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Comparative yield and nutrient contents between rainfed and irrigated Bermuda grass (*Cynodon dactylon*) in Bauchi State, Nigeria

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Abstract

This study was conducted to investigate the dry matter yield and content of Bermuda (*Cynodon dactylon*) grasses. The materials were grown at Abubakar Tafawa Balewa University, Bauchi in 2020 and 2021 rainy and dry seasons and the mean of the two years for each respective season was used as data for this study. The experiment was laid out in a Randomized Complete Block Design where growing season constituted the treatments and agronomic measurements were carried out at week 4, 6, 8, 10 and 12, respectively. *C. dactylon* was established on a 0.5ha paddock by transplantation of sprigs from the wild for both seasons establishment and irrigated experimental plots received sprinkler irrigation twice-weekly. The dry matter yield (t/ha), leaf dry matter (%), stem dry matter (%) and total dry matter (%) were measured. The results obtained indicated. Dry matter yield, leaf, stem and total dry matter (%) all increased as weeks increased ($P<0.01$) both in the rainy and dry season *C. dactylon*. Furthermore, dry matter and other yield contents were all higher in rainy than dry season *C. dactylon* except dry matter yield for rainfed at weeks 10 and 12 (6.63 and 7.52 t/ha), leaf dry matter for both rainy and dry season at weeks 10 and 12 (55.94-56.45 and 42.97-43.81 t/ha, respectively). The yield of Bermuda grass was better in the rainy season than dry season while the forage quality was better for dry season *Cynodon dactylon*. However, dry season *Cynodon dactylon* ensured sustainable production of good quality hay for animals during the dry season period.

Keywords: Dry season, Irrigated, Nutrient content, Rainfed, Weeks, Yield

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Introduction

Pastoralists employed livestock mobility as the main mechanism of adapting to the feed deficits during the dry season. (Bruce, 2003) This strategy is increasingly becoming untenable today due to a wide array of socio-economic, political and anthropogenic factors such as extension of crop farming and human settlements (cities and towns) in the rangelands and also clashes in the form of farmers-herders conflict (Kumar et al., 2006).

Bermuda grass (*Cynodon dactylon*) is highly tolerant to drought and heavy grazing which make it extremely valuable during the dry season period in Northern Nigeria. It is a rhizomatous or stoloniferous perennial grass found in warm temperature, tropical and sub-tropical areas. It's extremely resilient, if a large patch is damaged, it has an incredible ability to regenerate from deep, creeping roots and via mower clippings that land on bare soil and then in root (Happysprout, 2022). The environment to which grass has adapted for optimal growth directly influences its forage quality. Cool season grasses are generally more digestible and thus of higher quality than warm season species such as Switch grass and Bermuda grass, which have adapted to grow in hot, dry weather (Anderson, 2012).

The integration of irrigated pasture production into the overall land use package whereby plant growth can be sustained during water stress periods such as occasional droughts and long dry seasons has been proposed as a means towards improving the plane of animal nutrition and therefore increasing meat and milk output. The year-round stabilization of dry matter and crude protein yields prompted by irrigation certainly points out the significant role it can play in overall agricultural output and clearly suggests water shortage as a principal constraint to the full realization of the potential yield and quality of adapted forages (Akinola, 2015; Sani et al. 2022). Stage of maturity at harvest is probably the most important factor that influences forage quality, as forage matures, the leaf-stem ratio decreases and the plant becomes increasingly fibrous. Forage leaves contain considerably more protein and less fibre than the stems, so as forage matures and the stem becomes more prevalent and fibrous, quality decreases and the plant become less digestible.

The cost of establishment and maintenance of improved pasture has contributed to its confinement to only a few institutional and elitist farms. In view of this, there is a need to evaluate indigenous pastures that are drought tolerant and could improve productivity in animals. There is little or no information on the establishment of *Cynodon dactylon* under irrigation, this information is needed for making sustainable management of pastures during dry season due to scarcity and poor quality of forages. Hence this research work investigated the Comparative yield and nutrient composition of Bermuda grass (*Cynodon dactylon*) in both rainy and dry season in Bauchi, Nigeria.

