Effects of Fertilizer Types and Plant Spacings on Plant Morphology, Biomass Yield and Chemical Composition of Brachiaria Hybrid Mulato II Grass Grown in Lowlands of Northwest Ethiopia

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Abstract
This experiment was conducted to evaluate the effects of fertilizer types and plant spacings on plant morphology, biomass yield and chemical composition of brachiaria hybrid mulato II grass grown using irrigation in lowlands of northwest Ethiopia. The experimental design used was a 3×3 factorial layout in a randomized complete block design with three replications which had a total of 27 plots, each measuring 2×2 m^2. The plant spacings were 15, 30 and 45cm between plants and fertilizer types were commercial fertilizer (NPS), cattle manure and control (without fertilizer). Morphological parameters such as plant height (PH), leaf length per plant (LLPP), number of leaves per plant (NLPP), number of tillers per plant (NTPP), leaf to stem ratio (LSR), number of roots per plant (NRPP),root length per plant (RLPP), root circumference(RC), leaf area index (LAI), biomass yield and chemical composition were collected. All the data were subjected to GLM ANOVA (Analysis of Variance) following the procedures of SAS (Statistical Analysis System). The result showed that most of the morphological parameters were significantly ($P<0.05$) affected by fertilizer and plant spacings. Similarly, significant ($P<0.05$) differences were observed in most of chemical composition of the grass by fertilizer type; but not by plant spacing except for DM (Dry matter) and CP (Crude protein). In the current study it can be concluded that fertilizer types had significant contribution on the brachiaria grass morphology and chemical composition grown in the lowland area of Ethiopia. The commercial fertilizer (NPS) fertilizer is recommendable for brachiaria hybrid grass production if it is accessible by smallholder farmers; otherwise, the use of manure could be the next option in the study area and in similar environments. Regarding plant spacing, for better biomass production intermediate plant spacing (30 cm x 50 cm) is recommended.

Keywords: Brachiaria Mulato II, Fertilizer type, morphological characteristics, plant spacing

1. Introduction

Ethiopia has been endowed with the largest livestock population in Africa [1], that contributes 15-17% of GDP and 35-49% of agricultural GDP and 37-87% of the household income [2]. The major livestock feed resources in Ethiopia are mainly natural pasture and crop residues and the lesser contributions are coming from improved pasture, forage crops and agro-industrial by-products [1]. To exploit the potential of livestock, use of improved forages is one of strategies in tropical areas including Ethiopia. Brachiaria grass is one of the most important tropical grasses distributed in Africa [3], South America, Asia, South Pacific and Australia [4]. It has high biomass production potential and produces nutritious herbage resulted in livestock productivity [5]. Brachiaria hybrid mulato II grass contains 12-16% CP and IVDMD 55-62% [6]. Besides their use as livestock feed, they are known

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to contribute significantly to carbon sequestration through its large roots system, enhance nitrogen use efficiency and reduce greenhouse gas emissions and nutrient losses from soils, soil erosion control, and ecological restoration [7].

Brachiaria grass has the potential of meeting the challenges of feed scarcity since it provides more forage per unit area and ensures regular forage supply due to its multi-cut nature [8-9]. Brachiaria hybrid mulato II grass is suitable for intensive management and performs well at an altitude up to 1800 m.a.s.l, rain fall 700 mm [10]. It is known that the forage management practices such as fertilizer application and spacing affects DM yield and forage quality [11]. In Ethiopia, there is limited information on the management practices that influence the herbage dry matter yield, chemical composition and animal performance of Brachiaria hybrid mulato II grass. There is a need to develop a management practice for Brachiaria hybrid mulato II grass so as to contribute to the efforts of introducing adequate quantity and quality feed for livestock through natural pasture improvement. Such attributed of forage quality are affected by interaction of plant morphology, environmental factor and stage of maturity [12]. The extent to which the fertilizer type and plant spacing effects on the productivity and nutritive value are not well known and documented in Ethiopia, particularly, for Brachiaria grass cultivar mulato II. Therefore, the objective of this study was to evaluate effects of fertilizer type and plant spacing on plant morphology, biomass yield and chemical composition of Brachiaria grass grown in irrigation in the lowland of northwest Ethiopia

2. Materials and methods

Description of the study area

The experiment was conducted in Pawe District at Mender 30 farmer training center located (36°03 E’- 11°09’ N) of northwest Ethiopia located at 562 km from Addis Ababa. The mean annual rain fall is 1540mm with the main rainy season (June-September) of 2017-2018.The altitude is 1120 meter above sea level and the mean temperature is 32.7°c and soil sample analysis of the experimental plot is pH 5.878, P 20.997 ppm, organic carbon 3.609%, Organic matter 3.733% and total nitrogen is 0.191% and soil classification is clay 30%, silt 29.6% and sandy 40.4% and soil texture is clay loam soil. The major farming system of the area is a mixed crop-livestock production system.

Experimental layout, Design and Treatments

The experimental design used in the current study was a factorial arrangement of treatments in randomized complete block design (RCBD) consisting of 2 factors (fertilizer type and plant spacing) with 3 replications. There were three blocks, each containing nine plots resulting in twenty-seven plots in total with each plot measuring 2 m x 2 m. The experiment had a total of 9 treatments with a factorial combination of three levels of intra-row spacing/plant spacing between plant (15 cm, 30 cm and 45 cm) and was compared at 3 fertilizer application (organic, inorganic and without fertilizer). In all treatments inter-row spacing was 50 cm. The spacing between block and plots was 2 meter and 1 meter, respectively. The total experimental area is 10×26 m (260 m^2) with individual plot size of $4m^2$and net plot area (harvestable area) was 2 m^2 (1m*2m) used by excluding one outer row on both sides of each plot and 0.075 m for 0.15 m, 0.15 m for 0.30 m and 0.22 m for 0.45 m row length and 0.25 m for 0.5 m row width were subtracted during planting on both ends of the rows to avoid possible border effects.

