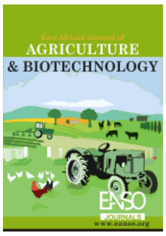

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Original Article

Effects of Organic Fertilization on Growth Response of Brachiaria (Mulato II) in Lushoto, Tanzania

Cyril Stephano Lissu[1], Dr. Bernardol John Manyanda, PhD[2] & Prof. Luther Luhongano Lulandala, PhD[2]*

[1] Action for Sustainable Agroforestry (AfSA), Non-Governmental organisation, P. O. Box 2682 Morogoro, Tanzania.
[2] Sokoine University of Agriculture, P. O. Box 3013, Morogoro, Tanzania.
* Author for Correspondence ORCID ID: https://orcid.org/0000-0001-8796-2752; Email: bernardoljohnm@gmail.com;

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ABSTRACT

The smallholder livestock keepers in Tanzania, like any other country in sub-Saharan Africa, depend heavily on the natural pastures that lack quality and nutrients for livestock. Efforts to establish pasture with Bracharia grass in most parts of sub-Saharan Africa to supplement the deficiency are inevitable. This study aimed to investigate the effects of farmyard manure fertilisation on the performance of Brachiaria grass (Mullato II) at Ubiri Village, Lushoto District, Tanzania. The study used two treatments, i.e., the number of harvest and fertility improvement options, whereby Randomised Complete Block Design (RCBD) with three replications were used. Data was collected on plant tiller number per bunch, tiller height (m), biomass (tha-1) and leaf area indices per treatment in replications. R software version 3.5.0 was employed to analyse the gathered data sets. We compared the mean difference using the standard error of the mean. The result indicated that tiller height, number of tillers, biomass yield and leaf area index, of the hybrid Brachiaria grass had increased significantly ($P<0.05$) by 59, 48, 68%, and 76 %, respectively, in the second Harvest (i.e., 22 weeks). It was revealed further that manure fertilisation showed positive effects on the growth response of the grass. The study recommended that the integration of farmyard manure should be promoted in Tanzania and elsewhere in sub-Saharan Africa. Moreover, a study should be conducted to investigate the effects of farmyard manure fertilisation on the nutritional value of Brachiaria grass in the area studied.

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INTRODUCTION

Despite the rise in demand for livestock products in sub-Saharan Africa, the supply has not been in square with the available demands, primarily due to inadequate production (Balehegn et al., 2021). Among the major drivers of the region's chronic low productivity is insufficient quality feed options with high nutrients. This is mainly caused by deforestation and low soil fertility that prompt other effects like fodder deficit (Foley et al., 2011; Barrow, 2014). Moreover, livestock growth rates and production depend much on the quality of feeds available to the livestock (Lissu et al., 2022; More & Sollenburg, 2004). However, most livestock keepers in Tanzania depend heavily on crop residue as well as the native pastures, which does not provide sufficient nutrients to livestock (Wambugu, 2011; Lissu et al., 2022). For improving pasture, various attempts including the application of organic as well as inorganic fertilisers have been used to add nutrients in the soil (Maerere et al., 2001; Hamaiel et al., 2015; Lissu et al., 2022; Bouathong et al., 2019). Unlike inorganic fertilisers that are too expensive, and need reapplication frequently, organic manures last longer in the soil, less expensive and are easily available. Additionally, frequent use of chemical fertilisers without organic manures cause reduction in soil health (Hamaiel et al., 2015).

Sustainable production of pasture for livestock production on a commercial basis inevitably requires fertilisation of available grasses by organic manure. The rate of animal manure production in Tanzania mainland is about fourteen million tons per year (Massomo and Rweyemamu, 1989; Kimbi, et al., 2001; Maerere et al., 2001). It has been established also that, the total Nitrogen (N) from manure in mainland Tanzania is about four folds the amount of nitrogenous fertilisers consumed in the country as of 1980 (Maerere et al., 2001; Kimbi et al., 2001). Therefore, frequent application of farmyard manure using available stock in some parts in the country could solve the problem of deficiency of land productivity, stunted nutritional content, and periodic presence of grasses for livestock production systems. Fertilising pastures with manure is not a common practice in most farming communities in Africa and Tanzania in particular (Maerere et al., 2001; Kimbi et al., 1992; Powell et al., 1996). Most communities use manure for fertilising food crops (Powell et al., 1996; Turner, 2002). There are should be a shift from food crops to pasture fertilisation using farmyard manure in developing countries in order to maximize production from livestock industry thereby balancing a scenario of supply and demand for livestock products.

