Biomass yield and quality of Congo and Rhodes grasses in Northern Guinea Savanna of Nigeria for ruminant animal production

Tersur Theophilus Akpensuen (theophilusa@unijos.edu.ng)
University of Jos https://orcid.org/0000-0001-6701-1407

Research Article

Keywords: Urochloa ruziziensis, Chloris gayana. Nutrient contents. Dry matter yield

Posted Date: August 10th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1787720/v1

Abstract

The study was conducted to evaluate forage dry matter and nutrient contents of Congo grass (*Urochloa ruziziensis*) and Rhodes grass (*Chloris gayana*) in the Northern Guinea savanna of Nigeria for livestock production. A two (two grass species) by three years (2019, 2020 and 2021) factorial design was used. The experimental design was arranged in a Completely Randomized Design with four replicates. The forage crops were harvested at early bloom stage in each year. *Urochloa ruziznsis* was greater ($p < 0.05$) in plant height, number of tillers and leaves per plant compared to *C. gayana*. Foarge dry matter yield (14.1 t/ha) and Crude protein yield (1.7 t/ha) were also higher in *U. ruziensis*. The year 2020 produced higher dry matter yield, while the lowest value was recorded in the year establishment year (2019). On the other hand, *C. gayana* had higher ($p < 0.05$) fibre contents than *U. ruziziensis*. There was positive correlation between dry matter yield and the phonological variables, while a negative correlation existed between crude protein and crude fiber. The forage legumes an provide the basic nutrient requirement for maintenance in ruminants when fed with the two grasses, but the feeds should be supplemented with higher protein content feeds for highly production such as fattening and lactating animals. Overall, *U. ruziziensis* showed valuable forage grass in terms of dry matter yield and quality than *C. gayana* in the environment considered.

Introduction

There is increasing demand for livestock products in Sub-Saharan Africa and this will keep rising due to population growth, improve living conditions and urbanization (Robinson and Pozzi 2011; Ghimire et al. 2015). The situation has been aggravated by insecurity, climate change, desertification, low productive lands and conflicts. Schiek et al. (2018) noted that one of the major factors for the low livestock productivity is the lack of quality feeds with good nutrient contents. Forage production is therefore gaining more attention in recent times. In most tropical countries, the inadequacy of quality feeds is a major limitation to successful ruminant production. Natural grasslands which constitute major feed resources of ruminants (Tolera and Abebe 2007) are normally poor in quality.

The total land mass in Nigeria is 923,786 km^2 (Shiawoya and Tsado 2011; LDN 2018) and grasslands form the largest landscape type with an area of about 341,800.82 km^2 (Jimoh et al., 2020), while cultivated croplands amount to about 39.41 million hectares (Kallah 2004). Grassland in Nigeria is classified in six agro-ecological zones according to precipitation, temperature, length of the growing season. Nigeria's forage and fodder species vary widely and spread across the major agro-ecological zones of the country (Babayemi et al. 2014).These zones provide a substantial amount of forage and fodder as a major source of feed, for the country's ruminant livestock, both domestic and wildlife. According to FAO (2019) 82% of cattle are reared through the pastoral system, 17% on agro-pastoral and only 1% from the commercial systems (which includes some levels of pasture improvement). Long periods of cropping, rough topography and frequent bush burning, among other factors, have given rise to mixed tree, shrub and grass vegetation in the savanna zones of the country (Shiawoya and Tsado 2011). Over-grazing is a primary contributor to low land productivity affection forage quality. The resultant soil, therefore, is not suited for growing food or forage production, since it loses it's essential nutrients due to erosion. Kubkomawa and Lawal (2021) stated that this loss of productive land directly results in the loss of food or forage available for human and animal consumption.

Despite the poor soil quality and unfavourably climatic condition, ruminant livestock survival depend on the natural, extensive pastures in Nigeria. Crop residues also constitute a valuable feed resource in this environment. Simbaya (2002) noted that the available natural pasture and crop residues after crop harvest during the dry season are usually fibrous and limited in most nutrients required for increased rumen microbial fermentation and improved performance of ruminants. Also, during the dry season, the nutritive value of pastures falls rapidly with maturity and, the available feed is lignified. When protein, vitamins and mineral elements are limited in grassland pastures during the dry season (Kubkomawa et al. 2015), most of the animals suffer from seasonal nutritional stress, resulting in weight loss, reproductive inefficiency and even death (Yohanna et al. 2015).

Forage and fodder crops are very central in the development of Nigeria's livestock industry and the bulk of the animal protein, especially milk and meat, consumed in Nigeria is derived from ruminant animals (Shiawoya and Tsado 2011). Attention is now being focused on the cultivation and management of forage crops to provide quality feed for optimum animal output. As a result of many factors such as population increase, urbanisation, desertification, industralisation among others, the land for forage production has significantly decreased, there is a need now to intensify forage production in a sustainable manner. There is also the need to examine the productivity of various forage species in the different agro-ecological zones of Nigeria as forage species productivity varies according to the zones (Babayemi et al. 2014)

Urochloa forage spp is native to Africa where the crop is an important component in grassland management and is also grown extensively in Latin America, Asia, Carribbean and Australia (Ghimire et al. 2015). The species *ruziziensis* is a perennial tropical forage reported to have good tolerance to acidic soils, tolerance of infertile soils, high dry matter yield and that responds well to nitrogen (Skerman and Riveros 1990; Rodrigues et al. 2014). *Chloris gayana* Kunth, is also a gramineous perennial species native to Africa, is one of the most important warm-season forage grasses in sub-tropical and tropical areas of the world (Ponsens et al. 2010). The forage crop is being introduced into temperate areas as a consequence of increasing minimum temperatures (i.e. less severe winters) because of global warming (Imaz et al. 2015). These two forage grasses were tested for productivity and quality in Jos, Plateau State which is located in the Northern Guinea savanna of Nigeria for ruminant animal production. The objective of the study was, therefore to (i) compare the yield and nutrient content of the two grass species (ii) determine the effect of year on biomass yield and quality of the individual grass species and (iii) the relationship between phonoloigcal variebles and dry matter yield.

Materials And Methods

Experimental site

The study was conducted at the Federal College of forestry, Jos North Local Government Area, Plateau State, Nigeria. Jos-north is located in Northwest of Plateau state a region of the middle belt of Nigeria with latitudes 9°57' North, longitude 8°52' East with an altitude of about 1,200m above sea level (Google Earth Pro, 2022).

The topography of the area is undulating, is a grassland area with scattered trees (Europe World Year Book, 2005). The climate of the area is cool with temperatures ranging from 15-27°C during the rainy season and 7-18°C during the harmattan season, while the temperature ranges of 18-32^{o}C are normally observed during the late months of dry the season (Aregheore, 2009). Rainfall starts in April ending or beginning of May each year. Peak rainfall is normally observed in the months of July and August each year and the d season starts middle to end of September.

The Soil samples of the experimental site were randomly obtained from the depth of 0-15 cm and 15-30 cm at different locations with an aid of a Soil auger. The samples collected were bulked taken for analysis for determination of the physical and chemical properties (Table 1). Based on the pH the soil is slightly acidic to slightly alkaline, typical of soils in the ares. The soil of the experimental site is very low in nitrogen(0.23 % and the available phosphorus as 7.54 mg/L.

