International Journal of Veterinary Sciences and Animal Husbandry

ISSN: 2456-2912
VET 2022; 7(5): 49-53

www.veterinarypaper.com
Received: 24-04-2022
Accepted: 25-05-2022

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Evaluation of improved *Brachiaria* (syn. *Urochloa*) grass cultivars for adaptation and nutritive values

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DOI: https://doi.org/10.22271/veterinary.2022.v7.i5a.444

Abstract
This study was undertaken in three experiments. The first experiment conducted to study adaptation and the nutritive value for the three varieties (*Brachiaria decumbence* cv. Basilisk, *B. brizantha* cvs. *Xaraes, & B. brizantha* cvs. *Piatã*) compared with *Rhodes grass* (*Fine cut*) and *local Brachiaria*, B. botuliform cv. Local, to evaluate DM. CP. CF. NDF.EE. Ash Moreover, Lignin contents. While the other two experiments are conducted for analysis of fresh and silage samples. For the fresh a sample was collected for shed drying in the Animal Nutrition Laboratory for a period of 28 days to establish a complete drying. As well, different sample was collected for fermentation as silage in the animal nutrition laboratory for 28 days, then shed dried, the samples were, then grinded, each well labeled and packed to avoid moisture transfer. The samples were taken to Central Animal Research Station at Kuku for the subsequent chemical analysis of the varieties under investigation. The present result revealed that when comparing the fresh samples and silage samples, there was a significant difference in chemical composition in (DM. CP., CF., EE, Ash and lignin). While there was no significant difference in NDF among the treatments.
On the other hand, *B. brizantha* cvs. *Xaraes, Piatã* revealed a higher crude fiber on a fresh basis and medium lignin content among the treatments when made as silage.
The DM showed significant differences in all treatments, local *Brachiaria* has a higher level of DM, CF, Ash and Lignin contents than other treatments. CP significantly showed a low-level content as silage and a high level of lignin.
This study concluded that local *Brachiaria* has a high level of CP on a fresh basis followed by *Rhodes grass* and lower CP as silage. *Rhodes grass and Brachiaria Decumbence* showed a higher crude protein level and low lignin contents than all other grasses under investigation, being in silage form. Because of high crude protein (11.79%) and lower Lignin content were recommended as the best forage grass followed by *Brachiaria basilisk and Brachiaria Xaraes* to be used as animal feed silage during the dry season.

Keywords: Brachiaria grass, Rhodes, grass, chemical composition, crude protein, dry matter yield, fresh basis, silage form

1. Introduction
Livestock in Sudan are an integral component of agriculture that contribute directly or indirectly to the populace by providing food, value-added products, fuel and transport, enhancing crop production and generating incomes, livelihood, and livestock provide food products like milt, meat. In addition, livestock also diversify production and income, provide year-round employment and reduce risk. Livestock play an important role in crop production. Approximately 80% of livestock in Sudan is raised under grassland-based animal production systems (GL) which are pastoral nomadic and semi-nomadic agro pastoralism sub-systems with average population of cattle, sheep, goats and camels as: 30376, 40210, 31227, and4809 (000 heads) in 2015 and31489, 40896, 32032 and4895 (000 heads) in 2019 respectively
Livestock had consistently provided more than 60% of the estimated value added to the agricultural sector in the years 2007-2010. Nonetheless, in the thirteen years' period since 1997, livestock and livestock products had on average provided 27% of the value of Sudan's agricultural exports (Igad, 2013).

