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Effects of Fertilizer Type and Harvest Date on Yield and Quality Traits of *Brachiaria* Hybrid Mulato II Grass (*Brachiaria Ruziziensis*) in Highlands of Ethiopia

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Abstract:

The experiment was conducted with the objective of assessing the effects of fertilizer type, and harvesting date on plant growth traits, dry matter (DM) yield and nutritional values of *Brachiaria* hybrid Mulato II grass. A two-factor factorial experiment was used based on a randomized complete block design (RCBD) with three replications. The fertilizer type had three levels: chemical fertilizer, manure, and control (without fertilizer) while the three harvesting dates were: 45, 75, and 105 days of plant age. The spacing between rows and plants within rows was 0.3 m and 0.5 m, respectively. All plots were harvested and a sample was taken from each plot for measurement of quality traits. The result of the analysis of variance showed significant effects of harvest date and fertilizer type on all the traits, with the exception of crude protein (CP) in fertilizers. The harvesting date and the fertilizer interaction effects were significant for plant height, leaf to stem ratio (LSR), root number, CP, Ash and neutral detergent fiber (NDF). All morphological traits except LSR were increased by increasing harvesting date. For LSR, the higher value was obtained in early cutting. For quality traits; the Ash and CP values decreased and NDF, ADF and ADL values increased as the plant age increased, indicating that forage quality was decreased in late cutting (105 day). In comparisons between fertilizer levels, the higher values of all morphological traits except LSR were obtained by the application of manure fertilizer followed by chemical fertilizer. The higher mean values of CP and LSR were obtained by the application of chemical fertilizer and without fertilizer, respectively. The results of this study showed that most of the morphological traits of the grass were less affected by the interaction between fertilizer type and harvesting days. BMII grass harvested from 105 days using manure fertilizer had greater DM yield than the application of chemical fertilizer and without fertilizer which would be more beneficial to get high quantity yields and considered as an option to solve the shortage of feed.

Keywords: Dry matter yield; Fertilizer type; Harvesting date; Nutritional qualities

1. Introduction

Ethiopia has a huge livestock population with 65 million cattle, 40 million sheep, 51 million goats, 8 million camels and 49 million chickens (CSA, 2020). That contributes to the livelihood of estimated 80% of the rural population of the nation. The sector contributes 15–17% of national gross domestic product (GDP), 35–47.7% of agricultural GDP and 37–87% of the household income (GebreMariam et al., 2013). Nevertheless, the contribution of livestock was not as expected (Shapiro et al., 2015) which might be linked to many constraints including lack of quality and in quantity feed (Mengistu et al., 2017). The major livestock feed resources in Ethiopia are the grazed pasture and crop residues, which are poor in nutritive values (Mengistu et al.,

Table 1. Effect of harvesting stage, fertilizer type and their interaction on plant morphological trait and yield of *Bracheiaria* hybrid Mulato II.

factors	plant height (cm)	tillers no.	leaf length (cm)	internode no.	leaf/stem ratio	root no	root length (cm)	DM yield (ton/ha)
harvesting stage (H)								
45 days	35.57 [c]	85.58 [c]	17.07 [b]	4.43 [c]	4.07 [a]	46.39 [c]	18.87 [b]	6.81 [b]
75 days	51.86 [b]	117.48 [b]	20.49 [a]	6.72 [b]	3.66 [a]	137.33 [b]	28.79 [a]	11.36 [a]
105 days	69.31 [a]	184.65 [a]	18.21 [b]	9.59 [a]	2.81 [b]	245.08 [a]	31.68 [a]	7.95 [b]
significance of H	***	***	***	***	***	***	***	***
fertilizer type (F)								
manure	67.50 [a]	160.41 [a]	22.59 [a]	7.79 [a]	3.46 [ab]	190.88 [a]	30.20 [a]	11.9 [a]
chemical	46.82 [b]	131.78 [b]	16.84 [b]	6.53 [b]	3.04 [b]	131.25 [b]	23.50 [b]	7.91 [b]
control	43.32 [b]	97.84 [c]	16.57 [b]	6.46 [b]	4.02 [a]	111.11 [b]	25.50 [b]	6.51 [b]
significance of F	***	***	***	*	**	***	**	***

*, **, ***= significant at 0.05, 0.01and 0.001 probability levels.
Means within column a followed by the same letters are not significantly different.