Table 1: Soil Physical and Chemical Properties of the Study Area

Properties:	Value
Particle size (%)	
Clay	24.0
Silt	30.0
Sand	55.0
pH	5.50 in 0.01M $Cacl_2$ and 6.90 in H_20
Class of soil-	sandy-clayey loam
Chemical properties:	
Total N(%)	0.23
Organic carbon (%)	2.51
K(mg/litre)	247.20
P(mg/litre)	7.53
Exchangeable cations (mol/kg^{-l}):	
P(mg/litre)	
Ca^{++}	14.15
Mg^{++}	0.98
CAC	16.60

Source of planting material and experiment design

The seeds of *chloris gayana* and *Brachiaria ruziziensis* were obtained from National Animal Production Research Institute, Ahmadu Bello University, Shika, Zaria, Kaduna State, Nigeria. The experimental design was two (2 forage grasses) by three (3 years) factorial arranged in a Randomized Complete Block Design (RCBD) with four (4) replicates. The space between the blocks was 1.0 m, while that between the plots within a block was 0.5 m. The plots sizes were 3 m x 1.5 m

Land preparation and pasture establishment

The land was ploughed once and harrowed twice with tractor mounted with implements. All debris were removed and the land was leveled with rakes and hoe making clean seedbeds. Seed rate was determined using the pure live seed (PLS) equation by Karki (2013) as follows;

Seed (PLS) index = (% germination x % purity) ÷10000

Seedrate (Kg ha^{-1}) = Recommended seeding rate ÷ PLS index

Therefore, the seeding rate used was 7.2 and 9.3 kg/ha for *C. gayana* and *B. riziziensis*, respectively. The forage grass seeds were sown on 5 July, 2019 when rains were well established. The seeds were drilled in rows of 50cm apart in each plot at a depth of 1cm. The plots were manually weeded with locally made hoes as the need arose. Prior to establishment, the seeds plots were fertilized with Sigle Super Phosphate (SSP) fertilizer at the rate of 30 kg/ha. The plots received nitrogen fertilizer in form of Urea at the rate of 120 kg/ha each at the 4^{th} and 8^{th} weeks after sowing.

Morphological Characteristics and herbage Yield Measurement

Morphological characteristics and herbage yield measurements were performed just before blooming. Four plants in the middle rows of each plot were tied loosely with twine(a slender rope) after establishment to measure plant height, number of leaves and tillers per plant. The heights of the tagged plants were measured from the ground level to the flag leaf with the aid of a graduated meter rule. The number of leaves and tillers of the plants were counted. Herbage dry matter yield was estimated by harvesting plots in the middle rows in a 0.7 by 1 m strip. All plants within the area were cut at a stubble height of 5 cm above the ground just before blooming each year. The cut plants were weighed immediately in the field with a two decimal digital weighing scale to estimate fresh matter yield per hectare. Sub-samples of 300 g were taken and oven-dried at a temperature of 55^{o}C for 3 days until a constant weight was achieved. This was used to estimate the dry matter yield per hectare.

Sample preparation and analysis

The dried samples were ground with a Thomas Willey Laboratory Mill Model and passed through a 1mm sieve. Crude Protein (CP) was determined by the Kjeldahl Method using digestion, distillation and titration. The percentage of CP was determined by multiplying the percent nitrogen by a factor of 6.25 (AOAC 1990). Neutral and acid detergent fibre (NDF and ADF) were done by the Refluxing method of Van Soest et al. (1991) and as specified in AFIA (2011) Laboratory manual. Approximately 2.0 g of biomass was burned in a box-type muffle furnace (SX2-4-10, Tianjin Zhonghuan Experimental Furnace Co., Ltd.) at 550 ˚C for 12 h, and the residue was weighed to determine the ash content. These were done at the Biochemical Laboratory Unit of the Department of Animal Science, Ahmadu Bello University, Zaria Nigeria. A Bomb calorimeter was used to determine the gross calorific value of samples. Mineral elements (Ca and P) were determined using the atomic absorption spectrophotometer of AOAC (1990) at the National Animal Production Research Institute, Ahmadu University, Shika, Nigeria.

Data Analysis

All data generated were subjected to analysis of variance (ANOVA). The general linear model of SAS (2002) using JMP statistical software was performed on data during the analysis. Means were compared using

Tukey (1949) HSD test and significance was declared at $p \leq .05$. The statistical model was as fellow;

$Y_{ijl} = \mu + A_i + B_j + A_i X B_j + e_{ijkl}$

where,

μ = population mean;

A_i = ith effect of grass;

B_j = jth effect year;

A_i X B_j= Interaction between grass and defoliation year; and

eijkl = Random error

Results

Morphological characteristics

The main effect of grass showed that *U. ruziziensis* was greater ($p<0.05$) in NLPP, NTPP and PH compared to *C. gayana* (Table 2). The year 2020 and 2021 showed no significant effect ($p>0.05$) in the morphological traits measured, but the two years were higher (p<0l05) than the year 2019 as presented in Table 2. The ANOVA showed a significant interaction between grass and year for PH.

Table 2: Main **e**ffect of forage grass and year on phenological characteristics

Factors	NLPP	NTPP	PH
Grass			
U. ruziziensis	221.1 a	30.1 a	119.8 a
C. gayana	58.0 b	14.9 b	110.3 b
SEM	10.6	1.3	2.2
Year			
2019	109.5 b	17.3 b	100.2 b
2020	157.7 a	25.1 a	124.0 a
2021	151.5 a	25. 2 a	121.0 a
SEM	12.9	1.3	2.7
Grass X Year	0.43	0.1	0.0006

Means with different letters within a column differ significantly. NLPP= Number of leaves per plant. NTPP= Number of tillers per plant. PH= Plant Height. SEM= Standard error of means.

Dry matter yield and nutrient contents

Forage grass and year had a significant ($p<0.05$) effect on herbage dry matter yield and nutrient contents (Table 3). *Urochloa ruziziensis* had the greatest dry matter yield (DMY), crude protein yield (CPY) and CP content. Dry matter yield was 66 %, CPY was 70 %, while CP content was 17 % higher in *U. ruziziensis* than *C. gayana*. Similarly, ash, and gross energy (GE) contents were also greater ($p<0.05$) in *U. ruziziensis*, while *C. gayana* was significantly higher in phosphorus content and no significant different was observed in calcium content. Herbage DMY was greater in the second year (2020) with 11.8 t/ha and 2019 produced the lowest yield. Crude protein yield ranged from 0.9 to 1.3 t/ha with the year 2020 having the greatest yield, with no significant difference between year 2019 and 2021. No significant difference was observed among the years in CP content. Ash and calcium contents were, however, higher significantly in the year 2019 and there were no differences in value between year 202 and 2021. On the other, GE was not significant ($p>0.05$) between the year 2020 and 2021, but the two years were higher than 2019 significantly ($p<0.05$). The ANOVA showed a significant interaction between the grass species and year for DMY, CPY and CP content.