Major livestock production system in Sudan include pastoral (Nomadic) agro-pastoral (semi-nomadic), transhumant, semi-transhumant and animal production around the Nile systems.
Grasslands in which grasses predominate still provide the basic feed requirements for growth and development of livestock particularly ruminants, their maintenance and the production of their product's needs. In some grazing lands, legumes and herbaceous species contribute to overall available feedstuff. Crop residues are of vast importance in many regions in Sudan, being as an alternative source for feed availability specially in dry season feeding for livestock.
A majority of these grasslands are located in regions characterized by erratic rainfall patterns and varying periods of extreme drought and often soils of poor fertility. Seasonal distribution of rainfall and soil conditions impose a direct influence on the amount and quality of forage available during the year and indirectly affect animal performance.
In many regions of the world, a major problem associated with the development of livestock industries is the supply of feeds. In Sudan, the major constraints of livestock production is attributed to low productivity associated with low quality and seasonal availability of feed, poor health, and breeds of low genetic potentials.
Poor natural pasture, an availability of crop residue, and limited use of improved fodder enhanced the situation for low animal productively
The challenges before animal researchers are multifold for achieving equilibrium between livestock numbers, production and productivity and scarce feed and fodder and other resources to satisfy the requirements of the populace across the globe.
In Sudan, improved fodder played a significant role in livestock sector transformation, such as *Rhode's grass, Sudan grass* in terms of meat and milk production. Importance of forage of African origin like Brachiaria in livestock intensification has now gained a significant interest role in improving productivity in animal production sectors. Interest on Brachiaria research was spurred by the exceptional performance of livestock production on Bracharia pasture in South America. In Brazil, an estimated acreage of 99 million hectares in Brazil alone (Jank *et al*., 2014), supporting a highly vibrant beef industry.
In East Africa, Brachiaria has also played a significant role in transformation in milk production. Climate Smart Brachiaria Grasses for Improving Livestock Production in East Africa – Kenya Experience of Brachiaria in increasing milk productivity, was clearly demonstrated by the work of Muinga, R. W., Njunie, M. N, *et al*. (2015) [8], which revealed that, Milk yield increased by 15-40% in cows fed Brachiaria grasses compared to local feeds which were varied mixtures of Napier grass, maize stover and natural pastures.
Brachiaria, has many agricultural benefits including, high biomass production, nutritive to livestock, improved livestock productivity (both milk and meat) Grasses in the genus Brachiaria have advantage over those in other genera including adaptation to drought and low fertility soils, ability to sequester carbon; increase nitrogen use efficiency through biological nitrification inhibition (BNI) and arrest greenhouse gas emissions (Mureithi, J. G. and Djikeng, A. (2015) [9].
Brachiaria grass is an important tropical forage of African origin with desirable attributes of agricultural and environmental significance. Brachiaria has been extensively cultivated as a pasture across the tropics except in its endemic provenance of Africa. In 2013, a collaborative research program was initiated in Kenya and Rwanda with the aim of improving the availability of quality livestock feeds adapted to drought and low fertility soils using Brachiaria. Poor feed options of low nutritional quality are among the major factors contributing to the low livestock productivity in Sudan.
The exploration and wider scale cultivation of high yielding and nutritious forage is the most pragmatic option for sustainable increase in livestock productivity in the country. In this study three *Bracharia* grass cultivars Brachiaria *decumbens* cv. Basilisk, *Brachiaria brizantha* cvs. Piatã and *B. brizantha* cvs. Xaraes were introduced and evaluated for adaptation and nutritive values as dried fodder (hay) and silage forms at the Research Farm, University of Bahri, Khartoum, Sudan.

2. Material and Methods

2.1 Study site

The study was conducted University of Bahri, College of Animal Production Research and Training Farm in Khartoum, Sudan. It was situated at the east north of the Khartoum North State at the Khartoum Bahri Locality. It occupies the northern part of the locality in between 15° 45\ to 15° 45\N latitudes, 32° 35\ to 32° 39\ E longitudes (Mohammed, 2005). The altitude changes from 398m above sea level (a.s.l.); (Sulafa and Mohammed 2010,). The area is almost flat, slightly undulated bounded by the River Nile and Elsilaid Agricultural Project to the west and east respectively. The area illustrates a typical agro-ecological profile of the windward side of Bahri Locality with nil or low precipitation with considerable annual fluctuations in the magnitude, intensity, and distribution of rainfall, a short rainy season from July to September with moderate temperatures and high humid. Mean annual rainfall is 155mm in the study area. Rain mainly falls from May to October. The mean daily minimum and maximum temperatures are 24˚C and 45˚C, respectively. The soil-type in the site is gardud soil (loamy-clay soil) with poor fertility. The parent materials of the clay soils which cover almost this entire area belong to two broad groups: Aridisols and Vertisols (Osman, 1970, Mohammed, 2005) in addition to Paludal sediments from rivers belonging to the Nile system (gradational clay plain) (Blokhus,). The most important soil types for farming in the study area are dominated by relatively expanding clays and Aridisols (Mohammed, 2005). The soils are classified as Aridisols and Vertisols by WRB soil classification (FAO, 2006) [2]. These soils are calcareous; strongly alkali and saline-sodic, moderately to poorly well-drained, but generally contain very low organic matter as well as nitrogen (Mohammed, 2005).

