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Forage yield and quality traits of Brachiaria spp. grass species at central Gondar Zone, Ethiopia)

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Abstract:
The experiment was conducted to evaluate the performance of various Brachiaria grass species. The study compared 10 Brachiaria grass species over 2019 and 2020 years. The experiment was laid down in a Randomized Complete Block Design (RCBD) with four replications. To assess their potential, plant height, tiller number, leaves number per plant, leaf length, forage fresh yield, forage Dry Matter (DM) yield, Leaf to Stem Ratio (LSR), Organic Matter (OM) ash, Crude Protein (CP), Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and Acid Detergent Lignin (ADL) and CP yield were collected. Data were analysed of variance, and when the difference was significant, the treatment means were compared by the LSD at 5%. Result showed significant differences between Brachiaria species/accessions for forage yield, all quality and morphological traits except tiller number. The finding revealed that as. B. mutica had significantly ($P < 0.05$) higher mean values for plant height, leaves number per plant and leaves length, fresh and dry biomass yield than other species. Species B. brizantha wild. Acc no 13726 had significantly higher man value for LSR (8.70) ($P < 0.05$). The observed fluctuation in biomass yield in different cuts indicated the need for fertilizer application at minimal at a point where lower biomass yield was recorded. The higher forage production with average values of 11.31 and 11.77 t h^{-1}) was obtained in species Brachiaria mutica at cut 1 and 3, respectively that was significantly higher than other cuts ($P < 0.05$). Relatively higher mean values of OM% (ranged 82.22 to 84.39%) were achieved with species B. brizantha wild. Acc no 13726 and Acc no 13755 and Brachiaria mutica. The highest ash contents (ranged from 11.96 to 13.60%) were also obtained in Brachiaria hybrid Mulato I, II, B. brizantha Marandu Acc no. 16550, Brachiaria hybrid Mulato and Brachiaria decumbens. Remarkable CP% (10.85%) was attained at B. mutica. For all Brachiaria grass species, fiber fractions were below the threshold. B. mutica was found efficient in CP yield (3.65 t h^{-1}). Total CP yield with less fiber content per hectare taking as an ultimate objective of forage production species B. mutica was found the most suitable for presenting feed of better quality.

Keywords: Brachiaria grass; Brachiaria mutica; Dry matter yield; Quality

1. Introduction

Ethiopia has the largest cattle population in Africa with an estimated population of 42.92 million sheep, 52.46 million goats and 70.29 million heads of cattle [1]. Despite the large livestock population in Ethiopia [2], its contribution to the national economy is below potential, owing to range of factors including unavailability of sufficient and quality animal feed, poor genetic potential of animals for productive traits, poor health care and poor management practices [3]. Of these factors, feed shortage both in terms of quantity and quality is a very crucial constraint for livestock production in the country and in the study area in particular [4]. Feed scarcity in both quantitative and qualitative dimensions remains one of the major impediments for the promotion of the livestock sub-sector in Ethiopia [5]. Animals are kept on poor quality natural pasture that commonly occur on permanent grasslands, roadsides, pathways and spaces between cropped plots. Much of these feed resources are utilized to support maintenance requirement of the animals with little surplus left for production and there are marked seasonality in quantity and quality of the available feed resources due to various environmental determinants (drought, frost, human interference such as deforestation etc.) [4].
The major feed resources in the country are natural pasture (55.33%) and crop residues (31.29%) with agro indus-

trial by products and manufactured feed contributing much less [2,6]. Tropical pastures, in addition to their scarce availability, are low in quality, which among other factors can be due to deficiency in soil nitrogen content [5]. Serious dry season feed shortage is a common phenomenon in marginal and semi-arid area of Ethiopia. The recurrent drought also affects seasonal mobility of pastoral households due to livestock losses and leaves many with few heads of livestock. Thus far, the contribution of improved forage in Ethiopia is very less significant; lower than one percent [2]. Because of sever feed shortage problem of the area, farmers are mainly depended on crop residue to feed their livestock which is poor in protein and vitamin content and digestibility. Nevertheless, to enhance livestock production in the country, integration of productive and highly nutritious improved forages in the farming system is mandatory [7].

Therefore, an alternative solution to overcome feed shortage and improve livestock productivity would be to introduce improved forage technologies into the farming systems. Feed shortage can be alleviated by introduction of high yielding new multi cut forages which can supply green herbage in adequate quantities during periods of scarcity. Perennial grasses, palatable and nutritive, mostly serve as a significant source of fodder in arid environments [5].