Table 3: Effect of grass species and year on yield and nutrient contents in Jos, Nigeria

Factors	DMY	CPY	CP	Ash	Ca	P	GE
	t ha^{-1}		g Kg^{-1} DM				MJ Kg^{-1} DM
Grass							
U. ruziziensis	14.1 a	1.7 a	122,5 a	64.9 a	3.0	1.3 b	18.7 a
C. gayana	4.8 b	0.5 b	101.2 b	50.0 b	2.9	1.9 a	17.3 b
SEM	0.2	0.1	0.1	0.9	0.1	0.1	0.1
Year							
2019	7.9 c	0.9 b	113.5	60.4 a	3.2 a	1.8	17.8 b
2020	11.8 a	1.3 a	114.7	56.7 b	2.9 b	1.7	18.0 a
2021	9.6 b	1.1 ab	111.8	55.1 b	2.8 b	1.5	18.2 a
SEM	0.3	0.1	0.8	1.2	0.1	0.2	0,1
Grass X Year	<.0001	<.0001	<.0001	0.1	0.4	0.7	0.2

Means with different letters within a column differ significantly. SEM= Standard error of means DMY=Dry matter yield. CPY= Crude protein yield. CP= Crude protein. Ca= Calcium. P= Phosphorus. GE= Gross energy

Fibre fractions of the grass species.

There was a significant effect in grass species and year as presented in Table 4. *Chloris gayana* was higher ($p<0.05$) in all the fibre contents measured. The crop was 10, 10.7, 17.9 and 5.0 % higher in CF, NDF, ADF and lignin, respectively compared to *U. ruziziensis*. The year 2021 was higher significantly in all the fibre variables measured, year 2019 had the lowest value.

Table 4: Effect of grass species and year on fibre contents *Urochloavariables ruziziensis* and *C. gayana*

Factors	CF	NDF	ADF	Lignin
Grass	g Kg^{-1} DM			
U. ruziziensis	333.6^{b}	694.2^{b}	370.6^{b}	81.3^{b}
C. gayana	372.3^{a}	777.7^{a}	451.7a	85.6^{a}
SEM	0.2	1.3	0.8	0.7
Year				
2019	344.8^{c}	712.7^{c}	397.8^{c}	78.2^{c}
2020	352.4^{b}	742.3^{b}	415.0^{b}	83.5^{b}
2021	361.7^{a}	753.7^{a}	420.7^{a}	89.0^{a}
SEM	1.7	1.5	1.1	0.8
Grass X Year	0.009	<.0001	<.0001	0.7

Means with different letters within a column differ significantly. SEM= Standard error of means CP= Cride protein. NDF=Neutral detergent fibre. ADF= Acid detergent fibre

The Interaction effect of grass species and year on yield and nutrient contents is presented in Table 5. Plant height was higher significantly in *U. ruziziensis* for the year 2020 and there was no difference (p>0.05) between *U. ruziziensis* and *C. gayana* in year 2021. *Urochloa ruziziensis* produced higher DMY (p<0.05) each year compared to *C. gayana*. The DMY was 30 % in 2020 compared to the years 2021 and 2019. The lowest yield of *U. ruziziensis* was 49 % higher than the highest yield of *C. gayana*. Similarly, in the year 2020, *U. ruziziensis* had higher (p<0.05) CPY (1.5 t ha^{-1}) compared to *C. gayana*. The same result was recorded in CP content as *U. ruziziensis* had a significantly higher value in 2020 and *C. gayana* produced the lowest value in 2019. On the other hand, *C. gayana* in 2020 and 2021 had the highest (p<0.005) CF and NDF contents, while *U. ruziziensis* had the lowest figure in the year 2021.

Table 5: Interaction effect of forage grass and year on plant height, yields and nutrient contents

Factors	PH	DMY	CPY	CP	CF	NDF	ADF
	cm	t ha^{-1}		g Kg^{-1} DM			
C. gayana,2019	102.8 c	3.8 e	0.3 d	94.5 e	366.2 b	749.2 b	433.5 c
C. gayana,2020	108.8 c	4.5 d	0.4 cd	103.2 d	374.8 a	791.5 a	457.7 b
C. gayana,2021	119.5 b	6.2 c	0.6 c	106.7 d	376.0 a	793.0 a	464.0 a
U. ruziziensis,2019	97.8 c	12.0 b	1.5 b	132.5 a	323.4 e	676.3 e	362.2 e
U. ruziziensis,2020	139.3 a	17.9 a	2.2 a	126.2 b	330.1 d	693.2 d	373.2 d
U. ruziziensis,2021	122.5 b	12.6 b	1.4 b	117.0 c	347.5 c	712.5 c	377.5 d
SEM	3.8	0.4	0.1	1.3	2.51	2.2	1.5

Means with different letters within a column differ significantly ($p<0.05$). PH= Plant Height. DMY=Dry matter yield. CPY= Crude protein yield. CP= Crude protein. SEM= Standard error of means. NDF=Neutral detergent fibre. ADF= Acid detergent fibre

Correlation between variables

Forage dry matter showed a significant positive correlation with the number of tillers per plants (R^2= 0.7501), plant height (R^2= 0.751) and number of leaves per plant (R^2= 0.789) (Figure 1a,1b and 1c, respectively). There was, however, a negative correlation between crude fibre and protein content (R^2= 0.706) (Figure 2)

Discussion

morphological characteristics

Morphological characteristics provide information on the quality of traits for productivity. A higher number of leaves recorded in *U. ruzensis* may indicate more CP content and digestibility as leaves are generally known to have higher CP contents than stem. Our data showed a higher number of leaves per plant for *C. gayana* than 10 to 13 reported by Dida et al. (2021) and Yesihak (2008) in the savannah region of Ethiopia and also more than 10 to 22 per plant recorded by Isa et al. (2020) in Nigeria.

The higher number of tillers observed in the second year of this study agreed with the reports of Silva et al. (2013) and Dida et al. (2021). In 2020 and 2021, the forage grasses were no longer at the establishment stage and therefore, developed more tillers. *Urochloa ruziziensis* has the potential for higher biomass as it had more tillers compared to *C. gayana*. A higher number of tillers is an important attribute of grasses as it increases the chances of survival and the amount of available forage (Daba et al. 2019; Laidlaw 2005), an indicator of resource use efficiency by the grass species (Wassie et al. 2018) and can recover faster after defoliation either by grazing or mechanical cutting. High tiller production not only indicates stability (Mukhtay 2006), but is also linked to better persistence after periods of unfavourable environmental conditions (Assuero and Tognetti 2010). In comparing to other studies, Na-Allah et al. (2018) in Nigeria reported a range of 16 to 36, Atif et al. (2012) recorded 17 to 30 in the Shambut region of Sudan and Dida et al (2021) got 19.8 per plant in Ethiopia which were all higher than our findings for *C. gayana*. However our result was higher than the report of Daba et al. (2019) in Ethiopia, but within the range of 10 to 22 recorded by Isa et al. (2020) in Nigeria. For *U. ruziziensis*, our data for the number of tillers per plant was higher than the result of Cheruiyot et al. (2018) who reported between 6.3 to 17.3 in cultivars of *Urochloa* in Kenya, but lower than the findings of Wassie et al. (2018) who reported up to 36 for *U. brizantha* cultivars in Ethiopia. Variations in the number of tillers may be a result of the type of cultivar, age of plant and other environmental factors (FAO, 2009)