Material and Methods

Study location

This study was conducted at Abubakar Tafawa Balewa University Bauchi, Nigeria, located at altitude of 640 m above sea level. Bauchi, a State in North Eastern part of Nigeria, located at geographical coordinates of 10º33ꞌ N and 9º31ꞌ E (Ovimap, 2022). The state lies within the guinea savannah of the ecological zone with an annual rainfall of between 1000 mm and 1300 mm per annum. Relative humidity ranges from about 12% in February to about 68% in August. At the beginning of the rainy season, relative humidity is about 37% (BSGN, 2022). The experimental soil was loamy sand and its characteristics are shown in Table 1 while rainfall, temperature and relative humidity of the experimental area are presented in Table 2.

Table 1 Soil characteristics of the experimental site

Properties	Values
Physical properties	
Particle size (%)	
Clay	10.8
Silt	18.3
Sand	71.17
pH	6.36
Chemical properties	
Total N (%)	0.10
Zn (ppm)	2.50
P (ppm)	9.30
Exchangeable captions (meg/100g of soil)	
Ca^{++}	6.65
Mg^{++}	3.18
k^{+}	9.52
Na	26.60

Table 2 Temperature, relative humidity and rainfall distribution of the experimental site

Months	Maximum Temperature (℃)		Relative Humidity (%)		Rainfall (mm)	
	2020	(2015-2019)	2020	(2015-2019)	2020	(2015-2019)
May	33.7	34.1	47.9	49.2	120.6	112.3
June	31.5	31.0	55.2	57.0	147.9	137.6
July	30.5	29.9	63.2	62.3	159.6	142.5
August	31.3	30.2	71.3	69.2	197.6	210.0
September	31.9	31.4	67.6	70.1	241.2	277.7
October	33.4	31.9	61.2	65.5	51.7	62.8
Total	228.7	225.5	387.8	396.9	914.3	982.1
Mean	32.7	32.2	55.4	56.7	130.6	140.3

Source: (Abubakar Tafawa Balewa International Airport Bauchi [ATBIA], 2020).

Experimental design and management of established pastures

The experiment was a Randomized Complete Block Design (RCBD) design, where the growing season (rainy and dry season) constituted the treatments. *Cynodon dactylon* was established vegetatively at Abubakar Tafawa Balewa University, Bauchi in 2020 and 2021 (re-growth) growing seasons and mean of the two seasons were used as data for analysis to minimize error. *Cynodon dactylon* was grown on 0.15ha uniform pasture area and agronomic study was conducted between June, 2020 to September, 2020 during 2020 raining season and same period for 2021 rainy season while the irrigation trial was between November, 2020 to February, 2020 during 2020 dry season and same period for 2021 dry season. The land was prepared by ploughing once and harrowing twice. The vegetative materials or springs for first year establishment were obtained within the school (institution) premises and were transplanted at an intra-row spacing of 50cm on the prepared land. Experimental plots received uniform supplementary irrigation to root zone soil saturation (80 centibars for irrigation treatment) was provided by flooding the soil surface using farmers' practice within the furrows. Irrigation was done fortnightly in the evening and the source of water was from a farm pond close to the experimental area. The planted area was first weeded and fertilized 2 weeks after establishment with urea (46%N) while second fertilizer doses were applied 4 weeks after the initial fertilizer application (week 6) using NPK (20:10:10) fertilizer and applied at 100 kg/ha. Measurements and sampling of pastures commenced 4 weeks after establishment and sampling was done at 4, 6, 10 and 12 weeks, respectively.