In this regard, Brachiaria grass is the most promising option for farmers in east-Africa in improving both feed availability during dry season and nutritive quality leading to increased animal performance. The genus Brachiaria roughly consists of 100 species which grow in the tropics and subtropics. Most of these species are native to Africa where they constitute important components of the natural savanna landscape [8]. The distribution of Brachiaria grass species B. brizantha is becoming high in Africa including Ethiopia Wubetie et al. and need more research to exploit maximum in the region [9]. Recent trials indicate that adoption of B. brizantha has the potential to increase milk production of $3-5$ L cow^{-1} day^{-1} on participating farms in Kenya [10]. A farm trial in Rwanda reported a 30% increase in milk production and a 20% increase in meat production [11]. Despite the diversity of Brachiaria spp. in Eastern and Central Africa, comparatively little information is available on their agro-morphological characteristics, yield and chemical composition.

Though the genus Brachiaria grasses are the best option for farmers in mid altitude areas, the productivity of the Brachiaria grass species could be distinctly different and is also highly influenced by biotic and abiotic factors [9]. It is therefore possible that different species will perform differently in different ecological zones, but information is lacking in the study area. Hence, the study was aimed to evaluate the performance of Brachiaria grass species and to select the best herbage yielding and quality among the species tested in mid altitude areas of Central Gondar Zone.

2. Materials and methods

2.1 Description of the study areas

The study was conducted in West Dembia district, central Gondar administrative zone, Amhara National Regional State, Ethiopia. The experimental site is situated at latitude of 12º 25′ 14.9″ north and longitude of 037º 36′ 18.5″ east and 720 km north to Addis Ababa and 212 km far from the regional city Bahir Dar to north. The soil texture of the study area is sandy loam with good water-holding capacity and the $0-40$ cm horizon has on average pH of 7.5, organic matter (3.96%), available P (6.4 ppm) and K/kg 2.16 cmol (+) [12]. The area has a moist tropical climate and the mean monthly maximum temperature is 26.2º C while the mean monthly minimum temperature is 12.6º C [13]. Based on 10 year's $(2008-2017)$ data, annual rainfall ranges between 665 and 1,524 mm (mean 1,095 mm).

2.2 Experimental design

Land preparation, planting, weeding and harvesting for Brachiaria grass were made according to the recommendations by [14]. The experimental sites were harrowed to crash clods and leveled out to maintain a well prepared seed bed. The prepared experimental land was divided into four blocks each of which comprised 10 plots to assign cultivars. Seeds of Brachiaria grass were sown using vegetative root splits in rows on a well-prepared seed bed under rain fed conditions in 2019 growing season. Planting was done at a spacing of 40 cm between rows and 20 cm between plants. Urea fertilizer as N source at a rate of 100 kg h^{-1} was applied at planting. Weeding and related management practices were applied according to the grass's requirements. Harvesting was done during early heading at each cut.

Ten Brachiaria grass species (B. brizantha cultivars Marandu Acc no. 16550, B. brizantha cv lalibertad Acc no. 16551, B. brizantha wild. Acc no 13726, B. brizantha wild. Acc no 13755, B. brizantha wild Acc no 13777, B. brizantha wild1Acc no 3809, Brachiaria decumbens, Brachiaria mutica, Brachiaria hybrid Mulato I (B.brizantha x B.ruziziensis) and Brachiaria hybrid Mulato II (B.brizantha x B.ruziziensis x B. decumbens) were used for the experiment (Table 1). The experimental plot was laid down in a randomized complete block design with four replications. Plot size was 2.5×2.5 m. Spacing for both between replications and between plots was 1 m.

2.3 Sampling method and data collection

In this experiment, after planting in the field their performance was evaluated with respect to plant height at forage harvest, tillers number per plant, Forage fresh yield and DM yield (t h^{-1}) and leaf to stem ratio (LSR). The morphological parameters were measured and counted from 10 plants that were randomly selected from the middle rows of each plot at maturity. Brachiaria grass forage harvested for herbage and DM yield were following each cut. Harvesting was done by hand using a sickle, at a stubble height of 10 cm above ground to give chance for faster recovery following each cutting according to the recommendations [14]. At each cut, sampling was done from the middle eight rows excluding the guard rows. To determine the biomass yield, fresh herbage yield of Brachiaria grass was measured immediately after harvest using a portable balance with sensitivity of 0.01 g. A minimum of 500 g individual fresh samples were dried in forced air draft oven at 65° C for 72 hours for partial dry matter (DM) determination. LSR was de-

Table 1. Mean of fresh biomass yield and yield components of Brachiaria grass species tested in 2019 and 2020 growing seasons at W/Dembia district.
Means of column with the same letter are not significantly different using LSD 5%
LSR=leaf to stem weight ratio.