The planting material grass was collected from Pawe Agricultural Research Center experimental site. Before planting, the experimental land was first cleared of weeds and then back-hoe, three times before subdividing it into blocks and plots. Before digging out the Brachiaria hybrid mulato II grass from the established area, the biomass was trimmed almost equally to facilitate re-growth after transplanting. The Brachiaria hybrid mulato II grass was planted on the experimental plot in December 2018 by root split propagation mechanism. Cattle manure was applied at the rate of 5.5 ton $ha^{-1}$and chemical fertilizer (NPS) was applied at the rate of 100 kg ha^{-1}during planting. Weeds were controlled by hand weeding to avoid competition for nutrients.

Data Collection

The morphological data and yield parameters were collected after three months of planting. In each plot five plants were randomly selected to record number of tiller per plant (NTPP), total number of leaves per plant (TLPP), leaf length per plant

(LLPP), number of root per plant (NRPP), root length per plan(RLPP), leaf to stem ratio (LSR), root circumference(RC) and leaf area index(LAI). Mean plant height from each treatment was determined by measuring the height of five randomly selected plants from ground level to the tip of the apical meristem. Sample tillers from each randomly-taken plant were used to determine the number of leaves per tiller (NLPT) [11].

Morphological parameters

Measurement of plant height, number of tillers per plant and number of leaves per plant

The heights of five randomly selected plants were measured from the base of the plant to the tip of the tallest leaf. The height of each plant was recorded in centimeters, and the mean values of five plants for each plot were determined. The number tillers per plants were counted from the randomly selected sample of five plant of each plot to calculate the mean of tillers number per plant. The number of leaves per tiller was counted from the sample of five tillers from the plot. The mean value of number of leaves per plant was calculated. These parameters were done according to [11] procedure.

Leaf length per plant

Leaf length per plant was measured from the base of the collar region of the leaf to the tip of the leaf. It was measured from five randomly selected sample plants from the two rows at each plant spacing [13].

Number and length of root per plant and root circumference

At the end of harvesting (120 days), five sets of root samples were collected from all plots. The procedure was conducted cautiously to avoid root damage and losses. The five sets of samples from each plot were washed gently using tap water to clean it from any residual soil and other debris. The numbers of roots per plant were counted and mean was calculated. Length of root was measured from the crown part to the tip of the root and their mean was calculated [13]. Similarly, each root circumference was calculated.

Leaf to steam ratio and leaf area index

The leaf to stem ratio of Brachiria hybrid cv. mulato II accession was calculated by measuring the fraction of weight of leaf of plants sampled to the weight of stem of plants sampled [11]. The leaf area index (LAI) was also calculated by measuring by the fraction of harvesting the vegetative part of leaf to the leaf area within a certain ground surface area [14].

Dry matter and crude protein yield

Dry matter yield was determined by harvesting in the central portion of the plot using 2 m^2 quadrant and the plants cut at the height of 5 cm from the ground level. The samples were weighed fresh using a spring balance; then sub-samples of about 500 g fresh plants were taken from the sample and weighed fresh after which they were air dried to give partial dry matter. Leaf and stem dry weight divided by leaf and stem fresh weight and multiplied by 100 to determine partial DM% for each sample. On the basis of these partial DM% and fresh biomass yield from the sample area of each plot were used to calculate total dry matter yields for each plot, thereafter, converted to metric tons [13].

Chemical Analysis

After drying, samples were ground to pass a 1-mm Wiley mill screen and stored in airtight containers pending for chemical analyses. Samples of each were subjected to chemical analysis such as dry matter, organic matter and crude protein following [15] procedure. Nitrogen analysis was conducted using Kjeldhal procedure, while Acid Detergent Fiber (ADF), Neutral Detergent Fiber (NDF) and Acid Detergent Lignin (ADL) were analyzed using [16]. Dry matter yield (DMY) was multiplied with CP content of the feed samples to determine Crude Protein Yield (CPY).

Statistical Analysis

Data on agronomic parameters and quality of forage samples were subjected to ANOVA based on the General Linear Model (GLM) designed for a factorial design. To compare significant differences in response variables, ANOVA analysis was done using SAS package (SAS 2007). Duncan's Multiple Range Test was carried out for subsequent comparison of means. Means were compared using significance level of 5% ($p<0.05$). Since there was no statistical significant difference on main factors interaction so it is not included in the model.

The statistical model for analysis of the data was:

$Yijk=\mu+Fi+Sj+eijk$, where:

Yijk=all dependent variables (morphological data and chemical composition) collected
μ=over all mean
F_i=the effect of i^{th} fertilizer types (control, chemical and manure)
Sj=the effect of j^{th} spacing between plants (15, 30 and 45 cm)
Eijk=random error
For correlation analyses of parameters such as morphological characteristics, chemical composition and yield, simple Pearson correlation was employed.

3. Results and discussion

Effects of fertilizer type and plant spacing on morphological characteristics and dry matter yield of brachiaria hybrid mulato II grass

The effects of fertilizer type and plant spacing on morphological characteristics of brachiaria cv. mulato II grass are presented in Table 1. Plant height was significantly (P<0.05) affected by fertilizer type and not by plant spacing. The highest mean plant height was observed for commercial NPS fertilizer followed by manure and control (79.31cm, 77.89cm and 64.56 cm), respectively.

Number of tillers per plant
The effect of NPS fertilizer and manure application were highly significant (P<0.01) affected number of tiller per plant (NTPP). The highest mean NTPP was observed from NPS fertilizer followed by manure and control (31.1, 27.67 and 21.5) respectively. In line with plant spacing there was highly significant difference (P<0.001) of NTPP of brachiaria hybrid mulato II grass. There was significant difference (p<0.01) in number of tillers per plant as the application fertilizer in the experimental plot.