Among the tropical grasses that seem to be encouraging when they are fertilised with farmyard manure is *Brachiaria mulato.* Two Mulato cultivars are currently available, i.e., Mulatto I (*Brachiaria* hybrid CIAT 36061) and Mulato II (*Brachiaria* hybrid CIAT 36087). Brachiaria species generally are low-growing decumbent perennial grasses with an aggressive growth habit that yield a dense ground cover able to suppress weeds. Its productivity is enhanced when manure is applied (Ojo et al., 2019). Besides their use as livestock feed, they also contribute significantly in mitigating the impact of climate change through their large root system that sequester large amount of carbon. Furthermore, they contribute tremendously in the efficiency use of nitrogen, nutrient losses prevention, soil erosion control, and ecological restoration (Arango, 2014).

Several studies (ACIAR, 2008; Marsetyo & Suharno, 2009; Bouathong et al., 2019; Hare et al., 2009) have been done worldwide to assess the effects of inorganic fertilisers on the production of *Brachiaria mulato* II. However, little has been

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done in Tanzania, to assess the effect of organic fertilisation on the growth yield of Brachiaria grass. Notable studies include (Maleko et al., 2015), which reported that, the biomass yield of the *Brachiaria ruziziensis* heightened tremendously when fertilised with farmyard manure. Moreover, (Yiberkew, 2020) reported that the supplementation of farmyard manure to *Brachiaria mullato* II significantly increased its dry matter yield from 11.61 t/ha to 13.89 t/ha at the lowland of Northern Ethiopia. Despite profound results of the production rate of Brachiaria grass when fertilised with manure in lowland parts of sub-Saharan Africa, scarce information exits on the effect of the fertilisation with farmyard manure on the growth response of Brachiaria mullato II in highland regions like at Ubiri Village in Lushoto district, Tanzania. The findings in other parts of sub-Saharan Africa cannot be scaled up in Ubiri village because they were obtained from lowlands where manure cannot be easily taken through water runoff. The present study therefore, deliberated over investigating the effects of farmyard manure fertilisation on the growth response of Brachiaria grass (Mullato II) in the Mountainous area of Ubiri Village, Lushoto District, Tanzania.

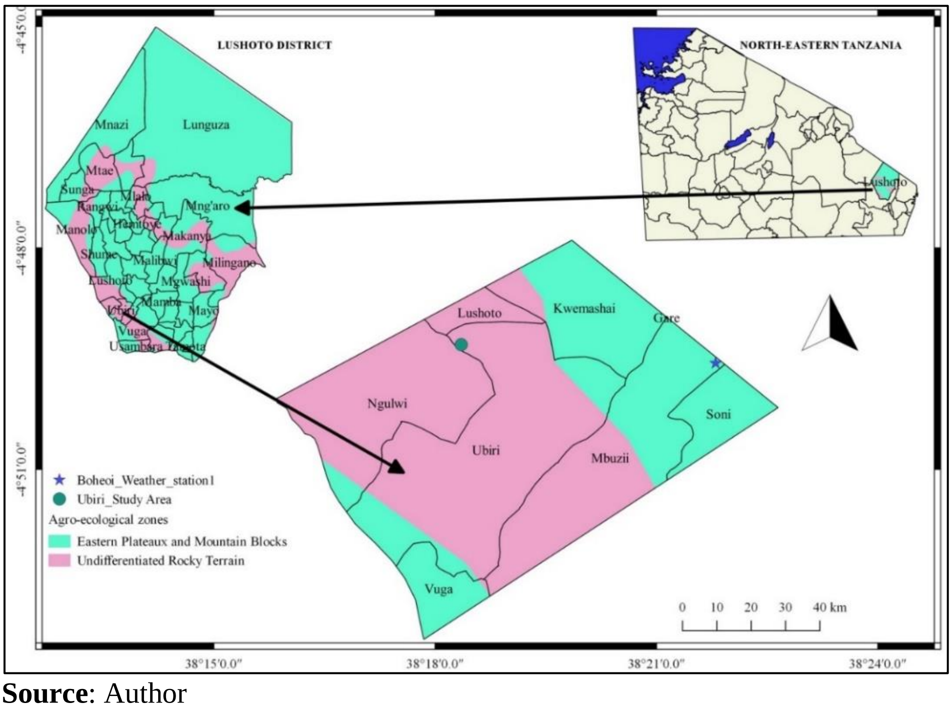
Understanding the effects of manure fertilisation on the growth response of Bracharia grass would help the adoption of integrating hybrid Brachiaria (*Brachiaria mulato II*) with farmyard manure and hence revamp the shortage of animal feeds to the smallholder livestock keepers in Lushoto and another areas with similar agro ecological settings.