The height of a crop may not be an important estimate of the expected biomass yield (Wassie et al., 2018), but may be a trait for crop improvement. The height of *U. ruziziensis* in the study was higher than the ranges; 50 to 100, 37.7 to 74.7 and 52.9 to 66.3 cm recorded for *Urochloa* cultivars by Katunga et al. (2021), Hebron (2021), Silva et al. (2021) in DR Congo, Southern Philippines, Brazil, but less than the range (201.3 to 218.8 cm) reported by Azangue et al. (2020) in Cameroon. In *C. gayana*, our data showed a higher value than 86.3 cm reported by Dida et al. (2021), but less than 120.8 cm for ILRI-6633 cultivar reported by Daba et al. (2019) in Ethiopia. However, our finding was within the range (100.7 to 121.3 and 107 to 117.1 cm) recorded by Yesihak (2008) as well as Na-Allah et al. (2018) in Ethiopia and Nigeria. respectively. Our finding was also higher than the work of Ribotta et al. (2019) who recorded 114.3 to 132.9 cm when *C. gayana* varieties were treated with non-saline in Argentina.

Dry matter yields

Higher DMY of the two forage kinds of grass recorded in the second year agreed with the works of Nouhoun et al. (2022), Dida et al (2021) and Rodrigues et al. (2014) who reported more DMY in the subsequent year after the year of establishment. This might be due to an increase in the number of tillers (Silva et al., 2013; Dida et al., 2021). Most plant resources are channeled into root development for perennial grasses in the year of establishment which in turn would enhance subsequent herbage production in the following season (Dida et al., 2021) and higher leaves number compared to the first year. *Urochloa ruziziensis* has larger leaves, a higher number of leaves and tillers which might improve performance in terms of DMY. This might have resulted in the accumulation of more photosynthates which led to higher DMY than *C. gayana*. The data for DMY of *U. ruziziensis* was higher than 7.3 t/ha, 2.0, 13.4 t/ha reported by Nouhoun et al. (2022), Katunga et al. (2021), Shuaibu et al. (2018), Katunga in Burkina Faso, DR. Congo, southwest Nigeria, respectively, but less than the range 22.3 to 30 t/ha reported by Azangue et al. (2020) in Cameroon. Cook et al. (2005) observed that *U. ruziziensis* varies yields between 5 to 36 t DM/ha depending on soil fertility, rainfall and level of fertilization and our result fell within the range. Most studies for *C. gayana* in Nigeria have reported between 4 to 14.3 t/ha as reviewed by Na-Allah and Bello (2019), and our result was within this range. Our data was, however, lower than the range of 8.1 to 11.2 t DM/ha reported by Isa et al. (2020) in Nigeria, but was similar to the reports of Dida et al. (2021) in Ethiopia. However, our finding was a higher value than the 2.2 to 3.1 t DM/ha reported by Mejía-Salazar et al. (2021) for 24 cultivars of *C. gayana* in Colombia.

Nutrient contents

Forage crops with a higher number of tillers and leaves normally have higher CP content and CPY (Paula et al. 2012) and our result agreed as *U. ruziensis* had more tillers and number of leaves than *C. gayana*, therefore, produced more CP and CPY. This shows *U. ruziziensis* is a promising crop in this environment compared to *C.*

gayana. Crude protein yield in our study was higher than the result of Wassie et al. (2018) who reported between 0.3 to 0.6 t/hain *U. brazantha* varieties in Ethiopia. As observed in this study, the NDF and ADF contents were lower in *U. ruziziensis* than *C. gayana* due to higher CP content and probably other soluble contents (Peyraud and Astigarraga, 1998). The NDF and ADF obtained in this study were similar to the reports by Nouhoun et al. (2022), Shuaibu et al. (2018), Silva et al. (2021) in Burkina Faso, South West, Nigeria, Brazil for *U. ruziziensis*. Silva et al. (2018) obtained a higher CP content of 150.9 g/kgDM in Brazil compared to our data for *U. ruziziensis*. On the other hand, our data for CP was higher than the reports of Silva et al. (2021) from Brazil, but similar to the findings of Nouhoun et al. (2022), Shuaibu et al. (2018). Our data reviewed a higher CP, but lower ash (15 %), similar NDF contents for *C. gayana* compared to the report of Daba et al. (2019) in Ethiopia. In colombia, Mejía-Salazar et al. (2021) reported similar CP content, but lesser NDF (63.5 to 64.7 %), ADF (34.6 to 35.5 %) and Lignin (7.0 to 8.0 %) contents in cultivars of *C.gayana* compared our findings. These differences may be due to cultural practices especially the level of nitrogen fertilizer applied as higher nitrogenous fertilizer is known to increase CP content in tropical grasses (Detmann et al. 2014). The difference in fibre contents between the grasses and other studies might be due to species, maturity, growing and environmental conditions (Temel et al. 2015; Mahyuddin 2007). It has also been reported that CP contents of species differ and these differences may essentially be resulting from genotype effect and environmental conditions (Temel et al. 2015).

Correlation of the variables

The positive correlation between DMY and the morphological variables in our study corroborated the findings of Wang et al. (2021) and Angelini et al. (2009) who showed a similar positive correlation for the grass *Miscanthus ×giganteus* in China and Italy, respectively. Filipe et al. (2016) also reported a negative correlation between CP and fibre contents in *U. decumbens* varieties in Brazil. As plant matures or increases in height, the concentration of CP decrease, since CP concentration is less in the stem than leaves. The increase in plant height also reduces the CP concentration because of the reduction in leaf-to-stem ratio as the plant grows (Crowder and Chheda, 1982; Kilcer *et al.,* 2005). As a result of protein decrease as plant height increases and there is a reciprocal relationship between protein and fibre contents (McDonald et al.1998; Tucak et al. 2013) which lowers quality and digestibility (Ball et al. 2001).

Meeting nutrient requirements for ruminant production

The CP contents of the two grass species examined in this study were above 8 % which is the level required for adequate body maintenance and rumen microbial synthesis (Osuga et al. 2011) and can also meet 9.6, 11.2, 11.7 % for pregnant ewes, does, kid finishing, respectively as prescribed by NRC (2007). Cows generally require crude protein in the range of 7 to 14% of daily dry matter intake. The requirement is less for dry cows, pregnant and lactating cows especially dairy cattle require more (Kubkomawa et al. 2015). For higher production such as lactating, pregnant, growing steers and replacement heifer, feed supplements with higher CP contents (12 to 14 %) should be provided for animal consuming the two grasses considered in this area. Most ash content in forages ranged from 3 to 13 % which indicates the percentage of inorganic concentration (Linn and Martins, 1999) and the two grass forages considered in this study fell within this range. The contents of NDF and ADF in forage are also considered the major factors affecting feed intake and feed conversion efficiency of ruminants, influencing animal performance (Barletta et al. 2012; Ephrem et al. 2015).