Leaf length per plant
Fertilizer application had significant effect (P<0.05) on LLPP of brachiaria grass while plant spacing was not significant. The highest mean of LLPP was observed chemical fertilizer than manure and control plot (34.2 cm, 32.1 cm and 28.8 cm) respectively. The effect of NPS fertilizer application was significantly different of leaf length than the control. The current result supported by Mihret et al. (2018) [13] who revealed that chemical fertilizer and manure were significantly difference on LLPP of desho grass. Other researcher revealed that the application of manure (cow dung and chicken) were significant affected of leaf length *Elephantopus scaber* [17].

Table 1. Morphological characteristics of brachiaria hybrid cv. mulato II grass as affected by fertilizer type and plant spacing

Parameter	Factors										SE	R^2	CV%
	Fertilizer type					Plant spacing							
	NPS	Manure	Control	Mean	Sig.	15x50	30x50	45x50	mean	Sig.			
PH (cm)	79.31^a	77.89^a	64.56^{ab}	73.92	*	78.3^a	70.78^a	72.68^a	73.92	Ns	2.47	0.55	14.86
LLPP (cm)	34.2^a	32.1^{ab}	28.8^b	31.72	*	34.2^a	31.2^a	29.8^a	31.72	Ns	0.96	0.39	15.59
NTPP (count)	31.1^a	27.67^a	21.5^b	26.76	**	15.2^c	28.4^b	36.7^a	26.76	***	2.06	0.88	17.76
NLPP(count)	287.7^a	273.2^a	194.7^b	251.87	**	133.54^c	260.3^b	362.89^a	252.2	***	21.94	0.85	22.05
LSR	1.15^{ab}	1.38^a	0.93^b	1.15	*	0.97b	1.1^{ab}	1.39^a	1.15	*	0.08	0.62	27.41
NRPP(count)	147.62^a	126.97^{ab}	120.78^b	131.79	*	103.76^b	139.24^a	152.39^a	131.79	***	6.69	0.73	17.38
RLPP(cm)	36.24^a	35.61^a	31.57^b	34.47	**	34.27^a	35.4^a	33.74^a	34.47	Ns	0.78	0.72	8.17
RC	154.9^a	145.2^a	148.7^a	149.6	ns	147.4^a	158.6^a	142.7^a	149.6	Ns	6.86	0.77	14.43
LAI	2.29^a	2.14^a	1.94^a	2.12	ns	1.78^b	1.89^b	2.69^a	2.12	***	0.13	0.77	19.06
DMY(t/ha)	18.28^a	13.89^b	11.61^b	14.59	**	16.83^a	15.72^a	11.22^b	14.59	*	1.07	0.71	26.37

*=significant at 0.05;**=significant at 0.01;***=significant at 0.001; mean within column followed by the same letter are not significant different; SEM=standard error of the mean; CV=coefficient of variation; PH=plant height; LLPP=leaf length per plant; NTPP=number of tiller per plant; NLPP=number of leaf per plant; LSR=leaf stem ratio; RNPP=root number per plant; RLPP=root length per plant; RC=root circumference; LAI=leaf area index

Manure is easily decomposed so that root can absorb more nutrient ions to be used in photosynthesis [18].
However, plant spacing was not significant in the study area. On the contrary, plant spacing was significant difference of LLPP of desho grass [13, 19]. This is agreement with other report that other plant species [20] who report that plant spacing has significant difference length of tuber arrowroot plants. This might be due to

environmental condition, agro ecology, genetic makeup and soil nutrient.

Number of leaves per plant

The effect of fertilizer type (commercial NPS and manure) were highly significant (P<0.01) effect NLPP of brachiaria hybrid mulato II grass (Table 3).The highest mean of NLPP was observed by NPS fertilizer followed by manure and without fertilizer treatment. Similarly, as plant spacing increase there was an increase in the NLPP of brachiaria hybrid cultivar mulato II grass. The number of leaf per plant (NLPP) of brachiaria hybrid mulato II grass was significant due to the effect of plant spacing (P<0.01).

Leaf to stem ratio

Leaf to steam ratio (LSR) was significantly (P<0.05) affected by fertilizer type and plant spacing. The highest leaf to stem ratio was observed at manure than NPS fertilizer application and control. The highest leaf to stem ratio was observed at wider spacing followed by intermediate and narrow plant spacing (1.39, 1.1 and 0.97) respectively, while the interaction was not significant (P<0.05).

Root number per plant

NPS commercial Fertilizer and manure were significant (P<0.05) affect NRPP of brachiaria hybrid mulato II grass. Similarly plant spacing was highly significant (P<0.01) difference of NRPP of brachiaria hybrid mulato II grass. As plant spacing increased there was an increase in NRPP of brachiaria hybrid grass. Means 45 x 50 cm of plant space was observed 152.39 followed by 30 x 50 cm of 139.24 and 15 x 50 cm was 103.76 of number of root per plant of brachiaria grass. The highest mean NRPP was observed for wider plant spacing while the lowest number was recorded at narrow plant spacing.

Root length per plant

The effect of chemical fertilizer (NPS) and manure were highly significantly (P<0.01) affected of root length per plant of brachiaria hybrid mulato II grass (Table 3). The highest mean of RLPP was observed by NPS fertilizer application followed by manure and without fertilizer (36.24 cm, 35.61 cm and 31.57 cm), respectively.

Leaf area index and root circumference per plant

Plant spacing was highly significant (P<0.05) difference of Leaf area index (LAI) of brachiaria hybrid grass while NPS fertilizer and manure application were not significant of this parameter. As plant spacing increase from 15 x 50 cm, 30 x 50 cm and 45 x 50 cm were observed 1.78, 1.89 and 2.69 respectively. The effect of plant spacing was significant difference LAI of brachiaria hybrid mulato II grass in the study area. As plant spacing increase with increase leaf area index, however, leaf area index is decrease as plant maturity. This reflects that loss some existing leaves through senescence. The highest mean leaf area index was observed as wider space (2.69) than narrow space (1.78).

Dry matter yield

In the current finding, dry matter yield (DMY) of the brachiaria hybrid mulato II grass was highly significant affected (P<0.01) by fertilizer type and plant space (Table 3). The highest mean dry matter yield was observed for NPS fertilizer application while the lowest value of dry matter yield of brachiaria grass was recorded for without fertilizer application.