Cultivars	Plant height(cm)	Tiller number	Leaf number	Leaf length (cm)	Fresh yield t h^{-1}	LSR
B. brizantha cv.s Marandu Acc16550	40.05^{ef}	93.66	204.00^{bc}	11.45^{e}	49.05^{bcd}	1.49^{c}
B. brizantha cv la libertad Acc 16551	54.37^{cd}	123.59	180.65^{c}	17.78^{abc}	52.24^{bc}	3.31^{bc}
B. brizantha wild. Acc no 13726	49.02^{fg}	82.44	89.50^{d}	15.44^{bcd}	36.65^{d}	8.70^{a}
B. brizantha wild. Acc no 13755	62.70^{c}	89.46	74.05^{d}	19.40^{ab}	44.92^{bcd}	1.62^{c}
Brachiaria brizantha wild 13777	73.56^{b}	114.12	115.80^{d}	18.60^{abc}	52.25^{bc}	3.59^{bc}
Brachiaria brizantha wild 13809	77.65^{ab}	108.20	96.85^{d}	20.87^{a}	53.72^{bc}	3.38^{bc}
Brachiaria decumbens	28.49^{g}	109.71	100.45^{d}	13.35^{cde}	40.70^{cd}	5.61^{b}
Brachiaria mutica	83.63^{a}	105.07	223.35^{abc}	19.98^{ab}	88.72^{a}	4.90^{b}
Brachiaria hybrid cv. Mulato I	36.85^{de}	101.65	261.20^{a}	12.30^{de}	59.31^{b}	3.53^{bc}
Brachiaria hybrid cv. Mulato II	34.63^{fg}	90.28	242.66^{abc}	11.00^{e}	41.85^{cd}	3.24^{bc}
Mean	53.47	101.82	158.85	15.93	51.94	3.94
Coefficient of variation (CV%)	11.56	18.61	22.50	18.33	16.86	19.26
LSD (0.05)	9.03	ns	52.11	5.54	15.40	4.59

termined by taking samples from five randomly selected plants at each cutting, dried in a paper bag and the leaves then were carefully stripped from the stems. The ratio was obtained by dividing the leaf weight to stems weight.

2.4 Forage quality analysis

Chemical analyses of feeds were carried out by taking representative samples from different harvests. The partially dried samples of feeds were milled using laboratory mill to pass through 1 mm screen (Willy mill) and stored in airtight plastic at room temperature pending chemical analysis. Dried and milled forage samples were sent to Debere Birhan Agricultural Research Centre (DBARC) for chemical analysis. CP, OM, and ash content of feed samples were determined according to the procedure of Association of Analytical Chemists [15]. Nitrogen was determined by micro-Kjeldahl method [15]. CP% was determined by multiplying N $\times$ 6.25. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed according to the procedures of [16]. The DM yield was determined by multiplying fresh yield by DM% of specific area and converted to hectare. The CP yield was also determined by multiplying DM yield by CP% at 10% flowering stage of the plant.

2.5 Data analysis

All data collected were analyzed with general linear model (GLM) procedure in Statistical Analysis System (SAS9) version 9.1.3 for analysis of variance [17]. Mean separation was done using the least significant difference (LSD) test for variables whose F-values declared a significant difference considered statistically significant at 5% significance level. Pearson's correlation coefficients were determined among the all studied traits using SAS9 software.

3. Results

3.1 Forage yield and related traits

The result of plant height as affected by species was illustrated in Table 1. Significant ($P < 0.05$) differences among species were detected. Brachiaria brizantha wild 13809 and Brachiaria mutica had higher plant heights (77.65 to 83.63 cm) while the lower values (ranged from 28.49 to 73.56 cm) were recorded by the rest of species during the entire 22 months combined (2019 and 2020).

There was no significant ($P < 0.05$) variation detected in mean of tillers number among all the Brachiaria species tested as shown in Table 1. Overall mean of tillers number per plant of all cultivars was 101.82.