Moreover, higher lignin content in C. gayana also suggests lower digestibility in the rumen due to the unique structure of lignin, it might have been difficult to be decomposed by rumen microorganisms (Camp et al. 1998). The lowwer NDF abd ADF contents in *B. ruzizneis* implies that the crop might have a higher intake and rumen degradability than *C. gayana*. In this study, the morphological differences between the two forage grasses were considered and our findings indicated that *U. ruziziensis* is a valuable forage grass for animal production compared to *C. gayana* in Jos, Nigeria. Overall, *U. ruziziensis* shows a promising forage resource for higher biomass yield and quality on the Jos Plateau, Northern guinea savanna of Nigeria which framers may have more value for their livestock compared to *C. gayana*. The higher CPY in *U. ruziziensis* indicates that the crop can supply CP to more animals than *C. gayana* in this environment.

Declarations

Funding

The author declare that no funds, grants, or other support were received during the preparation of this manuscript

Data Availability

Available from the corresponding author on reasonable request.

Conflicts of Interest

Not applicable

Acknowledgement

The Author is greatful to Prof. Joshua Taiwo Amodu of Feed and Nutrition Research Programme of the National Animal Production Research Institute, Ahmadu Bello University, Zaria, Nigeria for the forage seeds suplied and also appreciates Ms. Rebacca Bassange and Ms. Fatima Abubarkar for the assistance during field work.

References

1. AFIA, 2011. Laboratory Methods manual. Australian Fodder Industry Association, New Generation Print and Copy. P. 36–58 https://www.yumpu.com/en/document/view/13042923/afia-laboratory Accessed 12 August 2018
2. Angelini, L. G., Ceccarini, L., Nassi O. Di N., and Bonari, E., 2009. Comparison of Arundo donax L. and Miscanthus × giganteus in a long-term field experiment in Central Italy: Analysis of productive characteristics and energy balance. Biomass and Bioenergy, 33(4), 635–643. https://doi.org/10.1016/j.biombioe.2008.10.00
3. Atif, E.I., Alaaaldin, I.H.K., and Yassin, M.I., 2012. Evaluation of intercropping of Rhodes grass with Alfalfa under irrigation at Sambat, Sudan. Advances in Environmental Biology, 6(1), 100–102

4. A.O.A.C., 1990.Official Method of Analysis.15th edition. *Association of Official Analytical Chemists*. Washington DC, U.S.A. 200–210.
5. Aregheore, E.M., 2009. Nigerian pasture/forage resource profiles. FAO. Pp.19. https://docplayer.net/65169942- Country-pasture-forage-resource-profiles-nigeria-by-eroarome-martin-aregheore.html
6. Assuero, S.G. and Tognetti, J.A., 2010. Tillering regulation by endogenous and environmental factors and its agricultural management. The Americas Journal of Plant Science and Biotechnology, 4, 35–48
7. Azangue, G.J., Tendonkeng, F., Nguetsop, F.V., Wauffo, D.F. and Pamo, E.T., 2020. Growth and Biomass Yield of Brachiaria ruziziensis (Poaceae) under the Direct and Residual Effects of Fertilization with Hen Droppings at Flowering in West Cameroon. Journal of Agriculture and Ecology Research International, 21(1), 44–52, DOI: 10.9734/JAERI/2020/v21i130126
8. Babayemi, O.J, Abu, O.A. and Opakunbi, A., 2014. Integrated animal husbandry for schools and colleges. First edition, published in Nigeria by positive press Ibadan. pp. 1-299.
9. Ball, D.M., Collins,M., Lacefield, G.D., Martin, N.P., Mertens, D.A., Olson, K.E., Putnam, D.H., Undersander, D.J. and Wolf, M.W., 2001. Understanding Forage Quality.American Farm Bureau Federation Publication 1–01, Park Ridge, Illinois, USA
10. Barletta, R.V., Rennó, F.P. and Gandra, J.R., 2012. Blood parameters and performance of dairy cows fed with whole raw soybean. Archive. Zootechnical. 61, 483–492.
11. Camp, H.J.M.O., Verhagen, F. J.M., Kivaisi, A.K. and Windt, F.E.D., 1998. Effects of lignin on the anaerobic degradation of (ligno) cellulosic wastes by rumen microorganisms. Appied Microbiology Biotechnology. 29, 408–412. https://doi.org/10.1007/BF00265827
12. Cheruiyot, D., Midega, C.A.O., Berg, J.V., Pickett, J.A. and Khan, Z.R., 2018. Genotypic responses of brachiaria grass (Brachiaria spp.) accessions to drought stress. Journal of Agronomy, 17, 136–146. DOI:10.3923/ja.2018.136.146
13. Cook, B.G., Pengelly, B.C., Brown, S.D., Donnelly, J.L., Eagles, D.A., Franco, M.A., Hanson, J., Mullen, B.F., Partridge, I.J., Peters, M. and Schultze-Kraft. R., 2005. Tropical Forages: an interactive selection tool. CSIRO, DPI & F (Qld), CIAT and ILRI, Brisbane, Australia.
14. Crowder, L.V. and Chheda, H.R., 1982. Tropical grassland husbandry. Longman, UK. Pp.76–77.
15. Daba, A.W., Qureshi, A.S. and Nisaren, B.N., 2019. Evaluation of Some Rhodes Grass (*Chloris gayana*) Genotypes for Their Salt Tolerance, Biomass Yield and Nutrient Composition. Applied Science, 9 (1),143. https://doi.org/10.3390/app9010143
16. Detmann, E., Valente, É. E., Batista, E. D. and Huhtanen, P., 2014. An evaluation of the performance and efficiency of nitrogen utilization in cattle fed tropical grass pastures with supplementation. Livestock Science, 162, 141–153, **DOI**: 10.1016/j.livsci.2014.01.029
17. Dida, M.F., Lemore, A.B and Seid, K.A., 2021. Effect of Nitrogen Level on Herbage and Seed Yield of Rhodes Grass (*Chloris gayana*) Hindawi International Journal of Agronomy, 2021, 5540596, https://doi.org/10.1155/2021/5540596
18. Ephrem, N., Tegegne, F., Mekuriaw, Y. and Yeheyis, L., 2015. Nutrient intake, digestibility and growth performance of Washera lambs supplemented with graded levels of sweet blue lupin (Lupinus

angustifolius L.) seed. Small Ruminant Research. 130, 101–107. https://doi.org/10.1016/j.smallrumres.2015.07.019