Table 1: Geographical position, elevation, temperature, rainfall and soils at the experimental site, El Kadaro, Khatoum North Sudan

Site	El Kadro
Latitude	15° 45\ to 15° 45\N
Longitude	32° 39\ E
Altitude (m asl)	398m above sea level
Mean temperature (^{o}C) (minimum and maximum)	24˚C and 45˚C
Annual rainfall (mm)	155mm
Soil type	Vertisols

Source: Sulafa and Mohammed 2010 [16].

2.2 Experimental set-up

Three Brachiaria grass cultivars *B. decumbence* cv. Basilisk, *B. brizantha cv. Piata* and *B. brizantha* cv. *Xaraes*, and two local-forages species: Brachiaria grass species, *Brachiaria botuliform* cv. Local and Rhodes grass (Chloris gayana cv. Fine Cut) were evaluated in randomized complete block design (RCBD) with four replications. The individual plot size was 20 m^2 (5 m X 4 m). The space between replication was 1 m and plant to plant spacing of 50 cm.

2.3 Land preparation and intercultural operation

The land was ploughed and harrowed twice to a fine tilth. All the perennial grasses were removed from the experimental site.at the onset of rainy season, the seeds were drilled along the furrows (0.5-1 cm deep), using hand hoe and cover lightly with soil. Hand hoe was used to remove the weeds from the plots.

2.4 Research data collection

Plant height and Plant Population Count within a 1m x 1m frame, was performed **at** 4 weeks' interval during establishment phase, pests and diseases incidences were also put into consideration throughout the experimental period.

At maturity, all five forage cultivars/species under the experiment were harvested at 5 cm above the ground. 2 kg of fresh samples from each cultivar was weighed and dried in shade for 28 days in the Animal Nutrition Laboratory of University of Bahri. Whereas a fresh biomass weight of 5 kg was also weighed from the same cultivars under investigation was ensilaged for a period of 28 days in the same Laboratory. Then after 28 days, silages were removed out and stretched on papers on the Lab. Pinches for another 2 weeks to complete drying. Following the drying, the samples were grinded to a fine and powder form, each well labeled and packed to avoid moisture transfer. The herbage was ground to pass through a 1-mm screen in a Willey mill (Udy Corporation, Fort Collin, CO). Analysis was conducted for crude protein (CP), fibre, and lignin. The samples then were taken to Central Animal Research Station at Kuku for the subsequent chemical analysis. Ash was determined by heating the samples at 600 ^{o}C for 2 hours in a muffle furnace. Crude protein was determined using micro–Kjeldahl according to the method of the Association of Official Analytical Chemist (AOAC 2000) [1]. The neutral detergent fibre (NDF) and acid detergent lignin (ADL) were determined using the Ankom method of Van Soest *et al*. (1991).

2.5 Statistical Analysis

The DM%, CP%, CF%, NDF%%, EE% and Ash % subjected to two-ways analysis of variance (ANOVA), of the randomized complete block design using the General Linear Model procedure of Statix 8.0 U. S. A. version 2004. Differences between treatments means separated using the least significant difference (LSD).

3. Results & Discussion

The agronomical characteristics, including Plant count/m^2**,** Plant Height (cm), Pest infection and other notes were tabulated in Table N0.2 in terms of Plant count/m^{2,} B. brizantha cv. Piatã showed a better plant counts (38.00) than all other cultivars under the study, then followed by B. brizantha cv. Basilisk (33.00). While B. brizantha cv. Xaraes, Control 2, and Control 1 obtained 27.00, 25.00 and 14.00 plant count per m^2 respectively.

