contents are directly related to forage intake and IVDMD (Van Soest, 1994).

The dry matter digestibility of forage is directly related to milk lactose, where the more digestible, the greater the amount of nutrients available for milk synthesis. In this case, it was observed a higher concentration of lactose in the summer, probably being influenced by the greater digestibility of the forage components (Table 3).

There was significant positive correlation of milk protein with dietary protein content and TDN levels (P <0.05). This result corroborates with the literature (NRC, 2001, Bauman and Griinari, 2003), which describes that the milk protein content depends on the aminoacids profile absorbed by the animal in the small intestine, stimulated by the higher energetic concentration of the diet (TDN).

The high correlation observed between IVDMD and milk production was associated with the high CP and non-fibrous carbohydrate contents in the forage, which are precursors of
milk components and determinants of milk quality. These contents may also be behind the correlation between TDM production and SCC, which showed higher milk nutritional quality due to a higher forage quality yield (Table 3). The higher TDM and higher LB/S (Table 1) resulted in better forage quality with a higher IVDMD.

The negative correlation was observed between NDF and ADF and the milk quality parameters (i.e., the milk production and increased quality with the decreasing fiber contents) (Table 3), contrary to what was expected mainly to what relates to fat content. Large amounts of readily fermentable carbohydrates and reduced amounts of fibrous components tend to decrease milk fat content, due to the lower acetate:propionate ratio (Fredeen 1996).

Similarly, negative correlations were observed between forage TDN and the milk TDE and casein content. These parameters were related to a higher forage fiber content and lower CP and non-fibrous carbohydrate contents.

MUN showed a significant correlation with all forage components evaluated, being negative for NDF and ADF. Broderick and Clayton (1997) reported that NUL may suffer variations due to several factors, such as crude protein expressed in dry matter or in relation to energy, efficiency of nitrogen utilization, excessive nitrogen intake and ruminal ammonia.

**CONCLUSION**

Jiggs bermudagrass is a promising forage for the enhancement of milk production under intermittent stocking. However, its effects vary seasonally that exerts a greater influence during the winter, even with irrigation, because it directly affects milk production and quality. The correlation results demonstrated the importance of better quality forage for increasing milk production without compromising the levels of milk solids.
REFERENCES


Figure 1. Rainfall (mm) and mean temperature (°C) in Santa Helena de Goiás, GO, Brazil, from April 2014 to March 2015.
Table 1. Total dry matter production, leaf blade/stem ratio, chemical composition and in vitro dry matter digestibility of Jiggs bermudagrass during different seasons.

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<th>Summer</th>
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<td>2996c</td>
<td>4711b</td>
<td>5877a</td>
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<td>3.61ab</td>
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<td>693.5a</td>
<td>639.2b</td>
<td>658.7b</td>
</tr>
<tr>
<td>ADF (g kg⁻¹)</td>
<td>343.3b</td>
<td>378.8a</td>
<td>326.7b</td>
<td>346.3b</td>
</tr>
<tr>
<td>IVDMD (g kg⁻¹)</td>
<td>675.3a</td>
<td>589.5b</td>
<td>687.0a</td>
<td>708.3a</td>
</tr>
<tr>
<td>EE (g kg⁻¹)</td>
<td>23.9a</td>
<td>19.7b</td>
<td>25.0a</td>
<td>27.3a</td>
</tr>
<tr>
<td>TDN (g kg⁻¹)</td>
<td>671.9a</td>
<td>633.8c</td>
<td>648.0bc</td>
<td>675.2a</td>
</tr>
</tbody>
</table>

CVa (%)             | 14.4   | 17.49   | 6.19    | 3.29    |

Note: Means within rows followed by the same letter do not differ from each other according to an F test at the 5% probability level.

a Coefficient of variation.