Chemical composition of brachiaria hybrid mulato II grass

Dry matter content

There was a significant (P<0.05) effect between fertilizer type and plant spacing on dry matter content of Brachiaria hybrid mulato II grass (Table 2). The highest dry matter content was observed for NPS fertilizer than manure and control experiments. Moreover, in plant spacing high dry matter content (90.21% and 90.14%) was obtained at intermediate (30 cm) and narrow (15 cm) plant spacing. while relatively the lowest dry matter content (89.87%) was observed at wider plant spacing. Therefore, the result showed that, the DM content was higher in intermediate plant spacing than wider spacing.

Crude protein content and crude protein yield

Chemical fertilizer and manure were significantly affected (P<0.05) crude protein content (CP %) of brachiaria hybrid mulato II grass. The highest mean crude protein (CP %) was observed for NPS fertilizer (11.08%) while the lowest value crude protein content (CP %) of brachiaria hybrid mulato II grass was recorded for the control plot (10.4%). The effect of plant spacing on the crude protein content of brachiaria grass was significantly affected (P<0.05) in the study area. Similarly crude protein yield was significant affected (P<0.05) by fertilizer type.

While plant spacing was not affectd CPY of brachiaria hybrid cv. mulato II grass. The highest mean crude protein yield (CPY) was observed for NPS (1.81 t/ha) while the lowest value was recorded for the control (1.21 t/ha).

Table 1. Chemical composition of brachiaria hybrid mulato II grass as affected by fertilizer type and plant spacing

Parameter	Factors										SE	R2	CV%
	Fertilizer type					Plant spacing							
	NPS	Manure	Control	Mean	Sig.	15x50	30x50	45x50	Mean	Sig.			
DM %	90.2a	90.19a	89.91b	90.1	*	90.14a	90.21a	89.87b	90.1	*	0.07	0.84	0.19
Ash %	14.26b	14.93a	15.57a	14.92	**	14.92a	15.09a	14.75a	14.92	Ns	0.18	0.81	3.24
OM %	85.74a	85.07b	84.43b	85.08	**	85.08a	84.91a	85.25a	85.08	Ns	0.18	0.81	0.57
CP %	11.08a	10.44b	10.4b	10.65	*	10.19b	10.7ab	11.06a	10.65	*	0.14	0.79	3.77
CPY (t/ha)	1.81a	1.35ab	1.11b	1.42	*	1.54a	1.51a	1.21a	1.42	Ns	0.13	0.78	23.1
NDF %	61.7b	61.6b	62.43a	61.91	*	61.97a	62.06a	61.76a	61.92	Ns	0.21	0.81	0.82
ADF %	31.01a	31.34a	31.42a	31.26	ns	31.39a	31.23a	31.16a	31.26	Ns	0.24	0.63	2.90
ADL %	4.11a	4.27a	4.23a	4.2	ns	4.23a	4.23a	4.1a	4.2	Ns	0.03	0.47	3.64

*=(p<0.05) significant; **=significant at (p<0.01), ns=non-significant at 0.05; SEM=Standard Error of mean; DM=Dry Matter%; Ash=Ash%; OM=Organic Matter%; NDF=Neutral Detergent Fiber%; ADF=Acid Detergent Fiber%; ADL=Acid Detergent Lignin%; CP=Crude Protein% and CPY=crude protein yield in ton.

Ash content

The interaction between fertilizer type and plant spacing were no significant (P>0.05) effect on the total ash content of Brachiaria hybrid mulato II grass. In the current study total ash content was significantly affected (P<0.01) by fertilizer type. From all type of fertilizer type (NPS, manure and control) was resulted in higher ash concentration from control followed by manure and NPS fertilizer application (15.57, 14.93 and 14.26) respectively. However, plant spacing was not significantly difference (P<0.05) total ash content.

The highest mean total ash content was obtained in without fertilizer type compared with manure and NPS fertilizer application.

Neutral detergent fiber

The interaction between fertilizer type and plant spacing were no significant (P>0.05). But the effect of fertilizer type on NDF content had shown significant different (P<0.05). The highest mean NDF content was recorded without fertilizer, so it indicates that as application of fertilizer increases the NDF decreases. This may be elucidate that the urea fertilizer improves the plant growth and raise new leaves and shoots, which minimizes the NDF content as the urea fertilizer level increased, but there is no rejuvenation of leaves and tillers in the non-fertilizer treatments as a result plant tissue matures and accumulate more NDF.

Acid detergent fiber

In the current study, acid detergent fiber content (ADF) and acid detergent lignin of brachiaria cv. mulato II grass were not significantly affected (P>0.05) by both fertilizer type and plant spacing in the experimental period. The current finding was the application of chemical fertilizer was no significant difference on ADF content of brachiaria cultivar mulato II grass.

Acid detergent lignin

The effect of chemical fertilizer and manure were not significant difference of ADL concentration of brachiaria cultivar mulato II grass. This result is, similarly to Olanite's et al. (2018) [41] report that different nitrogen rate was not significantly affecting ADL concentration of Columbus grass in southwest Nigeria.

Correlation among morphological characteristics and chemical composition of brachiaria hybrid mulato II grass

The simple linear bivariate correlation analyses among morphological characteristics and chemical composition of brachiaria hybrid mulato II grass are presented in Table 3. Dry matter yield is positively correlated with leaf length per plant, root circumference, crude protein yield, organic matter and neutral detergent fiber with each other, but negatively correlated (P<0.05) with ash.