MATERIALS AND METHODS

Study Area Description

The present study was implemented between November 2014 and June 2015 at Ubiri Village, Lushoto District, Tanzania (*Figure 1*). Ubiri village lies between 4^0 49.44'S and 4^0 49.51'S and between 38^0 18.99'E and 38^0 19.33'E (Hieronimo et al., 2014). It has a mean elevation above sea level of 1199 m. The district in which Ubiri village falls has bimodal rainfall, which is experienced in November and April. While the maximum and minimum mean annual rainfall is 2,000 mm and 600 mm, respectively, the maximum and minimum temperatures are 30 °C and 7 °C, respectively, in the area (Lovett, 1996; Msuya & Kideghesho, 2009). Furthermore, the soil type and texture are chromic acrisols and sand clay loam, respectively (Mwango et al., 2014).

Figure 1: Study area location



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Soil Data Collection

Soil-sampling augur was used to take soil samples at a height of 0-20 cm below ground level mainly for the analysis of the chemical as well as physical properties. The physical properties of the study area with its proportions amount in bracket were silt (12.04048%), sand (27.8635%), CEC (27.8229 meq/100g), clay (60.094%), PH (6.52333) and bulk density (866 kg/m3). Additionally, the chemical properties and their amount in brackets were Nitrogen (0.23189%), Carbon (2.22411%) and Bray P (3.81094 mg/kg).

Management of the Experiment

Setting up the experiment was done from the beginning of November 2014 to the end of June 2015. Randomised complete block design (RCBD) with three replicates was adopted in this study. The plot dimension was 6 m x 4 m, in which four rows were distributed for each plot. The interrow and Intra-row spacing treatments were 1 m. Planting was preceded by tilling with a hand hoe, then harrowing with the use of forked hoe followed. The farmyard manure was gathered from the smallholder farms in the study area.

Furthermore, the mature healthy stem splits of the Brachiaria grass were collected from the Tanzania Livestock Research Institute (TALIRI). The farmyard manure was applied to the Brachiaria grass at the rate of 8.8 tha^{-1} (127.5 $kgNha^{-1}$). The farmyard manure was placed in small holes prepared and mixed with the soil in each hole. The grass was then planted in each hole within the row, in which each row had 6 Brachiaria grasses. Moreover, a series of weed controls were done in the experimental plots to ensure that the area was free from weeds.

Forage Data Collection

Periodic harvesting of Brachiaria grass was done between 15 and 29 weeks. While the first Harvest was done 16 weeks after planting, the successive harvesting was done immediately at the interval of 6 weeks. Eight bunches/clumps samples with an area measuring 4 m x 2 m each were collected at the centre of each plot. Moreover, a randomised technique was applied to select and mark three bunches/clumps from the eight bunches. The data on dry matter yield, tiller height, leaf area index and tiller number, were collected.

The tallest, medium and shortest tillers heights were also measured (cm) using measuring tape. Furthermore, an Accupar/Ceptometer was applied to record all the parameters for determining the leaf area index. For each leaf, recording was done for the above photosynthetic active radiation readings. Moreover, five below successive (photosynthetic active radiations) readings diagonally in the five randomly selected bunches at the plot centre were also recorded. All readings were taken at zero zenith angle in order to capture all the light energy from the Sun.

Conversely, harvesting of all Brachiaria grasses were implemented at 10 cm from the ground level. The harvested grasses were fastened together and its bulk weight determined with the use of beam balance. The grasses were then unfastened, and the tillers rigorously mixed. Randomisation technique was adopted to select five tillers from the mixture. The tillers were packed in paper bags after chopping and their fresh weights determined with the use of weighing balance. Moreover, the samples were taken to the laboratory for their dry weight assessment. The samples were dried in the oven at 65 ^{0}C for 48 hours (Hamaiel et al., 2015) to obtain the dry weight.