TDM: total dry matter production; LB/S: leaf blade/stem ratio; CP: crude protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; IVDMD: in vitro dry matter digestibility; EE: ether extract; TDN: total digestible nutrients.
Table 2. Milk production and quality of Holstein cows under intermittent grazing on Jiggs bermudagrass during different seasons.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Fall</th>
<th>Winter</th>
<th>Spring</th>
<th>Summer</th>
<th>CV(^a) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk production (kg)</td>
<td>17.09(a)</td>
<td>13.62(b)</td>
<td>17.54(a)</td>
<td>18.60(a)</td>
<td>10.18</td>
</tr>
<tr>
<td>Fat (g kg(^{-1}))</td>
<td>41.4(a)</td>
<td>33.5(b)</td>
<td>39.9(a)</td>
<td>44.7(a)</td>
<td>12.49</td>
</tr>
<tr>
<td>Protein (g kg(^{-1}))</td>
<td>35.4(ab)</td>
<td>30.1(b)</td>
<td>37.3(a)</td>
<td>40.8(a)</td>
<td>15.1</td>
</tr>
<tr>
<td>Lactose (g kg(^{-1}))</td>
<td>50.5(ab)</td>
<td>43.9(b)</td>
<td>50.9(ab)</td>
<td>53.8(a)</td>
<td>12.28</td>
</tr>
<tr>
<td>TDE (g kg(^{-1}))</td>
<td>123.4</td>
<td>125.7</td>
<td>127.2</td>
<td>129.4</td>
<td>6.67</td>
</tr>
<tr>
<td>NDE (g kg(^{-1}))</td>
<td>85.4</td>
<td>81.4</td>
<td>86.8</td>
<td>86.0</td>
<td>6.62</td>
</tr>
<tr>
<td>SCC (x 1000 SC mL(^{-1}))</td>
<td>150.0(b)</td>
<td>129.5(b)</td>
<td>267.4(a)</td>
<td>279.0(a)</td>
<td>12.45</td>
</tr>
<tr>
<td>TBC (x 1000 CFU mL(^{-1}))</td>
<td>19.93(a)</td>
<td>11.90(b)</td>
<td>17.53(a)</td>
<td>18.48(a)</td>
<td>12.93</td>
</tr>
<tr>
<td>MUN (mg dL(^{-1}))</td>
<td>2.22 (bc)</td>
<td>2.18 (c)</td>
<td>2.68 (a)</td>
<td>2.80 (a)</td>
<td>8.65</td>
</tr>
</tbody>
</table>

Note: Means within rows followed by different letters differ from each other according to an F test at the 5% probability level.

\(a\)Coefficient of variation.

TDE: total dry extract; NDE: nonfat dry extract; SCC: somatic cell count; SC: somatic cells; TBC: total bacteria count; MUN: milk urea nitrogen.
Table 3. Correlation coefficients relating forage production and quality with milk production and quality in Holstein cows under intermittent grazing on Jiggs bermudagrass.

<table>
<thead>
<tr>
<th>Milk variable</th>
<th>LB/S</th>
<th>DM</th>
<th>CP</th>
<th>IVDMD</th>
<th>TDN</th>
<th>NDF</th>
<th>ADF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk production</td>
<td>0.3840*</td>
<td>0.6428*</td>
<td>0.5134*</td>
<td>0.7217*</td>
<td>0.6089*</td>
<td>-0.5000*</td>
<td>-0.5529*</td>
</tr>
<tr>
<td>Fat</td>
<td>0.2425</td>
<td>0.5010*</td>
<td>0.4832*</td>
<td>0.6258*</td>
<td>0.5060*</td>
<td>-0.1669</td>
<td>-0.4810*</td>
</tr>
<tr>
<td>Protein</td>
<td>0.1697</td>
<td>0.6359*</td>
<td>0.4346*</td>
<td>0.4498*</td>
<td>0.3332*</td>
<td>-0.2526</td>
<td>-0.3100</td>
</tr>
<tr>
<td>Lactose</td>
<td>0.2578</td>
<td>0.4200*</td>
<td>0.4731*</td>
<td>0.5087*</td>
<td>0.3627*</td>
<td>-0.1415</td>
<td>-0.4000*</td>
</tr>
<tr>
<td>TDE</td>
<td>0.1595</td>
<td>0.2824</td>
<td>0.0460</td>
<td>0.1172</td>
<td>-0.0499</td>
<td>-0.0021</td>
<td>-0.1000</td>
</tr>
<tr>
<td>NDE</td>
<td>0.0915</td>
<td>0.2100</td>
<td>0.3256*</td>
<td>0.3263*</td>
<td>0.1997</td>
<td>-0.2644</td>
<td>-0.0600</td>
</tr>
<tr>
<td>SCC</td>
<td>0.1698</td>
<td>0.7300*</td>
<td>0.5963*</td>
<td>0.6226*</td>
<td>0.1062</td>
<td>-0.3220*</td>
<td>-0.4305*</td>
</tr>
<tr>
<td>MUN</td>
<td>0.3541*</td>
<td>0.6000*</td>
<td>0.6935*</td>
<td>0.5864*</td>
<td>0.4308*</td>
<td>-0.3718*</td>
<td>-0.4000*</td>
</tr>
<tr>
<td>Casein</td>
<td>0.0259</td>
<td>0.4260*</td>
<td>0.3962*</td>
<td>0.4025*</td>
<td>-0.0712</td>
<td>-0.3749*</td>
<td>-0.3400*</td>
</tr>
</tbody>
</table>

Note: *: P-value < 0.05 level.

DM: dry matter production; LB/S: leaf blade/stem ratio; CP: crude protein; IVDMD: in vitro dry matter digestibility; TDN: total digestible nutrients; NDF: neutral detergent fiber; ADF: acid detergent fiber; EE: ether extract; TDE: total dry extract; NDE: nonfat dry extract; SCC: somatic cell count; MUN: milk urea nitrogen.