Table 3. Correlation analysis of morphological parameters and chemical composition of brachiaria (hybrid mulato II) grass

	DM	DYM	CP	CPY	Ash	OM	NDF	ADF	ADL	PH	LLPP	NTPP	NLPP	LSR	NRPP	RLPP	RC	LAI
DM	1	0.04	-0.36	-0.01	-0.43*	0.43*	0.21	-0.37	0.12	-0.31	-0.12	-0.22	-0.22	0.34	0.11	0.17	0.37	0.07
DMY		1	0.15	0.99***	-0.49*	0.49*	0.57**	-0.18	-0.18	0.24	0.46*	-0.08	0.06	0.13	0.23	0.34	0.55**	0.34
CP			1	0.3	-0.38	0.38	-0.11	-0.25	-0.23	-0.08	0.08	0.69**	0.68**	0.10	0.25	0.24	0.19	0.27
CPY				1	-0.52**	0.52**	0.52**	-0.22	-0.23	0.2	0.44*	0.04	0.06	0.15	0.29	0.36	0.55**	0.36
Ash					1	-1.0***	-0.09	0.4*	-0.38	-0.07	-0.39*	-0.14	-0.16	-0.12	-0.39*	-0.29	-0.38	-0.48*
OM						1	0.09	-0.4*	0.22	0.06	0.39*	0.14	0.16	0.12	0.39*	0.29	0.38	0.48*
NDF							1	-0.02	0.63**	0.09	0.06	0.05	0.08	0.38	0.14	0.52**	0.71**	0.44*
ADF								1	0.59**	0.42*	0.07	-0.23	-0.25	-0.68**	-0.34	-0.38	-0.54**	-0.05
ADL									1	0.26	-0.01	-0.16	-0.11	-0.06	-0.23	-0.06	0.09	0.42*
PH										1	0.71**	-0.24	-0.25	-0.08	-0.38	-0.58**	-0.29	-0.02
LLPP											1	-0.30	-0.36	-0.04	-0.03	0.26	0.09	-0.45*
NTPP												1	0.98**	0.26	0.41*	0.19	0.22	0.44*
NLPP													1	0.24	0.39*	0.14	0.19	0.53**
LSR														1	0.09	0.71**	0.53**	0.27
NRPP															1	0.22	0.46*	0.48*
RLPP																1	0.67**	0.35
RC																	1	0.35
LAI																		1

Level of significance:**=P<0.01;*=P<0.05; DM=dry matter %; CP=crude protein%; Ash=ash%;OM=organic matter %; ND=neutral detergent fiber%; ADF=acid detergent fiber%; ADL=acid detergent lignin%; LLPP=leaf length per plant; NTPP=number of tiller per plant; NLPP=number of leaf per plant; PH=plant height; LSR=leaf to stem ratio; NRPP=number root per plant; RLPP=root length per plant; RC=root circumference per plant; LAI=leaf area index

Crude protein content was positively correlated with number of leaf per plant and number of tiller per plant. Crude protein yield was positively correlated with leaf length per plant, root circumference, organic matter and neutral detergent fiber while negatively correlated with ash content. The NDF content was positively correlated ($P<0.05$) crude protein yield, acid detergent lignin, dry matter yield and other morphological parameters such as root length per plant, root circumference and leaf area index. ADF was positively correlated ($P<0.05$) with neutral detergent fiber, acid detergent lignin, plant height and root circumference while negatively correlated with leaf stem ratio. ADL was positively correlated ($P<0.05$) with neutral detergent fiber, acid detergent fiber and leaf area index.

Plant height was positively correlated ($P<0.05$) with leaf length per plant and acid detergent fiber while negatively correlated with root length per plant. Leaf length per plant was positively correlated ($P<0.01$) with plant height, dry matter yield, crude protein yield, organic matter while negatively correlated with total ash content and leaf area index.

Number of tillers per plant was positively correlated ($P<0.001$) number of leaf per plant, number of root per plant, leaf area index and crude protein content. Similarly number of leaves per plant was positively correlated ($P<0.001$) number of tiller per plant, number of root per plant, leaf area index and crude protein content. Leaf stem ration was positively correlated ($P<0.01$) with root length and root circumference but negatively correlated acid detergent fiber. Number of root per plant was positively correlated with number of tiller per plant, number of leaf per plant, root circumference, leaf area index and organic matter content but negatively correlated with total ash. Root length per plant was positively correlated with leaf stem ratio, root circumference and neutral detergent fiber however negatively correlated with plant height.

The mean plant height (PH) of brachiaria (hybrid mulato II) grass in the current study was lower than earlier reports [6] for the same species. The reason might be associated with differences in the environmental conditions (soil type and fertility, temperature and altitude) and management practices applied on the plant. Similarly, the plant height obtained in the present finding was higher (73.92 cm) than the results of Rambau et al. (2016) [21] who reported that, plant height for Napier grass was 58.5cm after 12 weeks. In addition to the current result was higher than Damry and Syukur (2009) [22] report that different rate of urea application was plant height of 62.67 cm brachiaria hybrid mulato II grass in Indonesia. The differences in plant height could be attributed to soil fertility, management and climatic conditions.

Additionally, Mustaring et al. (2014) [23] indicated that, Brachiaria mutica had the highest plant height (207.47cm) than B. brizantha and Brachiaria mulato at 8 week of harvesting. Similarly, the present finding is less than the finding of Mustaring et al. (2014) [23] at the same grass. The reason for this variation may be due to different management system and agro ecology. The current results agree with the result of Tilahun et al. (2017) [19] who reported plant height was not significant due to variation between spacing of plants. In line with Velayudham et al. (2011) [24] noted that different spacing did not significantly influence the height of bajra napier hybrid grass in Coimbatore. Whereas application of higher dose of NPK 200: 70: 60 kg/ha had a marked effect on the growth and the plants grew taller. An adequate supply of nitrogen is essential for vigorous vegetative growth. The expected increment of plant height is application of fertilizer which improves soil nutrients results increase plant growth.