2017; CSA, 2018), unable to provide the nutrients required to maximize animal productivity. This calls for the introduction and evaluation of adaptable and high-yielding forage crops that produced large amounts of fodder limited land and resources. Among the candidate forages, *Brachiaria* grass could be suitable for the existing production system and adaptable to climate change. It is known that forage management practices such as fertilizer application, and harvesting stage determine DM yield and forage quality (Mihret et al., 2018; Ziki et al., 2019). The studies of Adnew et al. (2018) suggested that the grass could be one of potential fodders for livestock as well as land rehabilitation program. The extent to which these factors affect the productivity and nutritive value of *Brachiaria* grass in the country has not been thoroughly investigated. Hence, the objective of this study was to assess the effects of fertilizer type, harvesting date and their interaction on grass traits, biomass yield, and chemical composition of BMII grass.

2. Materials and methods

2.1 Site information

The study was conducted in Fogera district, Amhara region, Ethiopia. The experimental area is located at 13° 118.53‘N latitude and 36° 6443‘E longitude. The elevation of the experimental site is about 2050 m.a.s.l. The area receives an average annual rainfall of 1284.2 mm and has average daily temperatures of 37.5 °C (FDCO, 2019).

2.2 Land preparation, soil sampling and analysis

The experimental land was cleared, plowed by oxen, and harrowed again by traditional oxen for 20 to 30 days before laying out plots and planting a fine tithe to facilitate soil aeration, dry, and remove or reduce unwanted weeds. Soil samples were collected from the experimental site, pooled over, and analyzed for soil pH, organic carbon (OC), total nitrogen (N), available phosphorus (P), and organic matter (OM) using standard laboratory procedures. The total N in the soil was determined by the Kjeldahl method (Dewis, Freitas, et al., 1970). Available P in the soil was determined by Olsen's method using a spectrophotometer (Olsen, 1954). The pH of the soil was determined with a glass electrode attached to a digital pH meter (FAO, 2008). Finally, organic matter was calculated as (OC × 1.72) standard methods as described by Okalebo et al. (2002).

2.3 Research methodology

A two-factor factorial experiment arranged in a randomized complete block design (RCBD) with three replications was used. The factor A (fertilizer type) had three levels: chemical fertilizer, manure, and control (without fertilizer) while the factor B (harvesting date) had three levels: 45, 75, and 105 days of plant age. The spacing between rows and plants within rows was 0.3 m and 0.5 m, respectively. Each plot measured 1.5×3 m and the inter-row spacing was the same for all treatments (0.5 m). During planting, organic and inorganic fertilizer was applied at the rate of 100 kg NPS for the establishment and 25 kg/ha urea for maintenance, and organic fertilizer was 4500 kg/ha for the establishment and 1000 kg/ha for maintenance (Danano, 2007). Weed control by hand weeding to avoid interference interspecific competition.

2.4 Data collection

Data on the morphological and DM yield were recorded throughout the experimental period. In each plot, seven plants were randomly selected to record a number of tillers per plant, number of leaves per plant, leaf length, root length, root number per plant, and leaf to stem ratio (LSR). Plant height was determined by measuring the height of seven randomly selected plants from ground level to the tip of the apical meristem. Harvesting was done by hand using

Table 2. Harvesting date by fertilizer interaction on yield and morphological traits of BMII grass.

harvesting stage (H)	fertilizer type (F)	plant height (cm)	tillers no.	leaf length (cm)	internode no.	leaf/stem ratio	root no	root length (cm)	DM yield (ton/ha)
45 days	manure	47.49 ^{c}	95.64	20.39	5.12	5.32 ^{a}	51.90 ^{d}	21.44	2.79
	chemical	29.84 ^{d}	83.66	15.31	3.92	3.30 ^{b}	40.60 ^{d}	16.35	1.56
	control	29.41 ^{d}	77.49	15.50	4.23	2.03 ^{c}	44.95 ^{d}	20.51	2.39
75 days	manure	66.43 ^{b}	153.23	22.93	7.91	3.46 ^{b}	213.5 ^{b}	33.40	4.96
	chemical	48.72 ^{c}	112.58	19.25	6.17	3.43 ^{b}	97.58 ^{c}	26.26	3.87
	control	40.42 ^{c}	86.71	19.32	6.05	4.07 ^{b}	48.34 ^{d}	27.14	2.07
105 days	manure	82.54 ^{a}	215.84	23.46	9.59	2.25 ^{c}	277.8 ^{a}	35.38	3.69
	chemical	61.92 ^{b}	199.08	15.50	9.26	2.38 ^{c}	255.6 ^{a}	27.90	2.43
	control	63.43 ^{b}	138.99	15.31	9.87	3.82 ^{b}	201.8 ^{b}	31.77	1.81
significance of F×H		*	0.15	0.17	0.30	***	***	031	019