19. Filipe. I. M., Sanzio Carvalho, C.L.B., Cacilda B.D.V.,, Rogério G.M.,, Lucas, B.M. and Gustavo, V.M., 2016.
20. Estimate of genetic parameters in Brachiaria decumbens hybrids, Crop Breeding and Applied Biotechnology, 16, 115–122. http://dx.doi.org/10.1590/1984- 70332016v16n2a18
21. FOA, 2019. The future of livestock in Nigeria: Opportunity and Challenges in the face of uncertainty. Food and Agricultural Organaisation, Rome. Pp. 9
22. FAO, 2009. Rhodes grass (*Chloris gayana* Kunth). Food and Agricultural Organization of the United Nations (FAO). Accessed at; http://www.fao.org//ag/AGP/doc/Gbase/ Default.htm. Accessed 8 June 2022
23. Ghimire, S.R., Njarui, D., Mutimura, M., Cardoso, J.A., Johnson, L., Gichangi, E., Teasdale, S., Odokonyero, K., Caradus, J.R., Rao, I.M. and Djikeng, A., 2015. Climate-smart Brachiaria for improving livestock production in East Africa: Emerging opportunities. In: D. Vijay, M.K. Srivastava, C.K. Gupta, D.R.,Malaviya, M.M. Roy, S.K. Mahanta, J.B. Singh, A. Maity and P.K. Ghosh (eds). Proceedings of the XXIII International Grassland Congress, New Delhi, India, 20–24 November 2015. p. 361–370. hdl.handle.net/10568/69364
24. Google Earth Pro, 2022. Google earth pro imagery. https://earth.google.com/web/@10.4276805,1.26890278,-448.28087517a,5073929.77245212d,35y,0h,0t,0r. Accessed 15 June 2022
25. Hebro, I.U., 2021. Agronomic characteristics and herbage yield of mulato II (Brachiaria brizantha, B. Ruziziensis x B. Decumbens) with and without arachis pintoi at different cutting intervals. Journal of Agricultural Systems and Technology, 1, 41–56. Https://nemsu-njast.com/
26. Imaz, J,A., Giménez, D.O., Grimoldi, A.A., Striker, G.G., 2015. Ability to recover overrides the negative effects of flooding on growth of tropical grasses Chloris gayana and Panicum coloratum. Crop and Pasture Science 66, 100–106. doi: 10.1071/CP1417
27. Isa, M.M., Ibrahim, J. and Bah, S.U. 2020. Effect of Nitrogen Fertilizer and Inter Row Spacing on Herbage Yield and Some Yield Components (Number of Leaves and Number of Tillers per Plant) of Rhodes Grass (*Chloris gayana Tan*) in the Dry Sub Humid Zone of Sokoto Nigeria. Asian Journal of Advanced Research and Reports, 8(1), 10–21. http://www.sdiarticle4.com/review-history/53558
28. Jimoh, S.O., Taofeek, O.M, Belloe, S.K. and NourEldeenc, N., 2020. Emerging issues in grassland ecology research: Perspectives for advancing grassland studies in Nigeria. Acta Oecologica, 6, 103548. https://doi.org/10.1016/j.actao.2020.103548
29. LDN, 2018. Land Degradation Neutrality, Nigeria: Final report of the land degradation neutrality target setting programme. Abuja. Lemaire, G., 2007.
30. Kallah. M.S., 2004. Rangelands in Nigeria: A Partial Resource Appraisal towards Improving Livestock Production. In: Forage Production and Management in Nigeria. J. O. Gefu and J. T. Amodu (eds) National Animal Production Research Institute. Ahmadu Bello University, Zaria, Nigeria. pp.1–10
31. Karki, U., 2013. Forage definition and classification. In: U. Karki (ed). Sustainable Year-Round Forage Production and Grazing/BrowsingManagement for Goats in the Southern Region.Handbook for Training Field Extension and Technical Assistance Personnal.Tuskegee University Extension Programme.

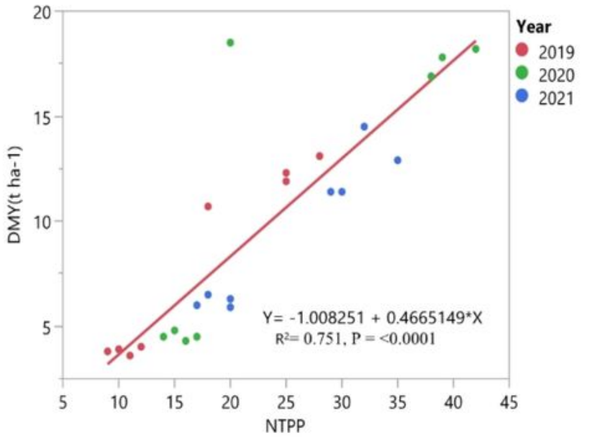
Alabama, U.S.A PP. 3–12. https://www.tuskegee.edu/Content/Uploads/Tuskegee/files/CAENS/TUCEP/Livestock%20program/Year-RoundPasture_Handbook(1).pdf. Accessed 06 February 2022

32. Katunga, M.M.D., Tshikoly, M., Bofunga, L.M., Ngona, D., Balemirwe, K.F., Mushagalusa, B., Nshokano, M.P. and Mugisho, N.P., 2021, Evaluation of Improved and Selected Brachiaria Grass Cultivars in DRC. Open Access Library Journal, 8, e8042. https://doi.org/10.4236/oalib.1108042
33. Kilcer, T. F., Ketterings, Q. M., Cherney, J. H., Cerosaletti, P., and Barney, P., 2005. Optimum stand height for forage brown midrib sorghum x sudangrass in North- eastern USA. Journal of Agronomy and Crop Science, 191, 35–40. **https://doi.org/10.1111/j.1439-037X.2004.00137.x**
34. Kubkomawa, H.I. and Lawal. A.U.. 2021. Management Practices of Pasture, Range and Grazing Reserves for Livestock Production in the Tropics: A Review. American Journal of Entomology, 5(2), 18–26 http://doi:10.11648/j.aje.20210502.11
35. Kubkomawa, H. I., Olawuye, H. U., Krumah, L. J.. Etuk, E. B., and Okoli, I. C., 2015. Nutrient requirements and feed resource availability for pastoral cattle in the tropical Africa: A review. Journal of Agricultural and Crop Research, 3(7), 100–116
36. Laidlaw, A., 2005. The relationship between tiller appearance in spring and contribution of dry-matter yield in perennial ryegrass (Loliumperenne L.) cultivars differing in heading date. Grass Forage Science, 60, 200– 2009 https://doi.org/10.1111/j.1365-2494.2005.00468.x
37. Linn, J.G. and Martin, N.P., 1989. Forage quality tests and interpretations. University of Minnesota Extension Serviceag-F0-2637. https://conservancy.umn.edu/bitstream/handle/11299/207442/MN2500_AGFO_2637_revised1989.pdf?seq uence = 1&isAllowed = y Accessed 21 June, 2022
38. Mahyuddin, P., 2007. Chemical composition of leaf and stem of tropical grasses at diferent stage of growth. Animal production ProduksiTernak., 93:153–159
39. McDonald, P., Edwards, R.A., Greenhalgh, JFD. and Morgan, C.A. (1998). Animal nutrition. Longman Publishers, Pp.431–438.
40. Mejía-Salazar, J.R., Nieto-Sierra, D.F., Mejía-Kerguelen, S.L., Arango, M., Burbano-Erazo, E. And Higuita-Corrales, I.D.J., 2021, Agronomic and nutritional evaluation of genotypes of Chloris gayana for the Colombian livestock. Agronomía Mesoamericana, 32(2), 382–398. http://doi:10.15517/am.v32i2.44042
41. Muktay, M., 2006. Dry matter productivity of the dwarf and normal elephant grasses as affected by the planting density and cutting frequency. Indonesian Journal of Animal and Veterinary Sciences, 11, 198–205
42. Na-Allah, Y., Bello, B. and Adeshin, M.H., 2018. Evaluation of growth and herbage yield of Rhodes grass (Chloris gayana Kunth) as affected by nitrogen fertilizer and inter-row spacing in Sokoto, Nigeria. Direct Research Journal of Agriculture and Food Science, 6, 404–413 https://doi.org/10.5281/zenodo.3535007
43. Nouhoun, Z., Traoré T. C., Sawadogo E. T. B. P., Ayantunde A., Prasad K. V. S. V., Blummel M., Balehegn M., Rios E., Dubeux J. C., Boote K., & Adesogan A. T., 2022. Herbage accumulation and nutritive value of cultivar Mulato II, Congo grass, and Guinea grass cultivar C1 in a subhumid zone of West Africa. Agronomy Journal, 114, 138–147. https://doi.org/10.1002/agj2.2086