Table 2: Average Plant population counts (22nd July 2018) one month after sowing date

Species	**B. brizantha cv. Basilisk**	**B. brizantha cv. Xaraes**	**B. brizantha cv. Piatã**	***Brachiaria baculiform* (*Um giir*) Control 2**	***Rodes grass* (*Finecut*) Control 1**
Plant count/m^2	33.00	27.00	38.00	25.00	14.00
Plant Height (cm)	20.00	53.00	25.25	18.50	9.00
Pest infection	Non	Non	Non	Non	Non
Other notes	Non	Non	Non	Non	Non

The approximate chemical analysis on a fresh basis has shown significant difference among the forages tested for different forage quality parameters ($P \leq 0.04$; Table 3). All three improved Brachiaria grass cultivars had significantly higher dry biomass production than two local check used in this study.

Table 3: Dry matter content and nutritive values of fresh herbage of three improved Brachiaria grass cultivars and two local forage species in Khartoum, Sudan

Forages	**DM %**	**CP %**	**CF %**	**NDF %**	**EE %**	**Ash %**
Brachiaria brizantha cv. Piata	91.567^{b}	9.360 ^{d}	34.033^{ab}	64.453	1.310^{a}	7.977 ^{b}
Brachiaria brizantha cv. Xaraes	91.467^{b}	8.097 ^{c}	32.467^{a}	59.967	2.073^{c}	7.280 ^{a}
Brachiaria decumbens cv. Basilisk	92.433^{b}	7.397 ^{b}	33.083^{a}	61.830	2.303^{c}	10.000^{d}
Brachiaria botuliform cv. Local	86.153^{a}	10.187^{e}	37.400^{b}	65.367	1.537^{b}	8.877 ^{c}
Chloris gayana cv. Fine Cut	86.697^{a}	6.683 ^{a}	45.517 ^{c}	59.467	0.973^{a}	8.887 ^{c}
Pr. > F (Model)	0.041	<0.0001	0.000	0.058	0.002	<0.0001
Significant	Yes	Yes	Yes	No	Yes	Yes

Note: DM = Dry matter, CP = Crude protein, CF= Crude fiber, NDF = Neutral detergent fiber, EE = Ether extract

Table 4 below shows color, smell and pH characteristics of ensilaged materials for all five forages evaluated. Cultivar *Piata* and *Xaraes* had a brown and dark brown color with a pH of 8 with light brown color indicating a good quality silage. On the other hand, local Brachiaria grass B. *botuliform* cv. Local had with light brown color and aromatic smell, showed a pH of 7.8 also indicating a good quality silage. This finding agrees with (Ernst *et. al.* 1990), who reported that good quality silage for wilted forages should range below 8.4 for wilted crops.

Table 4: *Visual and PH Evaluation of Silage* for different Brachairia cultivars

Sample	Color	Smell	PH
B. brizantha cv. Basilisk	Dark brown	Bad	8
B. brizantha cv. Xaraes	Brown	Adour	7.85
B. brizantha cv. Piatã	Brown & light brown	Adour/aroma	8.03
Brachiaria baculiform (*Um giir*) Control 2	Brown	Adour	7.8
Rodes grass (*Finecut*) Control 1	Brown &dark brown	Bad	7.93

Table 5: Dry matter and nutritive values of silage of three improved Brachiaria grass cultivars and two local forage species in Khartoum, Sudan.

Forages	DM %	CP %	CF %	NDF %	EE %	Ash %	Lignin
Brachiaria brizantha cv. Piata	92.433 ^{ab}	6.467 ^{b}	45.783 ^{b}	68.607 ^{b}	1.550 ^{b}	9.300 ^{bc}	13.090 ^{d}
Brachiaria brizantha cv. Xaraes	94.467 ^{b}	7.357 ^{c}	42.600 ^{b}	66.167 ^{ab}	0.873 ^{a}	8.503 ^{b}	11.273 ^{c}
Brachiaria decumbens cv. Basilisk	94.567 ^{b}	11.067 ^{d}	37.700 ^{a}	61.850 ^{a}	2.290 ^{c}	7.227 ^{a}	10.350 ^{b}
Brachiaria botuliform cv. Local	90.820 ^{a}	11.787 ^{d}	36.000 ^{a}	67.950 ^{b}	2.103 ^{c}	6.543 ^{a}	7.307 ^{a}
Chloris gayana cv. Fine Cut	94.567 ^{b}	3.483 ^{a}	54.367 ^{c}	75.617 ^{c}	1.940 ^{bc}	10.067 ^{c}	13.647 ^{e}
Pr. > F (Model)	0.045	<0.0001	<0.0001	0.005	0.001	0.000	<0.0001
Significant	Yes	Yes	Yes	Yes	Yes	Yes	Yes