*, **, ***= significant at 0.05, 0.01and 0.001 probability levels.
Means within column a followed by the same letters are not significantly different.
F×H= fertilizer by harvesting date interaction.

a sickle, leaving a stubble height of 10 cm (Tudsri et al., 2002).

2.5 Forage quality analysis

For measurements of forage DM% and chemical composition analysis, a 2 kg forage samples were collected from each plot dried in an oven and then, ground to pass 1 mm sieve for forage nutritive value analysis. Samples were subjected to a chemical analysis for the determination of organic matter following the methods (AOAC, 2004). Forage qualities such as DM, CP, and Ash were analyzed according to (AOAC, 1990). The CP content was determined using the Kjeldahl procedure while the fibers such as neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were analyzed using the methods of Van Soest et al. (1991). Ash was determined by igniting at 550°C for 6 hours. For DM content, sub samples were drying at 105°C for 24 hours. To determine the crude protein yield (CPY), the DM yield was multiplied by the CP content of the feed samples.

2.6 Data analysis

The collected data were subjected to analysis of variance (ANOVA) using the procedure outlined by Steel and Torrie (1986) for a factorial experiment using SAS9 software (SAS, 2004). When the F test was significant, treatment means were compared by Duncan's Multiple Range Test (DMRT) ($p < 0.05$).

3. Results

3.1 Yield and morphological traits

The effects of fertilizer type and harvesting date on morphological traits of BMII grass is presented in Table 1. The harvesting date and the fertilizer interaction effects were significant for plant height, leaf to stem ratio (LSR) and root number. All parameters with the exception of LSR were significantly increased as the harvesting date increases from 45 to 105 days. Plants that received manure fertilizer than NPS generally performed better than the control.

Plant height

The effect of fertilizer and harvest date was significant ($p < 0.001$) on plant height. As harvesting stage increases from 45 to 75 and 105 days, the plant height increased by 35.57, 51.86 and 69.31 cm, respectively. The highest means of plant height of 67.50, 46.82 and 43.32 cm were observed for manure followed by chemical fertilizer and control, respectively (Table 1). The fertilizer by harvesting date interaction was significant ($p < 0.05$) for height (Table 2), indicating that the response of plant height to applying fertilizer was not similar at three harvest schedules.

Tillers number per plant

There was a significant ($p < 0.001$) effect of both fertilizer type and harvesting date on tiller number per plant of BMII grass (Table 1). As harvesting stage increases from 45 to 75 and 105 days, the tillers per plant were counted as 85, 117 and 184 numbers, respectively, indicating that the tiller number increased with late harvesting date as the number of tillers developed. Similarly, the application of organic fertilizer (manure), chemical fertilizer (NPS) and control produced 160, 131 and 97 tillers per plant, respectively.

Leaf length per plant

The effect of both harvesting date and fertilizer was highly significant ($p < 0.001$) on the leaf length per plant. The BMII grass harvested at 45, 75 and 105 days produced leaf length per plant of 17.07, 20.49 and 18.21 cm, respectively, indicating that the leaf length was increased progressively with the enhanced age of harvesting. Application of manure, chemical fertilizer and control gave 22.59, 16.84 and 16.57 cm leaf length per plant, respectively showing that the application of manure

Table 3. Effect of harvesting date, fertilizer type and their interaction on nutritional quality and yield of BMII grass.