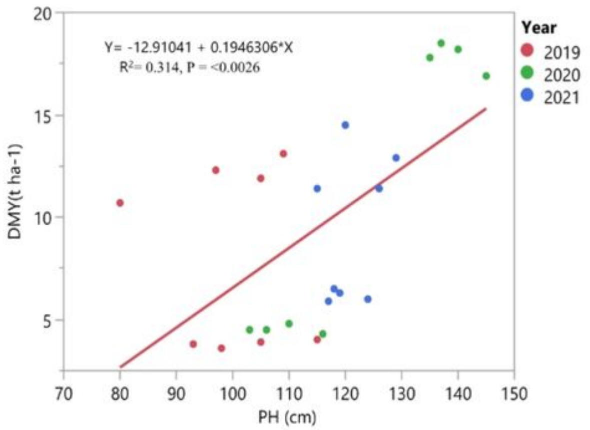
44. NRC, 2007. Nutrient Requirements for various classes of sheep and goat, National Research Council. National Academy Press, Washington, DC
45. Osuga, I. M., Abdulrazak, S. A., Muleke, C. I. And Fujihara, T., 2011. Effect of supplementing Rhodes grass hay (*Chloris gayana*) with *Berchemia discolor* or *Zizyphusmucronata* on the performance of growing goats in Kenya. Journal of Animal Physiology and Animal Nutrition, 96 (4): 634–639. https://doi.org/10.1111/j.1439-0396.2011.01189.x
46. Paula, C.C.L.D., Euclides, V.P.B., Lempp, B., Barbosa, R.A., Montagner, D.B. and Carloto, M.N., (2012). Forage accumulation, morphogenic and structural characteristics of Marandu grass under grazing heights. Animal Production Science. Rural, 42 (11): 2059–2065 https://doi.org/10.1590/S0103-84782012005000084
47. Peyraud, J. and Astigarraga, L., 1998. Review of the effect of nitrogen fertilization on the chemical composition, intake, digestion and nutritive value of fresh herbage: Consequences on animal nutrition and N balance. Animal Feed Science and Technology, 72, 235–259 DOI: 10.1016/S0377-8401(97)00191-0
48. Ponsens, J., Hanson, J., Schellberg, J., Moeseler, B.M., 2010. Characterization of phenotypic diversity, yield and response to drought stress in a collection of Rhodes grass (*Chloris gayana* Kunth) accessions. Field Crops Research, 118, 57–72. **DOI**: https://doi.org/10.1016/j.fcr.2010.04.008
49. Ribotta, N.A., Colomba, E.P., Bollati, G.P., Striker, G.G., Carloni, E.J., Griffa, S.M., Quiroga, M.P., Tommasino, A.E. and Grunberg, K.A., 2019. Agronomic and molecular characterization of *Chloris gayana* cultivars and salinity response during germination and early vegetative growth. Tropical Grasslands-Forrajes Tropicales, 7(1), 14–24. DOI: 10.17138/TGFT(7)14-24
50. Rodrigues, R.C., Sousa, T.V.R., Melo, M.A.A., Araújo, J.S., Lana, R.P., Costa, C.S., Oliveira, M.E., Parente, M.O.M and Sampaio, I.B.M., 2014. Agronomic, morphogenic and structural characteristics of tropical forage grasses in northeast Brazil. Tropical Grasslands – Forrajes Tropicales, 2, 214–222. DOI:10.17138/TGFT(2)214-222
51. Robinson, T. and Pozzi, F., 2011. Mapping supply and demand for animal-source foods to 2030. FAO Animal Production and Health Working Paper No. 2. FAO (Food and Agriculture Organization of the United Nations), Rome, Italy.
52. S.A.S., 2002. Statistical Analysis System, Users Guide. 7th Edition. North Carolina, U.S.A
53. Schiek, B., González, C., Mwendia, S. and Prager, S.D., 2018. Got forages? Understanding potential returns on investment in Brachiaria spp. for dairy producers in Eastern Africa. Tropical Grasslands-Forrajes Tropicales, 6(3), 117–133. DOI: 10.17138/TGFT(6)117-133
54. Shiawoya, E.L., and Tsado, D.N., 2011. Forage and fodder crop production in Nigeria: Problems and prospects. World Journal of Life Sciences. Medical Research, 1(4), 88
55. Shuaibu, A.Y., Fasae, O.A., Adeleye, O.O., Wheto, M. and Oluwatosin, B.O., 2018. Biomass Yield and Hay Quality of Irrigated Brachiaria ruziziensis Fertilized with Goat Manure as Dry Season Forage. Thailand Journal of Agricultural Science, 51(3), 152–161
56. Silva, D. R. G., Costa, K. A. P., Faquin, V., Oliveira, I. P. and Bernardes, T. F., 2018. Rates and sources of nitrogen in the recovery of the structural and productive characteristics of marandu grass. Zootecnia • Rev. Ciênc. Agron, 44, 184–191 https://doi.org/10.1590/S1806-66902013000100023