Dry matter yield and pasture production

Cynodon dactylon were cut using a knife at a height of 10cm above ground levels to enable re-growth of cut areas. Total fresh material cut per 1 m^2 quadrat was immediately weighed (Total FW) to determine the fresh forage yield per quadrate in each treatment mixture. In addition, each total fresh weight whole sample was sorted into leaf and stem after harvesting to determine the leaf and stem dry matter. The separated leaf and stem harvest was weighed individually and a sub-sample of 250g taken for oven drying to determine the dry weight. This procedure was done for each subplot for fresh forage yield and subsequent dry matter (DM) yield determination by oven drying sub-samples at 500 ^oC for 72 hours. The dry matter yield during the growing period was estimated (Tarawali et al., 1995).

Statistical analysis

Data collected from the field trial were statistically analyzed using the procedures for experiments in a Randomized Complete Block Design (SAS, 2005). Data were subjected to Analysis of Variance (ANOVA) using the General Linear Model of (SAS, 2005) while Duncan's Multiple Range Test (DMRT) was used to determine significant difference (P<0.05) between treatment means. The model of the experiment is; $Y_{ij} = \mu + T_i + B_j + e_{ij}$
Where $\mathbf{Y_{ij}}$ = Any observation for which $X_1 = i$ and $X_2 = j$ as X_1 is the primary factor while X_2 is the blocking factor, $\boldsymbol{\mu}$ = Overall mean, $\mathbf{T_i}$ = Treatment effect (growing seasons) of factor X_1, $\mathbf{B_j}$ = Block effect of factor X_2, $\mathbf{e_{ij}}$ = Random error

Results

The dry matter yield (t/ha) and component dry matter (%) of *Cynodon dactylon* under the rainy and dry season is presented in Table 3 below. Dry matter yield (t/ha) in the rainy season consistently increased (P<0.05) from week 4 to week 12 (3.72-7.52 t/ha, respectively). Similarly, the dry matter yield for the dry season increased (P<0.05) from week 4 to week 12 (2.56-4.08 t/ha, respectively). The mean dry matter yield for all weeks was higher (P<0.05) in rainfed (5.58 t/ha) than irrigated (2.94 t/ha) and the interaction between rainfed and irrigated dry season was significant (P<0.05). The component plant part and total plant dry matter (%) in Table 3 showed leaf, stem and total dry matter (%) of the grass in rainy season increased (P<0.05) from week 4 (38.93, 39.12 and 38.32 % respectively) to week 12 (56.45, 55.46 and 57.65% respectively). Similarly, the leaf DM, stem DM and total DM (%) during the dry season increased (P<0.05) from week 4 (34.63, 37.56 and 30.60% respectively) to week 12 (43.81, 49.20 and 46.17% respectively). The mean value for leaf DM in rainfed (48.43%) was higher (P<0.05) than dry season (40.55%). Similarly, stem dry matter for rainfed (47.04%) was higher (P<0.05) than 43.59% for irrigated. Also, total dry matter was higher (P<0.05) in the rainy (47.38%) than in the dry season (39.72%).

Table 3 Comparative dry matter yield (t/ha) and component dry matter (%) of *Cynodon dactylon* at different sampling period

	DM yield (t/ha)		Leaf DM (%)		Stem DM (%)		Total DM (%)	
Period (weeks)	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated
4	3.72^{cA}	2.56^{cB}	38.93^{dA}	34.63^{dB}	39.12^{e}	37.56^{e}	38.32^{eA}	30.60^{eB}
6	4.14^{cA}	2.83^{cB}	41.26^{c}	40.62^{c}	42.71^{dA}	38.96^{dB}	41.39^{dA}	37.00^{dB}
8	5.41^{bA}	3.40^{bB}	49.58^{bA}	40.72^{cB}	44.36^{c}	44.46^{c}	45.88^{cA}	41.89^{cB}
10	6.63^{aA}	3.52^{bB}	55.94^{aA}	42.97^{aB}	53.56^{bA}	47.75^{bB}	53.53^{bA}	42.91^{bB}
12	7.52^{aA}	4.08^{aB}	56.45^{aA}	43.81^{aB}	55.46^{aA}	49.20^{aB}	57.65^{aA}	46.17^{aB}
Mean	5.58	2.94	48.43	40.55	47.04	43.59	47.38	39.72
SEM	1.02	0.50	2.72	0.73	2.64	0.28	2.19	0.53

a, b. c, d, e = means with different superscript across columns are significantly different; **A, B =** Means with different superscript across rows for a parameter are significantly different; **DM** = Dry matter; **SEM =** Standard error mean