factors	DM %	Ash %	CP %	NDF %	ADF %	ADL %
harvesting stage(H)						
45 days	90.06 ^{a}	12.53 ^{a}	14.84 ^{a}	51.08 ^{b}	27.46 ^{a}	4.33 ^{b}
75 days	88.65 ^{b}	10.36 ^{b}	12.88 ^{b}	48.26 ^{b}	25.50 ^{b}	4.41 ^{b}
105 days	88.80 ^{b}	9.15 ^{c}	11.61 ^{c}	57.10 ^{a}	35.78 ^{a}	7.75 ^{a}
significance of H	*	***	***	***	*	**
fertilizer type (F)						
manure	89.14 ^{a}	11.01 ^{a}	12.38 ^{c}	51.23 ^{a}	29.32 ^{a}	6.44 ^{a}
chemical fertilizer	89.02 ^{a}	10.10 ^{a}	13.80 ^{a}	51.23 ^{a}	28.82 ^{a}	4.43 ^{a}
control	89.36 ^{a}	10.93 ^{a}	13.15 ^{b}	53.82 ^{a}	30.60 ^{a}	5.62 ^{a}
significance of F	ns	ns	***	ns	ns	ns

ns, *, **, ***= non-significant and significant at 0.05, 0.01and 0.001 probability level. Means within column a followed by the same letters are not significantly different. F=fertilizer; H=harvesting date; DM=Dry Matter; CP=Crude Protein; NDF=Neutral Detergent Fiber; ADF=Acid Detergent Fiber % and ADL=Acid Detergent Lignin.

produced the longest leaf length per plant.

Internode number

The effect of harvesting date was highly significant ($p < 0.001$) and the effect of fertilizer type was also significant ($p < 0.05$) on the internode number per stem (Table 1). The BMII grass harvested at 45, 75 and 105 days produced 4.43, 6.72 and 9.59 internode number, respectively indicating that the internode number increased with the enhanced age of harvesting. For the type of fertilizer, manure, NPS and control produced 7.79, 6.53 and 6.46 internodes, respectively.

Leaf to stem ratio (LSR)

The effect of fertilizer type and harvest date was significant ($p < 0.001$) on the LSR of BMII grass (Table 1). As harvesting stage increases from 45 to 75 and 105 days, the LSR values were decreased by 4.07, 3.66 and 2.81, respectively. In comparisons between fertilizer levels, by the application of manure, NPS and without fertilizer, the LSR indices were 3.46, 3.04 and 4.02, respectively. The interaction effect between harvesting date and fertilizer type was highly significant ($p < 0.001$) on the LSR of the grass, indicating that the responses of harvesting date to fertilizers application were not similar.

The LSR obtained at earlier stage compared to intermediate harvesting (75 days) had sharply decreased in 105 days harvesting. The lowest LSR was observed from late harvesting date coupled with applying chemical fertilizer (NPS), respectively.

Number of roots per plant

The effect of fertilizer type and harvesting date was highly significant ($p < 0.001$) on the root number of BMII grass (Table 1). As harvesting stage increases from 45 to 75 and 105 days, the root number increased from 46.39, 137.33 and 245.08, respectively. The highest number of roots was counted in late harvesting date (105 days). The highest root number counted from the late harvesting date (105 days). The lowest root numbers were counted from control in the early harvesting date (45 days). For fertilizer type, application of the manure, NPS and control produced 190.8, 131.2 and 111.1 roots number, respectively (Table 2).

Root length

The effects of both harvesting date and fertilizer were highly significant ($p < 0.001$) on the root length (Table 1). The BMII grass harvested at 45, 75 and 105 days produced 18.87, 28.79 and 31.68 cm root length, respectively. Indicating that the root length was increased progressively with the enhanced age of harvesting. For fertilizer type, the application of manure, NPS fertilizer and control produced 30.20, 23.50 and 25.50 cm root length, respectively, indicating that the highest value was obtained using manure fertilizer.

Forage DM yield

The effects of both harvesting date and fertilizer were highly significant ($p < 0.001$) on DM yield (Table 1). The total DM yield of the harvesting period (45, 75 and 105 days) was 6.81, 11.36 and 7.95 tons/ha, respectively. Also, by applying organic fertilizer (manure), NPS and control, the values of DM yield were 11.9, 7.91 and 6.51 tons/ha, respectively. The DM yield increased progressively with the effect of fertilizer type called manure more than chemical fertilizer with the least in the control. The yield based on harvesting dates showed an increasing trend from the early harvesting age up to moderate harvesting date.