3.1 Dry Matter
Table 3 and 5 showed the difference between forages for dry matter production. DM when compared in the two experiments, showed a slight increase in dry matter percentage for the three Brachiaria cultivars under the investigation when compared to local Brachiaria and Rhodes grass as fresh and silage forms showed a dry matter content of 91.467% for B. brizantha cv. Xaraes, B. brizantha cv. Piata B. decumbens cv. Basilisk, and Rhodes cv. Fine Cut, with the average production of DM of, 86.697%, and 94.467%, and 92.433%, 94.567, 94.567 respectively. In general, DM is higher in silage than in fresh (hay) for all five forages. However, a combined data analysis showed that silage samples significantly produce more DM than fresh (hay) form.

3.2 Crude Protein
On the other hand, results revealed a highly significant difference among the treatment in terms of CP. *Brachiaria botuliform* cv. Local with CP of (11.79%), was significantly better when compared with *B. decumbens* cv. Basilisk (11.07%), *B. brizantha* cv. Xaraes (7.36%), *B. brizantha* cv. Piata (6.47%) and *C. gayana* cv. Fine Cut (3.46%) which was the least in terms of CP content with an average yield of (3.46%), on a silage basis (Table 4) This finding agrees with the other research findings (Pamo et, al., 2007). Who found that the crud protein of grass silage ranging from 5.4 to 15.6%. While when compared with fresh samples results, it was found that, B. botuliform cv. Local has a high level of CP (10.187), followed by B. brizantha cv. Piata (9.360), while B. brizantha cv. Xaraes (8.097), is significantly better than B. decumbens cv. Basilisk, and Rhodes cv. Fine Cut with average CP of (7.397), (6.683), respectively (Table 1) and Figs.1(a,b&c). In addition, table 3 revealed that, B. botuliform cv. Local has the lowest lignin content (7.307%) and B. decumbens cv. Basilisk has the highest CP protein percentage (11.787%), when compared with Rhodes cv. Fine Cut.

3.3 Nutrient Detergent Fiber
On the other, the NDF between treatments showed no significant differences among the treatments in both for fresh and silage form for all samples (64.453, 68.607) Tables1(1&2). These results in line with the findings of Heuze *et al*. (2016) [5] who found that the NDF 66%, the same range which was found.

3.4 Lignin
On the other hand, the lignin results revealed a significant difference in silage form between the treatments, that *local Brachiaria* and B. decumbens cv. Basilisk, showed the lowest level of lignin content (7.307 & 10.350) among the treatment respectively, when compared with other treatments (Table 3). While Rhodes cv. Fine Cut *and* B. brizantha cv. Piata showed the highest level of lignin (13.647 & 13.090) when tested as silage form.

4. Conclusion
In conclusion, *Brachiaria Cultivars*: *B. brizantha* cv. Piata; *B. brizantha* cv. *Xaraes* and *B. decumbens* cv. Basilisk are well adapted and tolerant to the drought tropical Sudan climate, as such, it can be recommended as important constituent of Savannah grassland ecosystem in Sudan for supporting forage for herbivores. An initiative is recommended to promote Brachiaria to support the emerging livestock industry in the region, especially in the dry season, CP% and NDF%, Because of high crude protein (11.79%) and lower Lignin content were recommended as best forage grass followed by *Brachiaria basilisk and Brachiaria Xaraes* to be used as animal feed as silage during the dry season.

5. Acknowledgements
This study was supported in a collaborative program of BecA-ILRI Hub in partnership with, College of Animal Production, University of Bahri, Sudan. With financial support from the Government of Sweden (Sida).
Acknowledgement is extended to professor Sita Ghimire of The Biosciences eastern and central Africa, International Livestock Research

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