Nutritive value of rainfed and irrigated *Cynodon dactylon*

The chemical composition (%) of *Cynodon dactylon* under rainfed and irrigated dry season growth at different sampling weeks is shown in Table 4. The dry matter (%) ranged from 85.63% in week 4 to 89.70% in week 12 and was significant (P<0.05) across weeks. Dry matter (%) for dry season irrigated growth increased (P<0.05) from 88.78% at week 4 to 90.61% at week 12. The dry matter (%) for irrigated dry season growth was higher (P<0.05) compared to rainy season growth. The Crude Protein (CP) content for *C. dactylon* steadily declined (P<0.05) as week increased in both rainy and dry season irrigated growth. The highest CP for both rainfed and irrigated were at week 4 (10.19 and 10.50% respectively) and least week 12 (6.52 and 7.23% respectively). However, irrigated dry season *C. dactylon* had higher mean CP than rainfed and there was no significant (P>0.05) difference for CP between the two-season growth. The Acid detergent fibre (ADF) and neutral detergent fibre (NDF) of *C. dactylon* both increased for rainfed and irrigated *C. dactylon* as week increased (P<0.05). The ADF ranged from 28.19-37.60% for rainfed and 21.25-32.43% for irrigated dry season growth. Similarly, NDF ranged from 26.11-49.34 for rainfed while irrigated was from 28.21-38.46% at week 12. The mean NDF was least under irrigated dry season growth compared to rainfed. Both ADF and NDF between the rainy season and irrigated *C. dactylon* were both significant (P<0.05) from week 4 to 12.

Table 4 Chemical composition (%) of rainfed and irrigated *Cynodon dactylon* at different sampling period

	Chemical composition (%)							
	Dry Matter		Crude protein		ADF		NDF	
Period (Weeks)	RF	IR	RF	IR	RF	IR	RF	IR
4	85.63^{bB}	88.78^{bA}	10.19^{a}	10.50^{a}	28.19^{aB}	21.25^{aA}	26.11^{aA}	28.21^{aB}
6	88.92^{aB}	89.64^{abA}	9.73^{a}	10.29^{a}	29.92^{bB}	24.53^{bA}	39.62^{bB}	31.23^{bA}
8	89.63^{aB}	89.76^{aA}	8.91^{b}	9.24^{b}	31.79^{cB}	26.74^{cA}	43.16^{cB}	32.63^{cA}
10	88.96^{aB}	90.11^{aA}	7.64^{c}	8.62^{b}	36.34^{dB}	28.30^{dA}	42.73^{cB}	32.68^{cA}
12	89.70^{aB}	90.61^{aA}	6.52^{d}	7.23^{c}	37.60^{aB}	32.43^{eA}	49.34^{dB}	38.46^{dA}
Mean	87.57	88.18	8.00	9.18	30.77	26.65	38.19	32.64

a, b. c, d, e = means with different superscript across columns are significantly different; **A, B** = Means with different superscript across rows for a parameter are significantly different; **ADF** = Acid Detergent Fibre; **NDF =** Neutral Detergent Fibre; **RF** = Rainfed; **IR** = Irrigated

Table 5 showed the Ether Extract, Ash and Nitrogen Free Extract (NFE) content of *C. dactylon* at both rainy and dry season irrigated growth from week 4 to 12. The ether extract in rainfed ranged from 0.24% in week 4 to 0.58% in week 8. Irrigated dry season growth had 1.20% Ash at week 6 and a higher content of 1.80% at week 4. The ether extract did not show any regular change pattern and values were significant (P<0.05) across treatment for both rainfed and irrigated *C. dactylon.* The mean ether extract was higher for irrigated *C. dactylon* and lower for rainfed. The Ash content increased (P<0.05) from rainfed and irrigated *C. dactylon.* They were least at week 4 for rainfed and irrigated (2.34 and 8.24) and higher at week 12 (4.63 and 11.86 respectively). The mean value for Ash was higher for irrigated *C. dactylon* than rainfed. Nitrogen Free Extract (NFE) decreased (P<0.05) from week 4 to week 12 for both rainfed and irrigated *C. dactylon.* The mean NFE value was higher for rainfed than irrigated *C. dactylon* and values were significant (P<0.05) between the two-season growth.

