Evaluation of Growth Performance and Biomass Yield of Sugargraze and Columbus Grass in a Raining Season in Semi-Arid Zone, Nigeria

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Abstract

One significant potential remedy for seasonal variations in feed quantity and quality in ruminant nutrition is the conservation of grass or fodder. As potential solutions to the dry season feed scarcity, evaluating their biomass yield and nutritional value during the rainy season will be important for enhancing ruminant animal productivity. The research was designed in a Randomized Complete Block Design (RCBD) in a Factorial layout (2 x 3); Forage sorghum cultivars (Sugargraze and Columbus grass) and Planting spacing (10 x 30 cm, 15 x 45 cm and 25 x 75 cm); were combined and replicated four (4) times. The experiment was conducted in two locations; Binyaminu Usman Polytechnic, Hadejia (BUPoly farm) and Federal University Dutse Teaching and Research Farms (FUD farms) in the rainy season of 2023. There were significant (P<0.05) differences in the cultivars for the number of leaves, nodes, leaf area, plant height and biomass yield, with Sugargraze having the highest values compared to Columbus grasses in both the study locations. In both of the study locations (BUPoly and FUD farms), Sugargraze had the highest number of leaves per plant (12.31 and 11.77), while Columbus grass had the lowest number of leaves (10.15 and 9.54). On Sugar graze, however, leaf area values were higher (509.60 and 406.00 cm^2), whereas Columbus grass produced the lowest values (314.00 and 236.00 cm^2) in BUPoly and FUD farms, respectively. Except for biomass yield, which was significantly (P<0.05) different in both locations as influenced by spacing, there were no variations (P>0.05) in the number of leaves, nodes, leaf area and plant height. In both research locations, Sugargraze reported the highest biomass yield (73,092 kg/ha and 73,086 kg/ha) followed by Columbus grass (43,917 kg/ha and 43,913 kg/ha). Conclusively, Sugargraze planted in narrower spacing (10 x 30 cm) produced well and gives the highest biomass yield compared to Columbus grass.

Keywords: *Sorghum almum* and Sugargraze, Growth performance, leaf area, Biomass yield

Évaluation des performances de croissance et du rendement en biomasse du Sugargraze et du Columbus Grass pendant la saison des pluies dans une zone semi-aride du Nigéria

Résumé

La conservation de l'herbe ou du fourrage est un remède potentiel important aux variations saisonnières de la quantité et de la qualité des aliments pour la nutrition des ruminants. L'évaluation de leur rendement en biomasse et de leur valeur nutritionnelle pendant la saison des pluies constituera une solution importante pour améliorer la productivité des ruminants face à la pénurie d'aliments pendant la saison sèche. L'étude a été conçue selon un dispositif en blocs aléatoires complet (RCBD) avec un plan factoriel (2 x 3) ; les cultivars de sorgho fourrager (Sugargraze et Columbus grass) et l'espacement de plantation (10 x 30 cm, 15 x 45 cm et 25 x 75 cm) ont été combinés et répétés quatre (4) fois. L'expérience a été menée dans deux endroits : Binyaminu Usman Polytechnic, Hadejia (ferme BUPoly) et Federal University Dutse Teaching and Research Farms (fermes FUD) pendant la saison des pluies de 2023.

On observe des différences significatives (P<0,05) entre les cultivars pour le nombre de feuilles, de nœuds, la surface foliaire, la hauteur de la plante et le rendement en biomasse. Le Sugargraze présente les valeurs les plus élevées par rapport au Columbus grass dans les deux sites d'étude. Dans les deux sites d'étude (fermes BUPoly et FUD), le Sugargraze a présenté le nombre de feuilles par plante le plus élevé (12,31 et 11,77), tandis que le Columbus grass a présenté le nombre de feuilles le plus faible (10,15 et 9,54). Sur le Sugargraze, les valeurs de surface foliaire étaient plus élevées (509,60 et 406,00 cm2), alors que le Columbus grass a produit les valeurs les plus faibles (314,00 et 236,00 cm2) dans les fermes BUPoly et FUD, respectivement. À l'exception du rendement en biomasse, qui était significativement différent (P<0,05) dans les deux sites sous l'influence de l'espacement, on n'observe pas de variations (P>0,05) du nombre de feuilles, de nœuds, de surface foliaire et de hauteur de la plante. Dans les deux sites de recherche, le Sugargraze a présenté le rendement en biomasse le plus élevé (73 092 kg/ha et 73 086 kg/ha), suivi du Columbus grass (43 917 kg/ha et 43 913 kg/ha). En conclusion, le Sugargraze planté avec un espacement plus étroit (10 x 30 cm) a produit un bon rendement et a donné le rendement en biomasse le plus élevé par rapport au Columbus grass.