The number of tillers observed in line with fertilizer application study is in line with the study conducted by Kizima et al. (2015) [25] who reported that application of optimal level of nitrogen fertilization significantly affects the appearance of new tillers and increases the dynamics of tiller population of *Cenchrus ciliaris*. Moreover, the present result are also supported by the findings of Mushtaque et al. (2010) [26] who reported that Nitrogen triggers the activation of dormant buds and enhances the vegetation sward filling through the highest rate of tiller replacement, which supports a higher proportion of very active healthier young tillers for each plant. Means mulato II grass appears to efficiently absorb the increased nitrogen provided in the soil and use it to form new plants as indicated by increased tillage number associated with urea fertilizer and at the same time increased synthesis rate of nitrogenous substances of the plant tissues, either as protein or non-protein nitrogen.

This suggests stronger effect of genetic makeup and tiller capacity. Damry and Syukur (2009) [22] elucidated that different levels of urea fertilizer application was significant effect of tiller number of brachiaria hybrid mulato II grass. The effect of manure had shown intermediate value of NPS and control treatment. The NTPP obtained in the present finding was lower (26.76) than Mustaring et al. (2014) [23] who reported that, Brachiaria mulato was 117 tiller number of brachiaria mulato II grass after 8 weeks. The reason for this variation may be due to different management system, soil type and agro ecology.

In line with Berihun et al. (2005) [27] showed that the general trend of tiller increased as the spacing between plants and rows increased in Bana grass. The reason might be the fact that at wider spacing light can easily penetrate to the base of the plant this may have stimulated tiller development. In so far as, under wider spacing competition of environmental resource reduced especially light, space. As narrow spacing, lower tiller count than wider spacing due to high consumption for resources. The increase competition causes reduced growth and tillering capacity. So that overcrowding results in neighboring plants producing weak tillers [28]. Therefore, the competitor plants are forced to grow upright to dominate other tillers produced on the same plant rather than expanding laterally by bearing more tillers.

The significant value in the number of leaves per plant is in agreement with report of Mihret et al. (2018) [13] revealed that NPS fertilizer and manure were significant affect NLPP of desho grass. This means application of fertilizer augment of NLPP than without fertilizer application of the experiment. These results disagree with Riyana et al. (2018) [17] showed that manure has no significant effect on the tapak liman (*Elephantopus scaber* L) leaves number. The current finding observed that with the increase plant spacing, the greater the numbers of leaves which are an important for the photosynthetic and transpiration surface were produced from the newly emerging tillers. In addition to this more leaves per plant were produced at the wider plant spacing. This might be attributed to less competition between plants which resulted in taller plants and better growth of leaf which supports more leaves.

According to Qodliyati and Nyoto (2018) [20] report that plant spacing was significant difference of number of leaves per plant of arrowroot. Plants with a wide spacing will receive more light than plants with a narrow spacing. Plants that receive more light tend to have more leaves than the less one. This is because the more light received, the photosynthesis will goes well [29].This result disagree with Riyana et al. (2018) [17] report that plant spacing did not give significant difference of NLPP of tapak liman (*Elephantopus scaber* L) in Indonesia. The variation in the NLPP may come from the difference in their nature and nutrient in the soil over the extended growing period of the grass in the study area.

The effect of plant spacing was significant difference of LSR of brachiaria hybrid mulato II grass agree with the result of Berihun et al. (2005) [27] who reports that LSR increase with increased as the spacing between plants and row increase in bana grass. Similarly in line with Ishiaku et al. (2016) [30] report that as plant spacing increase with increase LSR of Columbus grass. This is the fact that Leaves expositions from narrow spacing were smaller in length compared to those from wider spacing Begna et al. (2000) [31]. Means competition of resource is reduced meaning individual plant bearing more leaves. Leaves are higher in quality than stems and the proportion of leaves in forage declines as the plant matures [32]. Generally, leaf stems ratio increase with increase plant spacing. Moreover, chemical fertilizer and manure application were significant difference of LSR of brachiaria hybrid grass.

The result of root number per plant in the current finding is similar to the results of Mihret et al. (2018) [13] and Sultana et al. (2012) [33] plant spacing of wider plant spacing was high number of root per plant of forage grass. The result is argued to Barros et al. (2002) [34] evince that, the root number per cassava plant is greater in plants with wider plant spacing, but yield per area is higher with narrower spaced plants. Chemical fertilizer and manure were significant difference NRPP of brachiaria hybrid mulato II grass. Similarly, the current result agrees with the results of Mihret et al. (2018) [13] who reveal that NPS and manure application were significantly difference of NRPP of desho grass. On the contrary, results of Chan et al. (1994) [35] who report that fertilizer application was not significant difference root number per plant. This might be due to fact that environmental condition, soil type and management system of the plant.

The root length per plant observed in this finding is the current results agree with Mihret et al. (2018) [13] who report that application of manure and chemical fertilizer were significant difference of desho grass. Moreover, the current result is similar to John (2006) [36] using organic and inorganic fertilizer increase dipper root and branched root patterns. This is disagreeing with Riyana et al. (2008) [17] report application of manure (cow dung and chicken) was not significant difference root length of takap liman (*Elephantopus scaber* L). The current result of plant spacing was not significant difference of root length of brachiaria hybrid mulato II grass. However, the current result contradicts to Mihret et al. (2018) [13] who report that plant spacing was significant difference of RLPP of desho grass. Also, other author, report that plant spacing was significantly affect root length of plant. According to Moniruzzaman (2011) [37] report that plant growth in wider spacing produce the highest root length due to the low density of plants per unit area.

The leaf area index observed in the current result agrees with Tajul et al. (2013) [38] report that lower plant density and higher application of nitrogen is higher LAI of maize. The increased LAI might be due to the increased availability of N under the higher levels of N-fertilizer with lower population, which resulted in larger leaves. Reduction of LAI might be due to an interplant competition of nutrient and space [39]. Plants with a wide spacing will receive more light than plants with a narrow spacing. Plants that receive more light tend to have more leaves than the less one. This is because the more light received; the photosynthesis will go well [29].