Data Analysis

Data collected on the number and height of tiller, leaf area index (LAI) and biomass were processed in R software (R. core Team, 2023).

Tiller numbers

The tiller number collected from the three bunches selected at randomly in the net plot of each plot was counted, and the average determined using equation 1.

$$TN = \frac{tb1+tb2+tb3}{3} \qquad [1]$$

Where by**:** TN is Average tiller number and *tb1, tb2* and *tb3* = Tiller number of the 1^{st}, 2^{nd} 3^{rd} bunch respectively,

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Tiller Heights

The average tiller height of the tallest, medium and the shortest was determined to get the bunch tiller height using equation 2.

$$Bth = \frac{Tt+Mt+St}{3} \quad [2]$$

Where; *Bth* = Average tiller height of the bunch, *Tt* = Height of the tallest tiller, *Mt* = Height of medium tiller and *St* = Height of the shortest tiller

Then, the average tiller heights was determined with the use of equation 3.

$$Ath = \frac{Bth1+Bth2+Bth3}{3} \quad [3]$$

Where: *Ath* = Average tiller height, and *Bth1*, *Bth2* and *Bth3* are the bunch tiller heights for the 1^{st}, $2^{nd,}$ and $3^{rd,}$ respectively.

The Dry Matter Yield Parameters

The weights of both fresh as well as dry sample were computed by subtracting the paper bag weights.

Furthermore, equation 4 was employed to estimate dry matter (*Dm*) percentage.

$$Dm = (dw/fw) \times 100\ \% \quad [4]$$

Where; *fw* = fresh sample weight, *dw* = dry sample weight

On the other hand, equation 5 was applied to determine the dry matter yield.

$$Dmy = Dm\ \times Bfw \quad [5]$$

Where *Bfw* = bulk fresh weight

Standard error of the mean was applied to compare differences in means. Statistical model (equation 6) was used to perform analysis of variance between manure and the variables harvested.

$$Dijz = \mu + \tau i\ + \alpha j\ +\ (\alpha\tau)ij\ + \beta z\ +\ eijz \quad [6]$$

Where Dijz = An observation from i^{th} level of Harvest, j^{th} level of manure and z^{th} replications, μ =Over all mean, τi= Effect of i^{th} level of Harvest, αj= effect of j^{th} level of fertiliser, (ατ)ij=Effect of i^{th} level of Harvest and j^{th} level of fertiliser interaction, Bz= Effect of z^{th} replications, eijz= Error

RESULTS AND DISCUSSIONS

Effect of Organic Manure on the number of Tiller of *Brachiaria mullato II* in the Three Growth Cycles

Figure 2 presents the findings about the growth response of the number of tillers of the hybrid Brachiaria grass when fertilised with farmyard manure at 16, 22 and 28 weeks of harvesting. It was found that the manure fertilisation significantly ($p<0.05$) enhanced the tiller numbers of the Brachiaria grass by 48% during the second Harvest (i.e., 22 weeks). However, the fertilisation had no significant effects in terms of tiller number during the 1^{st} (i.e., 16 weeks) and 3^{rd} (i.e., 28 weeks) harvests. This is because the area suffered a low amount of rainfall in the first (beginning of rain season) and third (end of rain season) cuts that were not enough for the area to have a sufficient amount of moisture for the plant to mineralise the available nutrients.

On the other hand, the significant increases in tiller number during the second Harvest (22^{nd} week) of the growth cycle were probably attributed to the efficient absorption of the increased nutrients from the soil because of the maximum amount of rainfall received in the area during this period. These findings are in line with that of Shokri (2020), who found that, the organic fertiliser whether sheep manure alone or combined with urea yielded superior tiller number of Napier grass over six cycles of harvesting. Additionally, the results are also consistent with those of Yiberkew (2020), who reported that the effect of manure on the number of tillers of *Brachiaria mulato* II was 28 tiller/m^2 compared to control, which was 22 tillers/m^2.