3.2 Chemical composition

DM content

The highest DM content was obtained at early harvesting date, followed by the moderate and last harvesting date, respectively ($p < 0.001$). However, there was no significant difference between moderate and last harvesting date. Similarly, fertilizer type had no significant ($p > 0.05$) effect on the DM content of BMII grass.

Table 4. Interaction of harvesting date and fertilizer on quality traits of BMII grass.

harvesting stage (H)	**fertilizer type (F)**	**DM %**	**Ash %**	**CP %**	**NDF %**	**ADF %**	**ADL %**
45 days	manure	90.13	12.11 ^{b}	14.39 ^{b}	50.88 ^{c}	31.53	4.99
	chemical fertilizer	89.94	11.90 ^{b}	15.31 ^{a}	51.27 ^{c}	25.22	3.84
	control	90.13	13.57 ^{a}	14.81 ^{ab}	51.09 ^{c}	25.64	4.15
75 days	manure	88.67	11.58 ^{b}	12.57 ^{d}	46.19 ^{d}	24.63	3.81
	chemical fertilizer	88.59	9.50 ^{c}	13.62 ^{c}	48.94 ^{cd}	24.88	3.83
	control	88.69	9.99 ^{c}	12.47 ^{d}	49.65 ^{cd}	26.98	5.59
105 days	manure	88.63	9.35 ^{c}	10.17 ^{e}	56.63 ^{b}	31.80	10.52
	chemical fertilizer	88.53	8.89 ^{c}	12.48 ^{d}	53.93 ^{b}	36.37	5.62
	control	89.25	9.22 ^{c}	12.18 ^{de}	60.72 ^{a}	39.18	7.11
sig, levels of F×H		ns	***	***	*	ns	ns

ns, *, **= non-significant and significant at 0.05 and 0.01 probability level.
Means within column a followed by the same letters are not significantly different.
F×H= fertilizer by harvesting date interaction.

Ash content

The early harvesting date had the highest ash content (12.53%) as compared to 75 and 105 days with values of 10.36 and 9.15%, respectively (Table 3). However, the result suggests that the mineral (ash) content of the grass was reduced with an increase in the stage of maturity.

The interaction effect between harvesting date and fertilizer type was highly significant ($p < 0.001$) for ash content, indicating that the responses of harvesting date to fertilizers application were not similar (Table 4). For example, at earlier harvesting stage, the higher ash content was obtained without fertilizer whereas in intermediate harvesting stage, the higher ash content was obtained by application of Manure fertilizer (Table 4).

Crude protein content

The highest CP% was obtained at early harvesting date, followed by the moderate (75 days) and late harvesting date (105 days) with values of 14.84, 12.88 and 11.61%, respectively. For fertilizer type, the application of manure, NPS and without fertilizer (control) produced the CP values of 12. 38, 13.80 and 13.15%, respectively. The highest CP value was obtained using NPS fertilizer (Table 3). The interaction effect between harvesting date and fertilizer type was highly significant ($p < 0.001$) for CP, indicating that the responses of harvesting date to fertilizers application were not similar (Table 4). BMII grass harvested at earlier age (45 days) with the application of chemical fertilizer (NPS) resulted in higher CP content while the lowest CP content was observed at the late harvesting age (105 days). On the other hand, the effect of fertilizer type (manure) was statistically similar to the control.

Neutral detergent fiber content (NDF)

The effect of harvesting date was highly significant ($p < 0.001$) on NDF (Table 3). As harvesting stage increases from 75 to 105 days, the NDF values increased by 51.08 and 57.10, respectively. The effect of fertilizer type was not significant ($p > 0.05$) on NDF content. BMII grass harvested in late harvesting period had higher NDF content whereas the lowest NDF value was observed at moderate harvesting date. The interaction effect between harvesting date and fertilizer type was highly significant ($p < 0.001$) for NDF, indicating that the responses of harvesting date to fertilizers application were not similar (Table 4). In early cutting stage, the fertilizer type had no effect on NDF whereas in late harvesting date, the higher NDF values were obtained in control (without fertilizer).