Opposite to the current result, Streck et al. (2014) [40] reported that treatments with smaller spacing had higher LAI throughout the development cycle, and the maximum LAI (7.6) was observed at the 0.8 m spacing, followed by 1.0 m, 1.2 m and 1.5 m spacing, with LAI of 5.3; 4.6 and 3.3, of cassava plant respectively. The same author report that plant spacing and nitrogen level were significantly different of leaf area index of coleus in Jabalpur. The increased DMY observed due to change of fertilizer and plant spacing is in line with the current study is agreement with the findings of Olanite et al. (2018) [41] report that plant spacing and nitrogen fertilizer level affect DM yield of Columbus grass (*Sorghum almum* stapf). Moreover, the current finding is similar to Hassen et al. (2015) [42] the highly significant effect of chemical fertilizer on natural pasture might be due to the fact that grasses are more responsive to application of nitrogen fertilizer than organic fertilizers such as cattle manure in the first year of growth.

According to Siddiqui et al. (1994) [43] application on nitrogen to Mott grass increased its DMY significantly over control. This result is supported by different researchers Mihret et al. (2018) [13] and Sumran et al. (2009) [44] who reported that plant spacing was significant effect on DMY of napier and desho grass respectively. However, this study is in contrary to report by [19] plant spacing did not show significant difference of DMY of desho grass. The reason might be due to environmental condition, agro-ecology and management aspect. Generally, the highest DMY at the narrow spacing could be attributed to more number of plants per unit area, the higher the plant population, the greater the amount of total DMY compared to wider plant spacing this result comparable to other reports [13]. In general, the production of greater forage per hectare is very important for producers. However, production of forages with high nutritive value is also important for livestock producers. As a result, high production of forage is a viable option for farmers in the mixed crop-livestock production systems of Ethiopia.

The DM production potential of the grass in the present finding was lower than Hassen et al. (2015) [45] for *Panicum coloratum* and *Chloris gayana* grass (93.4%, 93%). The reason might be associated with species difference and environmental condition. The current finding is contradict to [42] who reported that application of fertilizer rate was not significant effect on dry matter content of *Cenchrus ciliaris* and *Panicum maximum* grass. However, the reports of Mihret et al. (2018) [13] indicated tha type of fertilizer and plant spacing were no significant effect of dry matter content of desho grass. The current result is agreed with Tilahun et al. (2017) [19] reported that plant spacing was significant effect of dry matter content desho grass. Moreover, the current result conformed by Berihun et al. (2005) [27]

revealed that plant spacing pattern was significant (P<0.05) affected of DM content of bana grass. In the current study, the CP value for the brachiara hybrid mulato II grass was less than the value of brachiaria mulato II reported by Inyang et al. (2010) [46]. The reason might be associated with different of soil fertility level; agro ecology, use of fertilizer and management system on the plant.

The CP content obtained in this study agreed to other studies [13, 47] who reported decrease in CP content of grasses with narrow plant spacing and poor management the grass. The highest CP content (11.08%) and lowest CP content (10.4%) CP was recorded in plants which type of NPS fertilizer application and without fertilizer, respectively. Hence, this study agreed with Aderinola et al. (2015) [49], McRoberts et al. (2018) [50] reported that crude protein content increase in forages with the addition of fertilizer. According to Ahmad et al. (2011) [54] CP was affected significantly by different source of fertilizers so statistically the maximum crude protein (10.76%) inorganic fertilizer application on oat. The highest CP content was exhibit at wider spacing and intermediate plant spacing while lowest crude protein was recorded at narrow plant spacing (10.19%). This result indicated that CP content in samples harvested during the experiment period significantly increasing in plant spacing increasing. The higher CP content in plants harvested at the middle and wider spacing might be attributed to higher absorption of nitrogen available in the soil with low competition as compared to higher plant density under narrow spacing. This effect might be due to less efficient soil total nitrogen exploitation at high plant densities [13]. The positive trend in CP content on wider spacing could also be attributed to a higher number of tillers promoting higher proportion of leaf material which contains higher CP compared to the other morphological fractions of plants.

In the contrary, Tilahun et al. (2017) [19] indicated that pant spacing did not significant (p>0.05) effect of CP content of desho grass. The effect of manure and NPS fertilizer application were significant difference on CPY of brachiaria cv. multo II grass. The current result, agree to the result of Mihret et al. (2018) [13], who report fertilizer application had significant effect of CPY of desho grass. Because of as application of fertilizer which improve soil nutrient results increase CP and biomass yield consequently higher CPY. Similarly, the current result support by Tilahun et al. (2017) [19] plant spacing was not significant difference of CPY for desho grass. Spacing, intercropping and their interaction had no significant effect on crude protein yield (CPY) of the Napier grass [48]. Spacing 75 x 75 cm also gave higher protein yield (300 kg/ha) than 50 x 75, 50 x 50 and 50 x 25 cm spacing which gave a CP yield of 240, 220 and 227 kg/ha, respectively [51].

In general, the mean CP content of the brachiaria grass in the current study was higher than the critical value of 7% required for normal rumen microbial function and feed intake [52]. Pasture and other roughage feeds are classified as high, medium and low quality according to their CP contents. The brachiaria hybrid mulato II grass evaluated in this study could be classified as high quality feed based on their CP contents. In addition, indicated proper utilization of the DM of feeds when CP content is higher than the critical value of 7%. The present ash content of Bracharia Mulato II agrees with that reported by Hassen et al. (2015) [42] who noted that decreased ash content as a result of an increase in the level of urea application. In contradict to Solomon et al. (2009) [55] reported that ash content increased application of inorganic, organic and mixed both type of fertilizer than without fertilizer forage of oat (*Avena sativa* L.).

In the present study, the NDF content of the brachiaria was lower than the value reported for field pea [55]. However, the NDF concentration in the current study was higher than the value of desho grass [19]. The current finding is similar to Nemera et al. (2019) [56] who reported that the effect of organic and inorganic fertilizer application on improvement of degraded grazing land of the grass by using fertilizer and manure to decrease NDF content for different grass species. This is means, chemical fertilizer and manure improves 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 [52]. On the other hand, the current finding supported by Mihret et al. (2018) [13] who reported that NPS fertilizer and manure were significant difference of NDF content of desho grass.