For leaves number per plant, there was a significant ($P < 0.05$) difference among different Brachiaria species (Table 1). The highest mean leaves number was observed by Brachiaria hybrid cv. Mulato I, closely followed by Brachiaria hybrid cv. Mulato II and Brachiaria mutica (ranged from 223.35 to 261.20) while the smallest leaves number (74.05) was obtained from B. brizantha wild. Acc no. 13755.

For leaf length, there was a statistically significant ($P < 0.05$) difference observed among the species. The highest mean of leaf length was scored at Brachiaria brizantha wild 13809 (20.87 cm) followed by B. brizantha wild. Acc no 13755 (19.40 cm) whereas relatively the shortest (11.00 cm) leaf length was obtained from cultivar Brachiaria hybrid cv. Mulato II (Table 1).

For fresh yield, theBrachiaria mutica species ranked top fresh biomass yield by producing 88.72 t h^{-1} followed by Brachiaria hybrid cv. Mulato I (59.31 t h^{-1}). On the other hand, relatively the lowest fresh fodder yield (36.65 t h^{-1}) was obtained from cultivar B. brizantha wild. Acc no 13726 (Table 1).

The means of DM yields of 10 Brachiaria grass species are

Table 2. Mean of dry biomass yield over cuttings and total annual biomass yield for the Brachiaria grass species evaluated in 2019 and 2020 growing seasons at W/Dembia district.
Means of column with the same letter are not significantly different using LSD 5%.

Cultivars	Cut 1	Cut 2	Cut 3	Cut 4	Cut 5	Total annual yield (t h^{-1})
B. brizantha cv.s Marandu Acc16550	4.91^{b}	1.21^{d}	5.95^{b}	1.72^{c}	2.01^{d}	15.79^{bc}
B. brizantha cv la libertad Acc 16551	1.91^{cd}	4.94^{a}	2.04^{c}	3.25^{a}	4.11^{b}	16.24^{bc}
B. brizantha wild. Acc no 13726	1.15^{e}	1.97^{c}	1.28^{d}	1.91^{c}	6.16^{a}	12.46^{c}
B. brizantha wild. Acc no 13755	1.03^{e}	3.12^{b}	1.05^{d}	2.89^{b}	6.74^{a}	14.82^{bc}
Brachiaria brizantha wild 13777	1.65^{d}	4.53^{a}	1.79^{cd}	3.27^{a}	5.14^{b}	16.40^{bc}
Brachiaria brizantha wild 13809	1.61^{d}	4.32^{a}	1.72^{cd}	3.44^{a}	6.12^{a}	17.19^{bc}
Brachiaria decumbens	1.17^{e}	4.02^{a}	1.45^{d}	3.84^{a}	3.09^{c}	13.56^{c}
Brachiaria mutica	11.77^{a}	3.97^{ab}	11.31^{a}	2.36^{b}	4.25^{b}	33.65^{a}
Brachiaria hybrid cv. Mulato I	5.15^{b}	1.59^{c}	6.46^{b}	2.81^{b}	3.36^{c}	19.35^{b}
Brachiaria hybrid cv. Mulato II	3.32^{c}	0.94^{d}	5.41^{b}	2.26^{b}	2.27^{d}	14.20^{bc}
Mean	3.35	3.07	3.83	2.87	4.31	17.36
Coefficient of variation (CV%)	9.54	11.29	18.51	6.28	14.01	22.77
LSD (0.05)	6.91	3.21	9.27	2.03	4.26	5.74

presented in Table 2. The results showed higher DM yield with value of 33.65 t h^{-1} was detected in Brachiaria mutica followed by Brachiaria hybrid cv. Mulato I (19.35 t h^{-1}), while B. brizantha wild. Acc no 13726 gave the lowest DM yield (12.46t h^{-1}) ($P < 0.05$). As indicated in Table 1, leaf to steam ratio (LSR) was significantly ($P < 0.05$) affected by different Brachiaria grass species. Among the cultivars tested B. brizantha wild. Acc no 13726 recorded significantly ($P < 0.05$) higher LSR than the rest of Brachiaria grass species.