Mots-clés : Sorghum almum et Sugargraze, Performances de croissance, Surface foliaire, Rendement en biomasse

Introduction

Ruminant production is dependent on the consistent and sufficient supply of high-quality fodder, and one of the most significant fodder crops is sorghum (Pushparajah and Sinniah, 2018). However, the lack of high nutritional pastures is the major challenge to profitable animal production in developing nations (Pushparajah and Sinniah, 2018; Dutta *et al.,* 2021; Mudau *et al.,* 2021). Sorghum (*Sorghum bicolor* (L) Moench) is a C4 herbaceous annual grass that is grown from seed in the summer for fodder production (Srinivasa Rao *et al.,* 2013; Pushparajah and Sinniah, 2018). Sorghum (*Sorghum bicolor* (L) Moench) and Sudan grass (*Sorghum bicolor subsp. drummondii*), which are known for their quick growth, multiple cuts, and nutritious fodder with higher total digestive nutrients (TDN) and crude protein (CP) values ranging 53-60% and 9-15%, respectively, were crossed to produce hybrids (Pushparajah and Sinniah, 2018). Sugargraze (*Sorghum bicolor* L. x *Sweet sorghum* x *Sorghum sudanese L.*), one of the hybrids, is a top-quality three-way cross of Sorghum, Sweet Sorghum and Sudan grass that was developed for grazing, green chop or hay (Kar *et al.,* 2016; Kumar *et al.,* 2022; Ranajit *et al.,* 2022). Sugargraze possesses a quick growth rate, sweet, succulent stalks, broad and deep green leaves that produce great quality feed (Bandara *et al.,* 2016; Kar *et al.,* 2016). In addition to being multi-cut (3-5), hybrid, with soft stems, very sweet, a good source of energy, high drought tolerance, suitable for green forage, silage, and high biomass production, Sugargraze also has a high sugar content (16-18%), which helps to improve feed quality and high palatability resulting in significantly reduced feed wastage (Dutta *et al.,* 2021; Forage, 2021; Kumar *et al.,* 2022). It is taller than other cereal fodder because of its long inter nodes and more leaf per plant (Dutta *et al.,* 2021).

The forage sorghum known as Columbus grass (*Sorghum almum* Parodi), a stable and balanced cross between grain sorghum (*Sorghum bicolar*) and Sudan grass (*Sorghum sudanese*), was developed in Argentina (Na-Allah *et al.,* 2017; Muhammad, 2019). One of the many fodder plants introduced to Nigeria for use in both intensive and extensive ruminant livestock production systems is Columbus grass (Muhammad, 2019). It is suitable for grazing and has been assessed for agronomic traits, chemical composition, and conservation as silage or hay

(Ishiaku *et al.,* 2016; Na-Allah *et al.,* 2017; Muhammad, 2019; Asifat *et al.,* 2023). The broad objective of this study is to evaluate the growth performance and biomass yields of Sugargraze and Columbus grass under raining season in Semi-Arid Zone, Nigeria.