Acid detergent fiber content (ADF)

The effect of harvesting date was highly significant ($p < 0.001$) on ADF (Table 3). ADF of BMII grass harvested at late (105 days) harvesting date resulted in higher ADF=22.46% concentration while intermediate harvesting age (75 days) had given relatively lower content of ADF=25.5%. The effect of fertilizer and the interaction between harvesting dates had no significant effect on ADF content in the current experiment.

Acid detergent lignin content (ADL)

The effect of harvesting date was significant ($p < 0.01$) on ADF (Table 2). As harvesting stage increases from 45 to 75 and 105 days, the ADL values were increased from 4.33, 4.41 and 7.75%, respectively. The highest ADL was recorded at late harvesting date (105 days). The effect of fertilizer and its interaction with harvesting date was not significant on ADL content in the current experiment.

4. Discussion

4.1 Morphological traits and DM yield

Increment in plant height in the current finding at later harvesting date is in agreement with the findings of Zemene et al. (2020) in which the mean plant height was lower in early stage of growth. The plant height of BMII grass from the current result is significantly lower than earlier reports

(53.76 cm) by Adnew et al. (2018) and (180 cm) Zemene et al. (2020) for the same species. The difference of this result from earlier reports might be due to cultivar differences, management of the plant, harvesting date difference, soil type and climatic condition of the area where the experiment was done. The plant height obtained in the present finding was higher than the results of Nguku et al. (2015) who reported that plant height for *Brachiaria* hybrid Mulato II grass was 28.2 cm after 12 weeks. However, the present finding is less than the finding of Mustaring et al. (2014) for the same species. The reason for this variation may be due to different management systems and agronomic seasons.

The observed number of tillers in the current study was in line with the study conducted by Kizima et al. (2014) who reported that application of optimal level of nitrogen fertilization significantly affects the appearance of new tillers and increases the dynamics of the tiller population of Cenchrus ciliaris in Morogoro municipal, Tanzania. The effect of manure had shown higher values than that of NPS and control treatment in the present finding is greater than the finding of Mustaring et al. (2014) for the same grass in Indonesia. The reason for this variation might be due to different management systems, soil type, agronomic season, and fertilizer type use and agro-ecological variations.

According to Silva et al. (2013), among the *B. brizantha* cultivars, leaf length values did not differ with average values of 20.96, 21.55 and 26.92 cm/tiller for the CVs. Marandu, Piatã and Xaraés, respectively. However, this information demonstrated that those cultivars had given higher values as compared to the current result. This variation might be due to the difference in their species, soil fertility, and maturity stage and climate of the area where the study was conducted. The current result has been supported by Mihret et al. (2018) who revealed that chemical fertilizer and manure were significantly different in terms of leaf length of Desho grass. In the report, length of the leaf was greater than the earlier report. This could be associated with environmental condition, genetic makeup of forages.

The LSR declined sharply as the harvesting date increases. The reason for decreasing LSR with increasing harvesting date might be attributed to the accumulation of more cell wall components in plant tissues as a result of stem development with advancing maturity. But it is an important factor affecting diet selection, quality and intake of forage of animals (Smart et al., 2004). Therefore, this result is in agreement with different studies. Although Geleti and Tolera (2013) reported that the LSR of panicum coloratum was significantly affected by the age of re-growth. The significance of the value of LSR at the interaction of harvesting date and fertilizer might be related to the fact that stem weight increase although fertilizer had a positive effect on the growth habits of plants. This difference might come from the genetic variation of grasses, environmental condition, altitudes, soil type, and level of fertilizer, rainfall, temperature and management practices.

The number of roots per plant increases linearly with maturity of the plant. This might be due to the environmental condition, soil type and management system. The DM yield increased due to the rapid increase in the tissues of the plant, development of additional tillers and leaf formation, leaf elongation and stem development with increasing plant age. But the current result showed that at harvesting day 75 had a greater DM yield than 105 days due to the decreased chemical fertilizer when harvesting day was long (Awoke et al., 2020). Though DM yield increased as fertilizer applied, which means organic fertilizer (manure) increased more than chemical fertilizer. This result is in agreement with the report of Asmare et al. (2017) who observed that the total DM yield of the longest harvesting period (150 d) was the highest as shown in Table 1 whereas the lower DM yield was produced for the shortest harvesting period (90 d).