3.2 The effect of cuts on forage yield

The overall trends of dry matter yield production at each cut across the evaluation periods are presented in Table 2. The result showed that all the Brachiaria grass species produced biomass yield differently at different cuts (Table 2). Significantly, ($P < 0.05$) the highest forage biomass yield 11.31 to 11.77 t h^{-1} was obtained by Brachiaria mutica at cut 1 and 3, respectively. Overall, different Brachiaria species produced biomass yield differently at different cuts and the trend for different species was also different. The observed irregular biomass production at different cuttings in each species indicated the fact that the need for fertilizer application one after the other cutting so as to maximize the overall biomass yield production of the grass.

3.3 Forage quality of Brachiaria grass

The mean response for nutritive values to Brachiaria grass species is shown in Table 3. The organic matter content (OM%) is one of the main parameters determining the quality of the plant: feed with more OM has more components that can be utilized by livestock. Brachiaria species showed a significant ($P < 0.05$) difference in OM content. B. brizantha wild. Acc no 13726, B. brizantha wild. Acc no 13755 and Brachiaria mutica produced the most OM content that ranged from 82.22 to 84.39% compared to the rest of species.

Ash content was also affected by Brachiaria grass species and it was significantly ($P < 0.05$) higher in Brachiaria hybrid cv. Mulato I, B. brizantha cultivars Marandu Acc no. 16550, Brachiaria hybrid cv. Mulato II and Brachiaria decumbens ($11.96 - 13.60\%$) compared with other species. On the other hand, a significant ($P < 0.05$) difference was observed in CP content among the Brachiaria grass species. CP value (10.85%) was recorded in Brachiaria grass species Brachiaria mutica while lower CP content was obtained from Brachiaria brizantha wild 13809, Brachiaria brizantha wild 13777 and B. brizantha wild. Acc no 13755 that ranges from 7.72 to 8.82%. Comparing the contents of NDF between Brachiaria species (Table 2), we observed significantly ($P < 0.05$) lower NDF contents in Brachiaria hybrid cv. Mulato I, B. brizantha cv. Marandu Acc 16550, Brachiaria mutica and B. brizantha wild. Acc no 13755 (49.91 to 53.7%) than other Brachiaria grass species under study. Regarding the contents of ADF, a significant ($P < 0.05$) difference was observed between Brachiaria grass species (Table 3). Like that of NDF content, B. brizantha cv. Marandu Acc 16550 and Brachiaria hybrid cv. Mulato I also recorded significantly ($P < 0.05$) lower (35.30%) ADF content in relation with other species.

Significant ($P < 0.05$) difference was also observed between Brachiaria grass species in acid detergent lignin (ADL) (Table 3). Associated with their early maturing nature of the species, significantly ($P < 0.05$) higher ADL content was observed at B. brizantha cv la liberated Acc no. 16551, Brachiaria decumbens and Brachiaria brizantha wild 13809.

The combined 22 months analysis of variance result declared that there was a significant ($P < 0.05$) difference between Brachiaria grass species in total CP production (t h^{-1}) (Table 3). Among the cultivars tested, Brachiaria mutica recorded higher total CP production (3.65 t h^{-1})

Table 3. Mean of chemical composition and crude protein yield of Brachiaria grass species determined at 10% flowering stage of the forage over years (2019 and 2020) at W/Dembia district.
Means of column with the same letter are not significantly different using LSD 5%
ADF = acid detergent fiber; ADL = acid detergent lignin; CP = crud protein; CPY = crud protein yield;; NDF = neutral detergent fiber; OM = organic matter.