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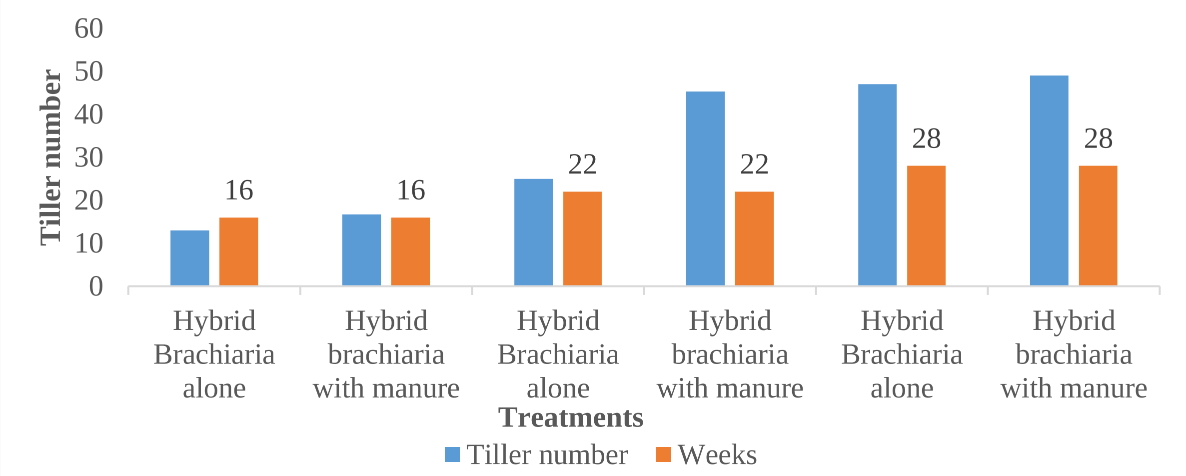
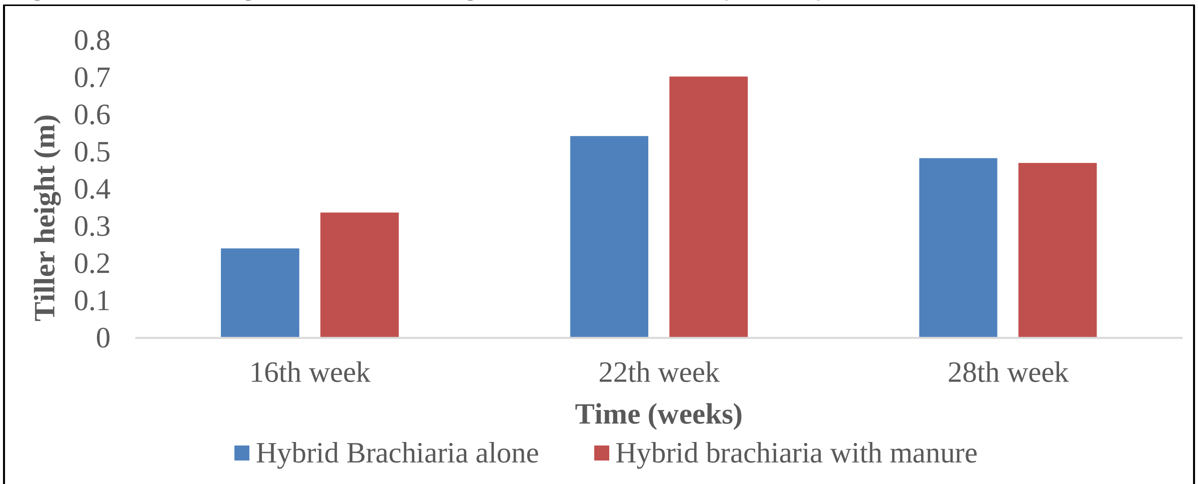
Figure 2: Tiller number of Brachiaria grass over the three (weeks) successive harvests



Effect of Farmyard Manure on the Tiller height of the *Brachiaria mullato* II in the three growth cycles

The effect of Farmyard manure application on the grass tiller heights over the three harvesting periods is presented in *Figure 3*. The findings indicate that the fertilisation factor generated statistically significant results (p<0.05) on the plant tiller height in the second cut (22 weeks) compared to the first and third cut (16 and 28 weeks). Furthermore, the performance of the grass, which is manifested through tiller height, followed a normal growth curve with a peak at the 22 weeks harvest.

Figure 3: Tiller height of Brachiaria grass as influenced by Farmyard manure addition.