Materials and Methods

Description of the study locations

The experiment (Evaluation of growth performance and biomass yields of Sugargraze and Columbus grass under raining season in Semi-Arid Zone, Nigeria) was conducted in two (2) distinct locations in the year 2023 rainy season. The first location was the Teaching and Research Farm of Binyaminu Usman Polytechnic, Hadejia, Jigawa State, coordinates of latitude $12^0$28' N and longitude $10^0$01' E (Muhammad *et al.,* 2023). While, the second location was Teaching and Research Farm of the Faculty of Agriculture, Federal University, Dutse, Jigawa State, coordinates of latitude 11.00^0 N to 13.00^0 N and longitude 8.00^0 E to 10.15^0 E (Gumel *et al.,* 2020). The means monthly weather parameters: temperature (°C), relative humidity (%) and total rainfall (mm) were reported in Table 1:

Soil sampling and analysis

Soil samples from each of the experimental fields were collected at random using a soil auger at 0-15 cm and 15-30 cm depths. The soil samples were air-dried, sieved, and analyzed for physical (Clay, Silt and Sand), and chemical properties (pH, Organic Carbon, Total Nitrogen, Available Phosphorus and Zinc, Caution Exchange Capacity: Ca^{2+}, Mg^{2+}, K^+ and Na^+) base on the procedure of Black (1965) and the results were presented in Table 2:

Treatments combination and Experimental design

The experimental plots were laid in a Randomized Completely Block Design (RCBD) consisting of two factors (2 x 3); Forage sorghum cultivars (Sugargraze and Columbus grass) and Planting spacing (10 x 30 cm, 15 x 45 cm and 25 x 75 cm), were combined as shown in Table 3; and were replicated 4 times

Table 1: Weather reports of the two study locations (Hadejia and Dutse)

Months	Hadejia			Dutse		
	TP (°C)	RH (%)	TR (mm)	TP (°C)	RH (%)	TR (mm)
May	29.80	44.80	-	35.80	44.80	68.30
June	22.10	38.70	62.50	33.50	53.60	299.80
July	22.20	54.20	153.00	31.50	48.30	122.40
August	29.50	41.70	198.00	30.40	39.70	305.20
September	27.60	54.40	60.50	30.10	57.20	184.10
October	24.50	37.40	30.00	32.20	74.40	13.00
November	24.50	69.50	-	32.60	75.60	-
Total	NA	NA	503.50	NA	NA	992.8
Mean value	25.74	48.67	NA	32.30	56.22	NA

Source: JARDA (2023). TP=Temperature, RH=Relative humidity, TR=Total rainfall and NA=Not applicable

Table 2: Physical and chemical properties of soils of the BUPOLY and FUD farms

Parameters	Hadejia (BUPoly Farm)		Dutse (FUD Farm)	
	0 – 15cm	15 – 30cm	0 – 15cm	15 – 30cm
Physical properties				
Particle size (%)				
Sand	92.00	94.00	96.96	92.96
Clay	1.00	1.00	1.76	1.76
Silt	7.00	5.00	1.28	5.28
Textural Class	Sand	Sand	Sand	Sand
Chemical properties				
pH (H_2O)	6.38	6.36	5.81	5.59
pH ($CaCl_2$)	5.55	5.83	5.29	4.98
Total Nitrogen (%)	0.11	0.07	0.105	0.14
Organic Carbon (%)	0.40	0.11	0.10	0.26
P (mg/kg)	6.90	8.61	12.40	15.00
Ca (cmol/kg)	2.39	1.79	1.96	2.24
Exchangeable cation				
Mg^{2+}(cmol/kg)	1.69	2.52	0.98	0.96
K^+ (cmol/kg)	0.40	0.26	0.26	0.18
Na^+ (cmol/kg)	0.62	0.66	0.14	0.16
Zn^{2+} (mg/kg)	7.11	2.99	0.64	0.03

Source: Soil analysis (2023).

Table 3: Experimental treatments combinations

Treatment	Combination
T1	**C1S1**
T2	**C1S2**
T3	**C1S3**
T4	**C2S1**
T5	**C2S2**
T6	**C2S3**

Forage Sorghum Cultivars: (Sugargraze = C1 and Columbus Grass = C2) while, **Planting Spacing:** (10 x 30 cm = S1, 15 x 45 cm = S2 and 25 x 75 cm = S3).

Experimental Plots

The total land areas for the trial in each of the two locations were 15 m x 14.5 m (217.5 m^2) and each plot size was 3 m x 2 m (6 m^2), an alley of 0.5 m and 1 m were left between plots and replicates, respectively. The land was ploughed and harrowed once and the plots were made to provide a clean seeds bed to enhance early seeds germination.