	OM%	Ash%	CP%	NDF%	ADF%	ADL%	CP Yield ($t\ h^{-1}$)
B. brizantha cv. Marandu Acc 16550	77.78^{c}	12.22^{a}	9.05^{b}	50.00^{c}	35.30^{c}	6.67^{c}	1.43^{bc}
B. brizantha cv la libertad Acc 16551	81.13^{b}	10.87^{b}	9.86^{b}	63.79^{a}	48.35^{a}	9.92^{a}	1.60^{b}
B. brizantha wild. Acc no 13726	83.30^{a}	8.70^{c}	8.89^{b}	60.00^{b}	44.00^{b}	8.67^{b}	1.11^{d}
B. brizantha wild. Acc no 13755	84.39^{a}	7.61^{c}	8.82^{c}	53.78^{bc}	41.83^{b}	7.92^{bc}	1.31^{c}
B. brizantha wild 13777	82.22^{b}	9.78^{b}	7.88^{c}	65.84^{a}	52.70^{a}	9.00^{b}	1.29^{c}
B. brizantha wild 13809	85.47^{a}	7.53^{c}	7.72^{c}	67.11^{a}	50.74^{a}	10.81^{a}	1.33^{c}
Brachiaria decumbens	75.40^{c}	13.60^{a}	8.88^{b}	62.55^{a}	48.35^{a}	9.97^{a}	1.20^{d}
Brachiaria mutica	84.39^{a}	7.61^{c}	10.85^{a}	53.35^{bc}	39.65^{b}	7.92^{bc}	3.65^{a}
Brachiaria hybrid cv. Mulato I	80.04^{b}	11.96^{ab}	8.89^{b}	49.91^{c}	35.30^{c}	6.58^{c}	1.72^{b}
Brachiaria hybrid cv. Mulato II	76.67^{c}	13.33^{a}	9.86^{b}	55.47^{b}	41.83^{b}	8.70^{b}	1.40^{bc}
Mean	81.08	10.32	9.07	58.18	43.81	8.61	1.57
Coefficient of variation (CV%)	2.5	2.61	1.33	1.86	2.12	2.77	14.62
LSD (0.05)	9.11	5.03	2.54	15.40	6.46	3.74	0.51

than the rest of species.

3.4 Correlation between traits

The simple linear correlation analyses among morphological characteristics and chemical composition of Brachiaria grass are presented in Table 3. Plant height was positively correlated with leaf length, dry matter yield, crude protein yield and organic matter but negatively correlated with tillers number, leaves number and fiber fractions. On the other hand, tillers number was positively correlated with leaves number, leaf length, DM yield, CP yield, OM% and CP%. The leaves number was positively correlated with leaf length, DM yield, OM%, CP% and CP yield. Leaf length was positively correlated with DM yield, CP%, CP yield and OM% but it was negatively correlated with fiber fractions (Table 4).

4. Discussion

4.1 Forage yield and related traits

Variations in plant height might be attributed to genetic make of the species. The current results agree with the result of Damry and Syukur who reported plant height of Brachiaria hybrid mulato II (84.67 cm) in Indonesia [18]. The mean plant height of Brachiaria grass species (Brachiaria mutica) in the current study was higher than earlier reports of Wondimagegn et al. for the Brachiaria hybrid mulato II (37.00 cm) when planted at 20×20 cm spacing coupled with application of 46 kg h^{-1} nitrogen fertilizer [19]. On the other hand, compared with the current result, Mustaring et al. obtained relatively higher plant height (207.47 cm) from species Brachiaria mutica at 8 week of harvest [20]. The reason could be associated with differences in the environmental conditions (soil type and fertility, temperature and altitude) and management practices applied on the plant.

The mean number of tillers per plant was 101.82 which were in contrary with the results of Mustaring et al. who reported that it ranges from 64.74 to 98.91 for the same species [20]. In contrary with the current result, Wondimagegn et al. also reported from 32.4 to 54.4 numbers of tillers per plant when Brachiaria hybrid mulato II was planted at different rows and plant spacing with different fertilizer rates [19]. This could be possibly due to differences in environmental conditions and management practices adopted at different studies.

The observed variation in leaves number could be due to the fact that as a result of genetic variation as the plant leaf width becomes narrower, it is attributed to less competition for light between plants which resulted in better growth of leaf which supports more leaves. The mean of leaves number per plant was in disparity with the pervious results of Mustaring et al. [20] who reported it in the ranges from 271.24 to 298.61 for the Brachiaria mutica and Brachiaria hybrid cv. Mulato I species. Wondimagegn et al. [19] also reported number of leaves per plant from 338 to 506 from Brachiaria hybrid cv. Mulato II when planted at 50×80 cm spacing, which is in disparity with the current result. This could be due to the fact that as compared to the current work, the authors planted their experimental materials in wider row and plant spacing (40 cm) that promotes for the emergence of more leaves from the newly emerging tillers which are important for the transpiration surface and photosynthetic process.