Table 5 Chemical composition (%) of rainfed and irrigated *Cynodon dactylon* at different sampling periods

	Chemical composition (%)					
	Ether extract		Ash		Nitrogen Free Extract	
Period (Weeks)	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated
4	0.24^{cB}	1.80^{aA}	2.34^{aA}	8.24^{aB}	61.12^{aA}	51.25^{aB}
6	0.53^{aB}	1.20^{dA}	3.50^{bA}	8.69^{aB}	46.62^{bB}	48.59^{bA}
8	0.58^{aB}	1.45^{cA}	4.26$_{bA}$	8.67^{aB}	43.09^{cB}	48.01^{bA}
10	0.45^{b}	1.53^{b}	4.62^{cA}	10.39^{bB}	44.56^{bB}	46.78^{cA}
12	0.32^{cB}	1.63^{bA}	4.63^{cA}	11.86^{cB}	39.19^{d}	40.82^{d}
Mean	0.42	1.52	3.87	9.57	49.52	47.09

a, b. c, d, e = means with different superscript across columns are significantly different; **A, B** = Means with different superscript across rows for a parameter are significantly different

Discussion

In Table 3, it was observed that in both rainfed and irrigated *Cynodon dactylon,* dry matter yield increased as plant age increased or matured which is because plant internodes and cell contents increased as plant matures. The dry matter yield for *Cynodon dactylon* (rainfed) obtained in this study was comparable with the range of 1.58 to 4.62 t/ha earlier reported for various cultivars of *Cynodon dactylon* (kanno et al., 2009) but lower than values obtained for *C. dactylon* yield at rainfed treatments reported by Stone et al. (2012). Higher yields of 7.3 to 13.4t/ha have however been reported (Woodard, 2011) and the higher yield may be attributed to differences in cultivars level of fertilizer application and age of plant establishment (Sani et al., 2020). The dry matter yields in irrigated *Cynodon dactylon* was lower than values obtained for rainfed probably because of the period of establishment. Burton et al. (1988) reported that *C. dactylon* will produce little forage after September regardless of the amount of fertilizer and water supplied. He also reported that applying water and Nitrogen fertilizer for increased fall production will give a much lower response compared to other seasons. Similarly, Agarwal et al. 2022 in his study reported that higher irrigation frequency did not have a significant effect on above ground biomass production

The dry matter content of leaf, stem and total plants as reported in table 3 were higher in rainfed than in irrigated because of better biomass production due to higher dry matter yield for the grass obtained in rainfed than dry season growth, also it could be due to higher soil moisture content and average relative humidity (Bruce, 2003) obtained during rainy season compared to dry season. There was a progressive increase in dry matter yield and in the dry matter content of the leaf, stem and whole plant with advancement in period because the plant matured more with changes in weeks (Minson, 1990). Stepwise increase in yield as weeks increased indicated that weeks of growth was the single most important variable related to yield.

Mean temperature and humidity had a positive relationship with yield in this study, this is probably connected to solar radiation which in turn influences photosynthesis. It was reported that increase in yield from sunlight and temperature was due to increase in the photosynthetic rate relative to the respiration rate (Mckell et al.,1996; McBee & Holt, 2012). This corroborates the finding of Burton et al., (1993) that daylength, solar radiation and rainfall were significantly correlated with forage yield.