4.2 Chemical Composition

Application of fertilizer had no significant ($p > 0.001$) effect on the DM content of BMII grass in the current study, which agreed with Mihret et al. (2018) on Desho grass type and fertilizer types that had no significant effect on the DM content at 120 days of harvesting date. The overall mean of DM content in the current result was lower than *Brachiaria mutica* grass as reported by Zemene et al. (2020) that was 94.46%. This difference might be due to difference in soil condition, genetics, fertilizer, interaction effect and drying methods of samples for both studies.

The declining mineral content is due to the fact that as grasses mature, the mineral content declines due to a natural dilution process and translocation of minerals to the roots (Minson, 1990). Concentration of minerals in forage varies due to factors like plant developmental stage, morphological fractions, climatic conditions and soil traits (McDowell, Valle, et al., 2000). In addition, ash concentration declined significantly as harvesting date increased and progressive increases in plant spacing resulted in significant increases in ash concentration of Desho grass (Tilahun et al., 2017). The reason might be associated with species difference; soil type and fertility and management system of the plant. Although Ahmad et al. (2011) reported that ash content increased application of inorganic, organic and mixed types of fertilizer more than the treatment without fertilizer forage of oat (Avena sativa L.). Mineral (ash) nutrients in the feed play major roles in the body function of the overall animal production and productivity activity including skeletal development and maintenance, energy, milk production and body function (Rasby et al., 2011).

The decline in CP content with advancing stage of maturity is due to the accretion of a higher proportion of fiber corresponding to plant growth. The decreasing CP contents of grasses with increasing plant harvesting may be because of reduced LSR (Chaparro et al., 1997). The CP content is one of the most important criteria to determine the nutritional nutritive value of livestock feeds; this is due to a level of CP increases, the DM intake by livestock and rumen microbial growth would also increase (Chanthakhoun et al., 2012). In the present finding, late harvesting contained low levels of CP (11.61%) at harvest, which is higher than the level above which feed intake is restricted. But despite the decline in CP content with increasing stage of maturity, the intermediate and earlier harvesting concentrations (12.88 and 14.84%) exceeded the minimum CP level

(7.5%) required for rumen function (Jusoh et al., 2014). This indicates the possibility of improving the feeding of animals in tropical regions by early, intermediate and late harvesting *Brachiaria* hybrid Mulato II grass, thus enhancing the quality of nutrients supplied to animals. As chemical fertilizer applied, the CP content was increased in cultivars. CP increased by applying chemical fertilizer in the current study. This might be because of continued application fertilizer, allowed to continuous sprouting of the grasses of new leaves, which was a bit fresh even during the harvest of forage biomass (Hassan et al., 2015). The current result is higher than the same species of *Brachiaria* hybrid Mulato II as reported by the same author on the different harvesting dates with the fertilizer of the current study. The results obtained in this finding were in agreement with those reported by Fraser et al. (2001) who attributed that the decline in CP concentration to cell wall contents were observed in more mature grasses. The CP concentration of leaves declined dramatically with an increase in cutting interval from 28.2% at 40 days to 8.8% at 80 days, respectively. The CP content serves as an important indicator of fodder quality (Jusoh et al., 2014).

This is due to the fact that as the plant becomes mature, the cellulose, hemicelluloses, lignin and silica found in the insoluble portion of the forage increase. Beside this, in the present finding, higher production of more seeds at plant maturity is another indication for high fiber accumulation. This might be due to the translocation of protein from leaf and stem to seed, thereafter high fiber is remaining on the plant. Aganga et al. (2005) has also reported clearly that when the maturity of the grass is increased, the quality and digestibility decreased, which in turn could be related to the increment in the quantity of fiber fractions. In fact, progress in the vegetative cycle triggers the increase in lignin rate and in cell wall thickness in the plant´s tissues, mainly due to a decrease in the LSR.