Sowing, materials and agronomic practices

Sowing and materials

The sowings were carried out on 24th July and 07th August at BUPoly and FUD Farms in rainy season of the year 2023, respectively. The experimental materials were Sugargraze (*Sorghum bicolor L.* × *Sweet sorghum* × *Sorghum sudanese L.*) and Columbus grass (*Sorghum bicolor L.* × *Sorghum sudanese*); which were sourced from National Animal Production Research Institute (NAPRI) Shika, Zaria and sown at 4-6 cm depth.

Fertilizer application

The fertilizer was applied using the drilling method as recommended for cereals (120 kg Nitrogen, 60 kg Phosphorus, and 60 kg Potassium) for optimum growth and development. The NPK (15:15:15) was applied as 1st dose (3WAS) and urea was applied at 2nd

dose (5WAS) as recommended (Dutta *et al.,* 2021).

Weed control

Weeding (1st and 2nd) were done manually using a hoe and handpicking at the initial stage of growing to avoid the suppression of fodder crop, the first and second were done at 3 and 6WAS, respectively (Dutta *et al.,* 2021; Forage, 2021).

Pest and disease control

Sugargraze and Columbus grass can be infected by Stem borer and Shoot borer. The seeds were treated with thiamethoxam high-quality insecticides (Actara®) prior to planting as recommended by Dutta *et al.* (2021).

Measurement of morphological parameters

The morphological parameters (plant height, leaf length, leaf width, leaf area, number of nodes and number of leaves) per plant in four different plants per plot per replicate were measured.

Plant height (cm)

The heights of four tagged plants from ground level to the growing point (tip of flag leaf) were measured using a measuring tape per each plot in each replicate and the mean values were recorded at boot stage (stage at which the plant panicle/head is in the flag leaf sheath and can be seen as a swelling) that is 10 Week After Sowing.

Leaf length (cm)

The leaf lengths of four tagged plants from the base to the apex were measured using a measuring tape per plot in each replicate and the mean values were recorded at boot stage (10 Week after Sowing).

Leaf width (cm)

The leaf widths of four tagged plants were measured using a measuring tape per plot in each replicate and the mean values were recorded at boot stage (10 Week after Sowing).

Leaf area (cm^2)

Leaf area were determined using length x width x correction factor (0.75) for four tagged plants per plot in each replicate and the mean values were recorded at boot stage (10 Week after Sowing).

Number of nodes per plant

The number nodes from four tagged plants were counted per plot in each replicate and the mean values were recorded at boot stage (10 Week after Sowing).

Number of leaves per plant

The numbers of leaves from four tagged plants were counted per plot in each replicate and the mean values were recorded at boot stage (10 Week after Sowing).

Biomass yield (kg/ha)

For determination of biomass yield, all plants from the two rows in the middle (Net plot) of each plot per replicate per treatment were cut from soil surface, weighed and recorded (Abdullah and Ayse, 2022) at boot stage (10 Week after Sowing) on 02nd and 16th October, 2023 at 1st and 2nd locations, respectively.

Statistical data analysis

The data collected were subjected to analysis of variance (ANOVA) using Genstat Statistical package (17th Edition), and means differences were separated using Student-Newman Keuls Test (SNK) at a 5% level of significance.

Results and Discussions

Effects of Cultivars and Plant Spacing on Number of leaves, Number of nodes and Leaf area

The effects of plant spacing and cultivars on the number of leaves, nodes, and leaf area are shown in Table 4. Cutivars had significant ($P<0.05$) influence on the three (3) parameters evaluated, Sugar graze had the highest values in factually all the parameters observed when compared with Columbus grass obtained in both the two study locations. However, no significant ($P>0.05$) differences were found in the number of leaves, nodes and leaf area in both locations as affected by spacing. The highest number of leaves per plant (12.31) recorded in Sugar graze in the current study was lower than the value (14.66) reported by Pushparajah and Sinniah, (2018) in dry zone of Sri Lanka for Sugar graze. However, the value (12.31) obtained was higher than the

values (10.46 and 8.00) reported by Gumel *et al.* (2020) and Ishiaku *et al.* (2016) in the Semi-Arid zone, Nigeria, respectively.