Nutrient content decreases in forages as the plant matures and age increases (Anderson, 2012; Sani et al., 2020). The decrease in forage quality from early stage of plant growth to late stage is due to increase in stem over leaf in plant leaf-stem ratio. As stem increases relative to leaf, fibre and lignin content of plant replaces crude protein and free carbohydrate in forages and hence reduction in forage quality (Sani et al., 2020) as observed in this study. The crude protein content of *Cynodon dactylon* was observed to decrease as plant age increased in both rainfed and irrigated dry season growth. Stone et al., 2012 and Mandebvu et al., 1999 also observed a similar trend for *C. dactylon* grass both for rainfed and irrigation. They observed that CP concentration decreased with increasing harvest intervals and that irrigation application rate had little difference among CP concentrations for individual harvest. The overall Crude protein concentration in the study for *Cynodon dactylon* at week 4 averaged 10.19% for rainfed and 10.50% for irrigated and both were lower than 12.1% obtained by Stone et al., 2012 for irrigated *C. dactylon* grass. Crude protein content of 8.91% at rainfed and 9.24% for irrigation obtained in this study were however, both higher than 8.3% obtained by Stone et al., 2012 during irrigation for Bermuda grass (*Cynodon dactylon*). Lower CP concentration for the 8-week harvest interval was also reported by Mandebvu et al. (1999) who found irrigation application corresponding with significant increases in yield for irrigation treatments and tends to reduce CP with increased irrigation application rate. The CP in irrigated dry season growth was higher than rainfed in this study, which disagrees with the report of Aregheore (2002); Evitayani et al. (2004) who observed lower content of CP in dry season than rainy season growth. The CP levels in the study from week 4 to 12 in both rainfed and irrigated dry season growth were higher than 7% which is the minimum required to ensure optimum rumen function (Van Soest, 1994).

The mean Acid detergent Fibre (ADF) concentration obtained for both rainfed and irrigated were similar to the range of 26.3% to 35% obtained for Bermuda grass by Mandebvu et al. 1999 while mean Neutral Detergent Fibre (NDF) were lower than 59% to 72.3% obtained by same author above. Mansfield et al. 1990 observed significant differences for ADF and NDF in individual harvests. In general, data on fibre fraction showed that grass contained more NDF and ADF in the rainy season than the dry season. Such seasonal changes in tropical regions are routinely noticed and are due to maturity and age of grass species, with ADF and NDF increasing with age and maturity in plant species. As the plant grows. There is greater need for fibrous tissues to maintain their structure, hence the increase in lignin and decrease in protein concentration (McDonald et al., 2002). Rainy season yield *Cynodon dactylon* was higher than dry season yield at corresponding weeks which explains more maturity and lignification in rainfed than irrigated *C. dactylon* grass in overall mean value. This finding is, however, contrary to the report of Stone et al. (2012) who reported higher values for ADF and NDF in the dry season.

The Ash content was higher for dry season than rainy season, the analysis of ash levels gives an indirect indication of the amount of minerals extracted from soil by plants. Therefore, the ash content is useful to calculate the amount of fertilizer needed to meet plant nutritional requirements, maintain productivity and soil fertility (Ribeiro & Pereira, 2011) and to provide information for balancing diets. Similarly. Ether extract (EE) content was influenced by treatments with irrigation having higher mean values than rainfed growth which makes EE seem to be susceptible to various seasonal growth and plant maturity. The mean Nitrogen Free Extract (NFE) was higher in the rainy season than the dry season. According to Pates et al., 2008, the production of potentially digestible components (soluble carbohydrates, proteins, minerals and other cellulose contents) tends to decrease as the plant matures which corroborates the results obtained in this study.

Conclusion

The result of this study indicated that the yield of Bermuda grass (*Cynodon dactylon*) was better in the rainy season than dry season while the forage nutrient composition (quality) was better for irrigated *Cynodon dactylon*. However, irrigated *Cynodon dactylon* ensured sustainable production of *Cynodon dactylon* with good nutritive value for animals during the dry season period. Further research on irrigation should be conducted to determine the best type of irrigation system (flooded or sprinkler) for the grass in Bauchi State, Nigeria.

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