The NDF obtained in the present finding was low (57.10%) at the late harvesting as compared to the results of Zemene et al. (2020) and Beyadglign (2019), who reported for *Brachiaria* Mutica, BMII grass was (70.98, 65.75%) at 120 and 90 days of harvesting, respectively. The differences in NDF are attributed to the nature of the grass, soil properties, the harvesting date variation and climatic conditions. The current result is also lower than the findings of Adnew et al. (2018) that report the NDF content of *Brachiaria brizantha* ecotypes (74.08%) from the late harvesting (120 day after sowing) while it was comparatively lower for earlier harvesting periods (61.60% at 60 day and 67.08% at 90 days). This variation might be due to the reason that BMII has higher leaf material than *Brachiaria brizantha* ecotypes. According to Mustaring et al. (2014) who noted the NDF content of *B. brizantha*, *B. mulato* and *B. mutica* as 65.66, 63.66 and 71.96% at 8 weeks after planting, respectively. The current finding is similar to Nemera et al. (2017). The application of organic and inorganic fertilizer did not significantly affect the NDF content of natural pasture which might be interconnected with stage of harvest rather than treatments as plants at matured stage plants become lignified and had the highest neutral detergent fiber as indicated (Tessema et al., 2010). In contrast, the current finding by Nemera et al. (2017) reported that the effect of organic and inorganic fertilizer application on improvement of degraded grazing land of the grass using fertilizer and manure to decrease the NDF content for different grass species. This means that chemical fertilizer and manure improve the plant growth and raise new leaves and shoots, which minimize the NDF content of the grass. NDF concentration is the component most consistently associated with forage intake (Van Soest, 1994). According to Van Saun (2006), forage grass with less than 50% NDF described as high nutritive value whereas NDF greater than 60% is considered as low nutritive value. The current result of NDF content from experimental cultivar is classified as high nutritive value forage according to the same author classification.

In the current study, it has been observed that ADF content is increased as maturity of the plant. This is due to the fact that the structural cell wall components increase as plant gets matured because photosynthesis components are converted to structural components at the expense of soluble carbohydrates (Ammar et al., 2010). The ADF is the percentage of highly indigestible and slowly digestible material in a feed or forage for ruminant animals. Higher forage ADF results in reduced dry matter digestibility (DMD) as a consequence of increased lignification of cellulose in the latter stage of the plants development (Depeters, 1993). In the current study, ADF content is increased as maturity of the plant increases. An increase in ADF content in the current result with the advance in harvesting days of grass was reinforced by the results of Adnew et al. (2018) who showed that *Brachiaria brizantha* ecotypes harvested at 120 days after planting had a higher ADF (52.88) than that for samples harvested at 60 days and 90 days after planting (40.65 and 47.52%, respectively) which is greater than the result of the present finding (35.78% at 105 days). The current finding corresponds to the finding of Mustaring et al. (2014) who demonstrated that the ADF content of *B. brizantha*, *B. mulato* and *B. mutica* (38.21, 38.79 and 46.09%) are increasing with plant maturity. But among the *Brachiaria* cultivars, *B. mutica* scores higher ADF which is again higher as compared to the current result (35.51%). The variation might be due to the agro-ecology and season of the experiment where the research was conducted.

The result indicated that ADL was increased linearly with increased plant maturity. This is due to the reason that with the age increases, the level of lignin in plant also increases, which shows a rapid lignification to occur in the late development stage and the presence of insoluble fiber, particularly lignin lowers the overall digestibility of the feed by limiting nutrient availability (Van Soest, 1994). Therefore, forages with lower ADL concentrations are more desirable in livestock feeding (Ansah et al., 2010). The effects of chemical fertilizer and manure were not significantly different from DL concentration of BMII grass. This result is similar to Olanite et al. (2010) reporting that different nitrogen rates dis not significantly affect the ADL concentration of Columbus grass in southwest Nigeria. The current result is lower than that (Mustaring et al., 2014) reporting ADL content (8.18%) for BMII grass. The reason might be associated with environmental condition, soil type and management system of the grass.

5. Conclusion

The results of this study showed that most of the morphological traits of the grass were less affected by the interaction among fertilizer type and harvesting days. Therefore, based on this information, beneficiaries make their decisions based on the relative importance of forage yield and quality in their operations. BMII grass should be cultivated using manure to maximize biomass yield if accessible by smallholder farmers; otherwise, it is possible to use chemical fertilizer which could be an alternative to produce good quality forage. Hence, BMII grass harvested at 105 days of harvesting would be more beneficial to get high quantity yields and considered as an option to solve the shortage of feed.

Ethical Approval
This manuscript does not report on or involve the use of any animal or human data or tissue. So the ethical approval does not applicable.

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Availability of Data and Materials
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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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