According to Pushparajah and Sinniah (2018), the cultivar's genetic influence was responsible for the larger leaf area value (861.04 cm^2) obtained in Sugargraze, which was higher than the current findings' recorded (509.60 cm^2). The observed leaf area values obtained in this study was however higher than the values (427.50 cm^2) reported by Pahuja *et al.* (2016) for Sugargraze planted in India with a spacing of 15 x 45 cm. According to Amin (2011), forage leaf area increases with leaf length with the help of efficient photosynthesis, contributing to the increase of forage output.

Table 4: Effects of Cultivars and Plant Spacing on Number of leaves, Number of nodes and Leaf area

Treatment	Number of leaves		Number of nodes		Leaf area (cm^2)	
	BUPoly	FUD	BUPoly	FUD	BUPoly	FUD
Cultivar (C)						
Sugar graze	12.31^a±0.37	11.77^a±023	10.88^a±0.23	7.88^a±0.41	509.60^a±13.46	406.00^a±18.80
Columbus grass	10.15^b±0.37	9.54^b±0.23	8.75^b±0.23	6.98^b±0.41	314.00^b±13.46	236.00^b±18.80
P – value	<0.001	<0.001	<0.001	0.147	<0.001	<0.001
Spacing (S)						
10 x 30 cm	11.06^a±0.46	10.66^a±0.28	9.66^a±0.28	7.78^a±0.50	408.30^a±16.48	311.10^a±23.00
15 x 45 cm	10.91^a±0.46	10.19^a±0.28	9.50^a±0.28	7.31^a±0.50	399.90^a±16.48	329.00^a±23.00
25 x 75 cm	11.72^a±0.46	11.12^a±0.28	10.28^a±0.28	7.19^a±0.50	427.20^a±16.48	322.00^a±23.00
P – value	0.437	0.097	0.160	0.690	0.504	0.861
Interaction						
C*S	NS	NS	NS	NS	NS	NS

Means ± SEM follows by same letter(s) within treatment column are not significantly (NS) different using SNK at 5% probability level.

Effects of Cultivars and Plant Spacing on Plant height and Biomass yield at BUPoly and FUD Farms, 2023

Table 5 shows the effects of cultivars and plant spacing on plant height and biomass yield. In both study locations, Sugar graze outperformed Columbus grass in terms of plant height and biomass yield, with differences between the cultivars significantly (P<0.05) affecting only biomass yields as a function of spacing.

Plant height is a growth characteristic that results from the elongation of the stem internodes, which is influenced by the environment (soil) and climatic conditions (Pushparajah and Sinniah, 2018). In this findings, higher plant height value (222.50 cm) was obtained from Sugargraze spaced at 10 x 30 cm ~~spacing,~~ which was similar with the value (222.93 cm) recorded by Pushparajah and Sinniah (2018) for Sugargraze with 15 x 30 cm spacing but higher than the value (188.833 cm) reported by Pahuja *et al.* (2014) in India. However, at 60 days after planting, Epasinghe *et al.* (2012) reported a similar plant height (218 cm) for Sugargraze in the wet zone of Sri Lanka. Similarly, Erandathi *et al.* (2013) reported 213.5 cm for Sugargraze in the wet zone of Sri Lanka. In the wet zone of Sri Lanka, Bandara *et al.* (2016) recorded a lower plant height value (191.1 cm) for Sugargraze. Gumel *et al.* (2020) recorded a Columbus grass plant height value of 190.50 cm with plant spacing of (25 x 20cm) which was higher than the value (186.10 cm) found in the current study for Columbus grass. Ishiaku *et al.* (2016) reported plant height (173.05 cm) for Columbus grass at (25 x 85 cm) plant spacing and stated that; the highest plant height recorded in closer plant spacing were attributed to higher competition for space and nutrients by plants at closer plant spacing than at wider plant spacing.