According to Buxton (1996) [57], intake potential of feeds is negatively related with NDF contents.

The NDF content of some of the varieties grown as intercropping were similar to the critical level of 55-60%, which was reported to decrease voluntary feed intake and feed conversion efficiency due to longer rumination time [58]. Similarly, Adugna and Said (1994) [59] reported that total cell wall concentration (NDF) exceeding 60% was reported to be associated with lower voluntary feed intake, longer rumination period and decreased efficiency of conversion of ME to net energy. According to Singh and Oosting (1992) [60], roughage diets are categorized into average quality feed, if NDF content is between 45%-65%, and feed, which had below 45% NDF contents were generally classified as high quality roughage feed. In the current study, the mean of NDF concentration (61.92%) of brachiaria grass was considered average quality feed.

The ADF values of brachiaria grass in this study was lower than the values of desho grass reported [13, 19] faba bean and forage oats [61]. Kellems and Church (1998) [62] characterized roughages with less than 40% ADF as high quality and above 40% as low quality. Likewise, legumes with ADF contents less than 31% are considered as high quality, although those with values greater than 55% are rated as poor quality. Hence, the lower value of ADF in this study could be indicative of its better digestibility of rumen.

This result is reinforced by Olanite et al. (2018) [41] who report that the application different rate of N (60, 20 and 180 kg) were not significant difference of ADF content of Columbus grass in southwest Nigeria. The current finding is similar to Marques et al. (2017) [63] who reports that ADF concentration of brachiaria cultivar mulato II grass (32.72%). The research result, within parameter, ADF content was observed higher in without fertilizer than manure and NPS fertilizer application. ADF is the percentage of highly indigestible and slowly digestible material in a feed or forage. Higher forage ADF results in reduced digestibility dry matter as a consequence of increased lignification of cellulose in the latter stage of the plants [64]. According to Van Soest et al. (1994) [52], this fact is negatively co-related to intake. However, fiber is also used by ruminants as an important energy source by the short fatty acids chain produced during fermentation in the rumen [52]. Hence, chemical fertilizer and manure attribute to improve ADF concentration of forage. With regard to plant spacing, ADF content of brachiaria cultivar mulato II grass was not significantly affected. In line with the result, similar result of Olanite et al. (2018) [41] who noted that plant spacing was not significant difference of ADF concentration of Columbus grass in south west Nigeria. Similarly, other author noted that plant spacing was not significant difference of ADF concentration desho grass [19]. Although similar finding shows, plant spacing has no significant effect on the ADF [48].

The result of Acid detergent lignin found in the current result is lower than Mustaring et al. (2014) [23] who reported ADL content of (8.18%) Brachiara mulato grass. The reason might be associated with environmental condition, soil type and management system of the grass. In the contrary, Mihret et al. (2018) [13] who report that NPS fertilizer application and manure were significant difference of ADL concentration of desho grass. Similarly, other author noted that use of fertilizer affect of ADL content of grass [42, 65]. With regard to plant spacing, ADL content of brachiaria cultivar mulato II grass was not significantly affected. In line with the result Tilahun et al. (2017) [19] noted that plant spacing was not significant difference of ADL concentration of desho grass. The finding is agreed with reports of Semman et al. (2016) [48]. However, the current results disagreed with the result of Mihret et al. (2018) [13] who noted that plant spacing was significant difference of ADL content of desho grass. Similarly, line with Berihun (2005) [27] who report the ADL content bana grass increase when plant spacing decrease from 100 × 75 cm to 75 × 50 cm.

The analysis show that highest strongly positive correlation (r=0.99) was recorded between DMY and CPY also strongly positive correlated (r=0.98) was observed between NLPP and NTPP and the moderately correlation NDF, RC and OM. A negative correlation ($P<0.01$) was observed ash. While NRPP with ash negatively correlated. Such results agree with other studies [13]. DMY was negatively correlated with Ash but it is positively correlated with leaf length per plant, CPY, OM and NDF. This result is similar with the finding of Rambau et al. (2016) [21] that shows, high correlations between growths parameters grass such as plant height, leaf length were observed in Napier grass. It is an agreed fact that leafy plants allow higher penetration of light and increased photosynthesis. Therefore, maximum growth rate of the plant results in increased dry mass production with rather efficient utilization of water, light and resources. Similarly in line with Zewdu et al. (2003) [53] reported that DMY was positively correlated with leaf length of napier grass.

The positive association of DMY with some of the morphological parameters (leaf length per plant and number of leaf per plant similar result with Mihret et al. (2018) [13]. Generally, Plant height has a negative correlation with root length per plant. While LLPP and ADL are positively correlated. This is due to the Fact that growth parameters play a vital role in enhancing fodder yield [66] plant height as an important yield component and suggested that canopy height could be considered a valuable tool to make rough estimation of dry matter yield. Therefore, high correlations between production parameters such as plant height, leaf length and biomass yield have been observed. Similarly, in line with Imran et al. (2007) [66] reported that production parameters positively correlated to enhance biomass yield.

4. Conclusions

Inorganic fertilizer application allows for improvement in the productivity and chemical composition of brachiaria hybrid mulato II grass, With regard to plant spacing narrow plant spacing means (15 x 50cm) can be best to obtain maximum biomass yield. The result of this study implied that brachiaria hybrid mulato II grass can be planted with available fertilizer and proper spacing recommendable since it has exhibited good result for yield and quality of the grass. Therefore, based on this information, beneficiary making their decisions based on the relative importance of forage yield and qualities. Brachiaria cultivar mulato II grass should be cultivated using chemical fertilizer to maximize biomass yield and improve forage quality. The grass should be cultivated at narrow spacing to get high biomass yield and as an option to solve the scarcity of land. Of the spacings, the two closest spacing, 15 and 30 cm, are recommended for the production of high dry matter yield than the wider spacing (45 cm). Finally, to make the current finding valuable, the result should be supported with animal evaluation trials.

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