57. Silva, M.R.D., Abreu, J.G., Weber, O.L.D.S., Barros, L.V.D., Bonfim-Silva, E.M., Damasceno,A.P.A.B. and Oliveira, W.C.M.D., 2021. Cultivation of ruziziensis grass (*Urochloa ruziziensis*) using swine liquid manure fertilization. Australian Journal of Crop Science, 15(03), 377–386. http://doi:10.21475/ajcs.21.15.03.p2751
58. Simbaya, J., 2002. Potential of fodder/shrub legumes as a feed resource for dry season supplementation of Smallholder ruminant animals. FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, International Atomic Energy Agency, Vienna, Austria), ISSN 1011–4289. https://inis.iaea.org/search/search.aspx?orig_q=RN:33032973. Accessed 21 June 2022
59. Temel, S., Keskin, B., Simsek, U. and Yilmaz, I.H.. 2015. Performance Of Some Forage Grass Species In Halomorphic Soil. Turkey Journal of Field Crops, 20(2), 131–141. DOI: 10.17557/tjfc.82860
60. Tolera, A. and A. Abebe., 2007. Livestock production in pastoral and agro – pastoral production systems of Southern Ethiopia. Livest. Res. Rural Dev. 19(2). http://www.lrrd.org/lrrd19/tole19177.html. Accessed 12 December 2021
61. Tucak, M., Popović, S., Čupić, T., Španić, V., and Meglič, V., 2013. Variation in yield, forage quality and morphological traits of red clover (*Trifolium pratense* L.) breeding populations and cultivars. Zemdirbyste- Agriculture, 100 (1): 63–70. DOI 10.13080/z-a.2013.100.009
62. Tukey, J.W., 1949. (Comparing individual means in the analysis of variance. Biometrics, 5(2), 99–114. https://doi.org/10.2307/3001913
63. Van Soest, P. J., Robert, J. B. and Lewis, B. A., 1991. Method for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. Journal of Dairy Science, 74, 3583–3597. DOI: 10.3168/jds.S0022-0302(91)78551-2
64. Wang, Y., Wang, H., Li, R., Fan, X., Peng, Z., Wu, J. And Duan, L., 2022. Biomass yield and quality of the Miscanthus × giganteus in northern China. Agronomy Journal, 114, 1091–1099. https://doi.org/10.1002/agj2.2099
65. Wassie, W.A., Tsegay, B.A., Wolde, A.T. and Limeneh, B.A., 2018. Evaluation of morphological characteristics, yield and nutritive value of Brachiaria grass ecotypes in northwestern Ethiopia. Agriculture ans Food Security, 7(89), 7–19 https://doi.org/10.1186/s40066-018-0239-4
66. Yesihak, K., 2008. Effect of seed proportion of Rhodes grass (Chloris gayana Kunth) andWhite seed clover (Melilotus alba) at sowing on agronomic characteristics and nutritional quality. Livestock Research for Rural Development. 20 (28). http://www.lrrd.org/lrrd20/2/yise 20028.htm Accessed 23 March 2022
67. Yohanna, B.I., H.D. Nyako, M.I. Hyeladi, A.H. Yohanna and I.D. Mohammed. 2015. Formulation and nutrient com position of dry season rations for ruminants using crop residues and their rumen degradation characteristics in semi – arid region of Nigeria. Annals of Biology Research, 6(7), 1–6

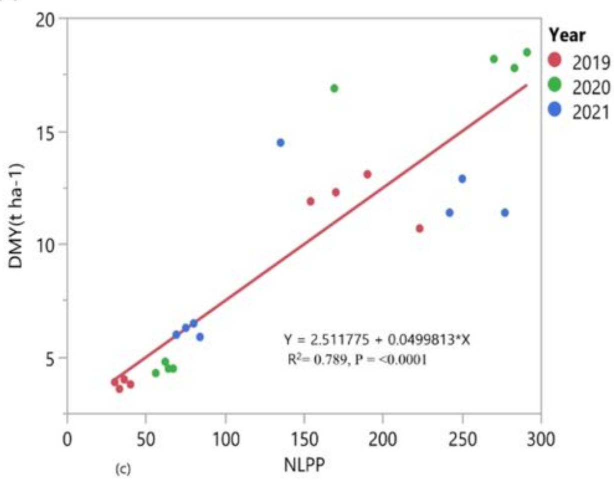
Figures



(a)



(b)



(c)

Figure 1

Correlation between dry matter yield and (a) Number of tillers number per plant (NTPP), (b) plant height and (c) number of leaves per plant (NLPP)

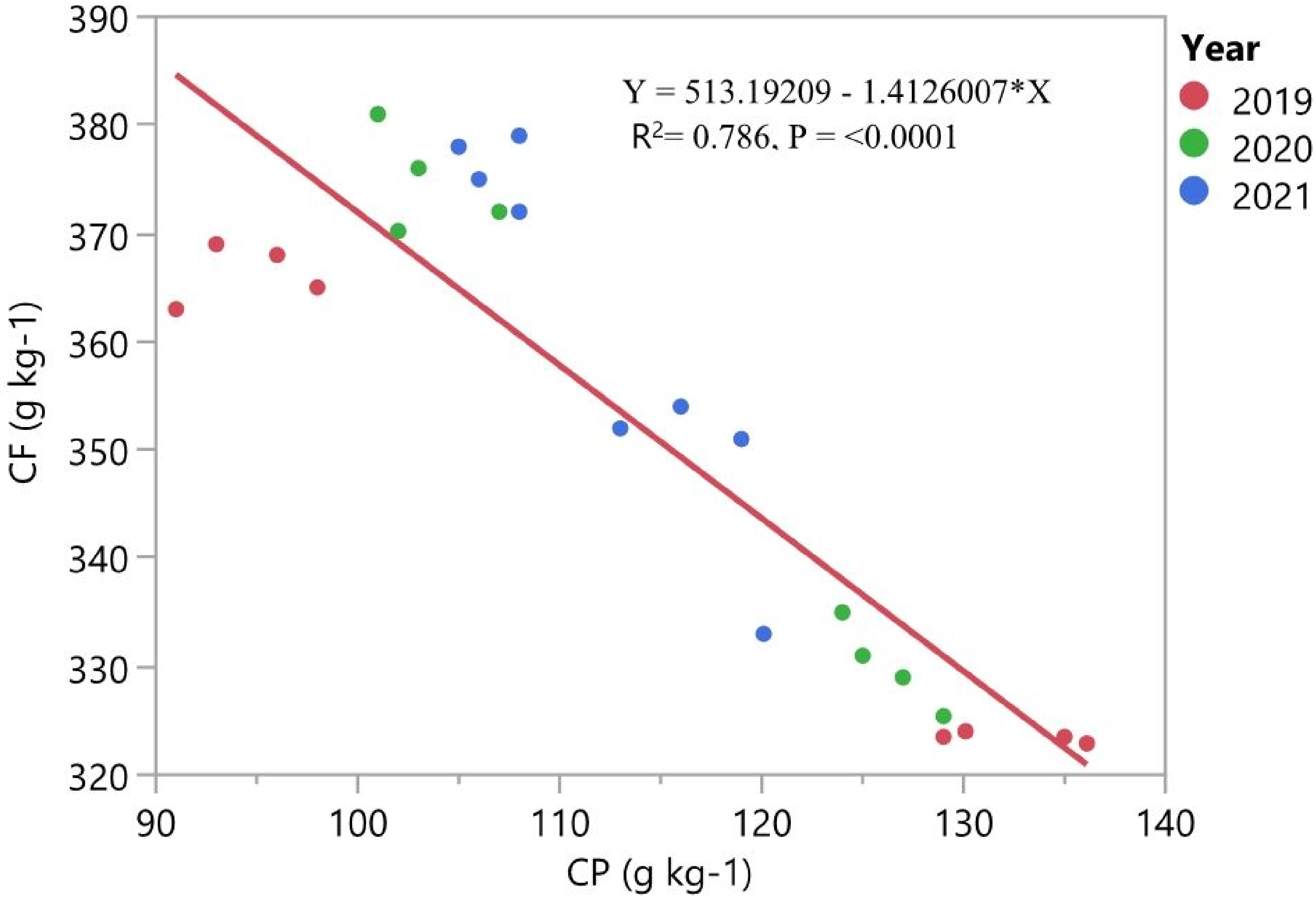


Figure 2

Correlation between crude fibre and crude protein content