The difference among the species in leaf length could be related to genetic makeup of cultivars and that caused difference in suitability of the environment for the specific species. The mean value for the leaf length was 15.93 cm, which is lower than the Brachiaria hybrid cv. Mulato II (21.62 cm) as reported by Guiot and Melendez [21]. Variations in the leaf

Table 4. Correlation coefficients among morphometric characteristics and chemical content of Brachiaria grass.
** and * = significant at 1% and 5% probability level
ADF = acid detergent fiber; ADL = acid detergent lignin; CP = crud protein; NDF = neutral detergent fiber; OM = organic matter.

	plant height	Tiller no.	Leaf no.	Leaf length	DM Yield	CP Yield	Ash %	OM %	CP %	NDF %	ADF %	ADL %
Plant height	1											
Tiller no.	-0.35	1										
Leaf no.	-0.26	0.8	1									
leaf length	0.66	0.31	0.68	1								
DM Yield	0.74*	0.55	0.61*	0.74	1							
CP Yield	0.66*	0.63*	0.67*	0.80*	0.97**	1						
Ash%	0.09	-0.25	-0.34	0.08	-0.2	-0.3	1					
OM%	0.54	0.72*	0.66*	0.89*	0.75*	0.83**	-0.24	1				
CP%	0.17	0.68	0.68*	0.71*	0.5	0.69*	-0.17	0.74*	1			
NDF%	-0.37	-0.74	-0.88	-0.37	-0.53	-0.63	0.12	-0.81	-0.79	1		
ADF%	-0.45	-0.74	-0.63	-0.89	-0.52	-0.61	0.04	-0.8	-0.8	0.96**	1	
ADL%	-0.02	-0.75	-0.61	-0.82	-0.47	-0.62	0.17	-0.79	-0.88	0.82**	0.82**	1

length could be attributed to the agro ecological and edaphic divergence with study areas. This could be attributed to the genetic differences by the different cultivars. Wubetie et al. reported similar results for Brachiaria hybrid cv. Mulato II when harvested within 90 days interval in Northwestern Ethiopia [9].

The differences in fresh forage yield among the species could be attributed to the performance and potential of different species grown in the same condition. Compared to the previous results, we obtained relatively highest fresh fodder yield (47.22 to 96.18 t h^{-1}) which was observed by different species in Central Sulawesi, Indonesia [20]. Variations in the yields could be attributed to differences in the level of soil fertility, climatic zones, seasons, agronomic practices adopted and differences in species used in different study areas. Wubetie et al. recorded that there were considerable variations in the performance of the species with respect to fresh forage yield, and this variation was due to varietal potential [9].

The variations in DM yields might be due to the differences in yield related components like plant height, leaves number, leaf length and differences in fresh biomass yield. These results are in line with those of Mustaring et al. [20] that reported the DM yield of Brachiaria grass from 10.52 to 34.01 t h^{-1} when different species were cultivated at different levels of nitrogen fertilizer and tested at different cuttings under rain fed conditions. However, this study result is in contrary to that reported by Wubetie et al. [9] who reported the DM yield of Brachiaria hybrid cv. Mulato II that ranges from 7.42 to 11.71 t h^{-1} in low, mid and high altitude areas of Northwestern Ethiopia. This could be due to differences in seasons, length of evaluation time, soil fertility and climatic zones in studies conducted.

The observed LSR difference might be due to the genetic differences; variations in leaves number, leaf length and relative difference in amount of water in their meristematic tissue in different species. The mean LSR of the current study was in contrary with the pervious results of Ramírez de la Ribera et al., for Brachiaria decumbens cv. Basilisk tested at Cuba, which was 1.46 [22]. This could be due to the cultivar differences used and other edaphic and environmental differences within the study areas.

Variability in overall trends of forage dry matter production for different species at different cuts might be associated with the genetic variation of Brachiaria grass species and suitability of the environment, soil type, and soil fertility for specific Brachiaria species [8, 20].

4.2 Forage quality

Better OM% in some species could be due to the better ability of these species in optimizing the use of nutrients available in the soil better than the other Brachiaria grass species. In disparity with the current result, Negasu et al. reported that the OM% of Brachiaria grass was in the range from 85.74 to 87.01% when Brachiaria grass species Brachiaria hybrid cv. Mulato II was planted either by Urea or manure fertilizer in the lowlands of Northwest Ethiopia [23]. The observed difference could be due to differences in plant maturity, plant spacing, fertilizer used and nutrient content of the soil in different study situations.

Greater ash content in some of the species might be due to much less OM% and much higher cell wall content accumulated with these species. This result was in conformity with the findings of Mustaring et al. who reported the ash content of Brachiaria grass may reach at 12.92% [20].

The observed CP% result was similar to that observed by Mustaring et al. as 10.89% CP for the same species [20]. Crude protein quality characteristics results indicate that due to better root penetration, the ability of plants in assimilating nitrogen from the planting medium to internal nitrogen networks resulted in more effective and efficient utilization of nitrogen to have higher protein contents [24].