There was a significant ($P < 0.05$) difference on biomass yield among the two cultivars in the two study locations as affected by spacing. Sugargraze had the highest values (73,092.00 kg/ha and 73,086.00 kg/ha) than Columbus grass (43,917.00 kg/ha and 43,913.00 kg/ha) in both the two study locations (BUPoly and FUD Farms), respectively.

On the other hand, the biomass yield increases with decreasing plant space. Çoban and Acar (2018) observed that the lowest and maximum biomass yields in sorghum were 70,383.30 kg/ha and 94,006.70 kg/ha, respectively. The results observed in this study contradicted the findings of Acar and Akgun (2009) and Geren *et al.* (2011) who reported high (68,000 kg/ha) and lower (56,000 kg/ha) biomass output values respectively. Mahmood and Honermeir (2012) stated that there are substantial differences between the variants in terms of biomass production and chemical composition. Variations in soil types, climates, and genotypes can all lead to differing consequences in different regions (Abdullah and Ayse, 2022).

The interaction between the cultivars and plant spacing on biomass yield at the two experimental locations showed that the cultivars responded well to plant spacing. The yield obtained from Sugargraze was higher than that of Columbus grass. As seen in Table 6, however, spacing 1 (10 x 30 cm) yielded a substantially larger biomass results for both cultivars, followed by spacing 2 (15 x 45 cm), while spacing 3 (25 x 75 cm) yielded the lowest yield.

Table 5: Effects of Cultivars and Plant Spacing on Plant height and Biomass yield at BUPoly and FUD Farms, 2023

Treatment	Plant height (cm)		Biomass yield (kg/ha)	
	BUPoly	FUD	BUPoly	FUD
Cultivar (C)				
Sugar graze	242.90^{a}±6.45	202.00^{a}±8.69	73,092^{a}±155.00	73,086^{a}±154.80
Columbus grass	186.10^{b}±6.45	144.80^{b}±8.69	43,917^{b}±155.00	43,913^{b}±154.80
P – value	<0.001	<0.001	<0.001	<0.001
Spacing (S)				
10 x 30 cm	222.50^{a}±7.90	185.70^{a}±10.65	67,777^{a}±189.80	67,773^{a}±189.50
15 x 45 cm	218.60^{a}±7.90	177.30^{a}±10.65	60,375^{b}±189.80	60,369^{b}±189.50
25 x 75 cm	202.40^{a}±7.90	157.10^{a}±10.65	47,362^{c}±189.80	47,357^{c}±189.50
P – value	0.190	0.184	<0.001	<0.001
Interaction				
C*S	NS	NS	*	*

Means ± SEM follows by same letter(s) within treatment column are not significantly (NS) different using SNK at 5% probability level.

Table 6: Interaction between cultivars to plant spacing on Biomass yield at BUPoly and FUD Farms, 2023

Treatment	Biomass Yield (kg/ha)	
	BUPoly Farm	FUD Farm
T1 (C1S1)	84,969^{a}±268.40	84,961^{a}±268.10
T2 (C1S2)	71,676^{b}±268.40	71,671^{b}±268.10
T3 (C1S3)	62,632^{c}±268.40	62,626^{c}±268.10
T4 (C2S1)	50,588^{d}±268.40	50,585^{d}±268.10
T5 (C2S2)	49,075^{e}±268.40	49,067^{e}±268.10
T6 (C2S3)	32,091^{f}±268.40	32,087^{f}±268.10
P - Values	<0.001	<0.001

Means ± SEM follows by same letter(s) within treatment column are not significantly (NS) different using SNK at 5% probability level.

Conclusion

In conclusion, the two study locations (BUPoly and FUD farms) showed the maximum growth performance and biomass yield for the forage sorghum cultivars (Sugargraze and Columbus grass) planted in a narrower spacing (10 x 30 cm).

However, Sugargraze produced well and gives the highest biomass yield compared to Columbus grass.

Recommendation

Forage sorghum cultivars (Sugargraze and Columbus grass) should be planted with a narrower spacing (10 x 30 cm) as this will give the maximum yield of biomass, plant population, and growth performance when compared to other plant Spacings.

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