The variations in NDF content in different species might be due to differences in their LSR. For all Brachiaria grass species, NDF contents were below 72%, which indicates they have no negative effect on feed intake when the forage was harvested at 10% flowering stage. These features make these species excellent alternatives for use in the integrated crop-livestock systems, with the purpose of providing quality feed in the dry season. Lima et al. reported that NDF is relevant to the improvement of the forage nutritional value and can be an important parameter to define the forage quality because the more fibrous pasture occupies more space for longer and limits the intake rate [25]. Unlikely to this study result, Pariz et al. who studied the chemical composition of Brachiaria after intercropping with corn and achieved NDF content above 60% for Marandu palisade grass and ruziziensis grasses [26]. Furthermore, Pariz et al. examined four species of Brachiaria intercropped with corn and reported NDF content of $66.4\% - 74.3\%$ and $70.3\% - 78.1\%$ for Mulato and Marandu palisade grass, respectively [27]. Variations could be due to differences in species used, plant maturity, fertilizer used, agro ecology and nutrient content of the soil in different areas.

The observed higher ADF content may be correlated with the observed difference in LSR in different species. In this context, the digestibility of feeds is related to the fiber because the indigestible portion has a proportion of ADF, and the higher the value of ADF, the lower the feed digestibility [28]. Nussio et al. also reported that forage with ADF content around 40% or more shows low intake and digestibility [29].

The result of ADL found in the current result is in line with Mustaring et al. who reported ADL content of (8.18%) for Brachiara mulato I grass speces [20]. However, the current result disagreed with the result of Pariz et al. who noted that ADL content of Mulato and Marandu palisade grass was in the range of 10.91 to 12.06% [27]. The reason might be associated with environmental condition, soil type and management practices adopted in different areas.

The observed significant CP yield in Brachiaria mutica was due to the higher biomass production achieved and the higher the CP% recorded by the species since CP yield is a function of total biomass produced and CP%. This result was in accordance with the findings of Mustaring et al. who reported a significant difference among the Brachiaria grass species in CP yield that ranges from 0.98 to 3.81 t h^{-1} [20].

4.3 Correlation among traits

DM yield was positively correlated ($r = 0.75$ to 0.97) with CP% and CP yield, but negatively correlated with ash and fiber fractions when the plant was harvested at 10% flowering. This result is similar with the findings of Negasu et al. that show high correlations between DM yields and CP yields in different Brachiaria grass species in development of growth protein decreases and fiber increase [23]. The observed positive association of DM yield with some morphological parameters (plant height, tiller number, leaf length and leaf number) was similar with the results reported by Wondemagegn et al. [19] for Brachiaria grass cv. Mulato II. This is due to the fact that growth parameters play a vital role in enhancing fodder yield. Similarly, in line with the current result, Imran et al. reported that production parameters are positively correlated to enhance biomass yield [30]. CP yield was positively correlated with OM%, however negatively correlated with fiber fractions. OM% was positively correlated with CP% while a strong negative correlation was detected in OM% and CP% with fiber fractions. The highest positive correlation ($r = 0.82$ to 0.96) was detected between fiber fractions. On the other hand, the increased forage yield decrease forages quality.

5. Conclusion

From this study result, it can be concluded that biomass yield, quality parameters and CP yield differed among the 10 Brachiaria grass species under study. Based on the combined analysis result, higher biomass yield was harvested from Brachiaria grass species Brachiaria mutica. During the evaluation, an inconsistent biomass yield production was observed one after the other cutting that alarms the need for Nitrogen source fertilizer application at cutting that showed declining in biomass production. Maximum CP% was obtained from Brachiaria mutica. All Brachiaria grass species including Brachiaria mutica were found low in fiber fractions which were below the threshold that makes the forage better in intake and highly digestible. The species of Brachiaria mutica in its better biomass yield production and relatively higher CP% was found efficient in producing total CP yield per hectare. Therefore, based on the study results, total CP yield with less fiber content was taken as an ultimate objective of forage production for the study area and Brachiaria mutica was found the most suitable for presenting feed of better quality. To maximize the total biomass production, the need and amount of Nitrogen source fertilizer should be studied at cutting where it showed decline in biomass production.

Conflict of interest statement:
The authors declare that they have no conflict of interest.

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