On the other hand, the increase in tiller height at 22 weeks harvest might be attributed to the formation of a stable roots system due to the availability of moisture content that created a favourable condition for the plant to mineralise the nutrients from the soil (Hamaiel et al., 2015). Additionally, the positive effect of farmyard manure on tiller height could be attributed to farmyard manure' ability to improve soil drainage ventilation and increase the soil's ability to retain water. It improves the holding capacity of soil and increases the availability of elements for grasses (Hamaiel et al., 2015; Shokri, 2020). These findings are in close conformity with those of (Azangue et al., 2019) in west Cameroon, who reported the height of *Brachiaria ruziziensis* supplemented with chicken manure produced a tiller height of 157.47 cm which was significantly higher compared with the control which produced tiller with height of 153.42cm. On top of that (Apollon, 2022) experimented with the Faculty of Agronomic and Veterinary Sciences (AGROVET) of the Autonomous University of Santo Domingo in Mexico and reported that

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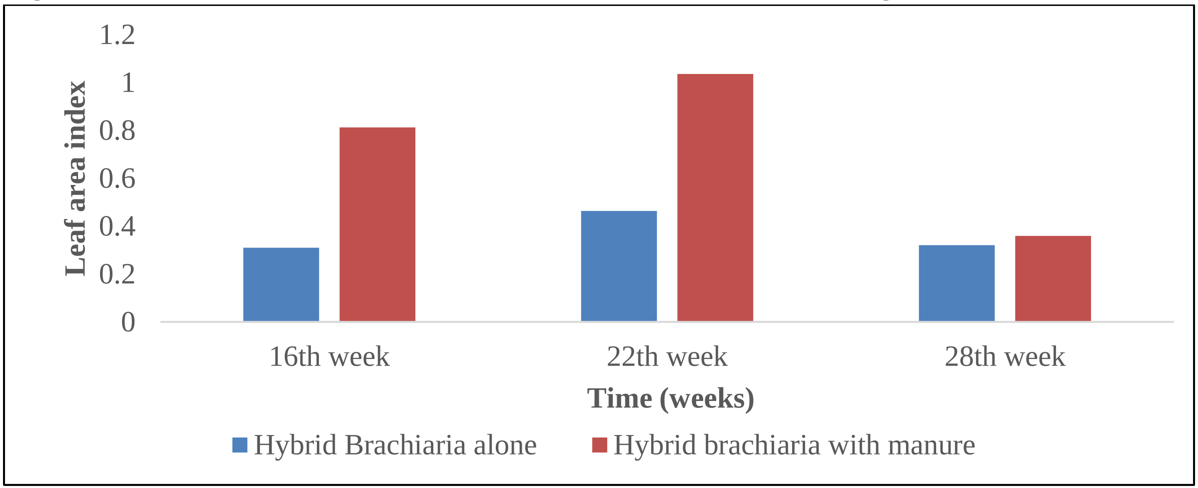
plants that received bovine manure achieved the highest height (average value of 96.06 cm) compared to those that had mycorrhizae (average value of 84 cm).

Effect of Organic Manure fertilisation on the Leaf Area Index (LAI) of the *Brachiaria mullato* II

Figure 4 shows the effect of Farmyard manure fertilisation on the leaf area indices of the Brachiaria grasses over the 1st, 2nd, and 3rd i.e., 16, 22, and 28 weeks of harvests respectively. Moreover, the leaf area index attained the optimal point at the 2nd Harvest and dropped exponentially at the 3rd Harvest. Statistical tests indicate that fertilisation significantly ($P<0.05$) increased the leaf area indices by 76% during the 2nd harvest. Nevertheless, the manure application had no significant ($P<0.05$) effect on the increased leaf area indices of Brachiaria grasses in the 1st and 3rd growth cycles. This means that fertilisation with manure did not influence the leaf yield of the plant during these cuts. This is because the area suffered a low amount of rainfall in the first (beginning of rain season) and third (end of rain season) cuts that were not enough for the area to have a sufficient amount of moisture for the plant to mineralise the available nutrients.

However, the significant rise in the leaf area index observed in the second cut could have been attributed to the increased moisture content of the soil that enabled the plant to yield more leaves that encouraged absorption of Sunlight. The results from this study concur with those of Berdjour (2020) who revealed that poultry manure and NPK fertiliser heightened the leaf area index of maise relative to their respective control. On top of that, (Addai & Alimiyawo, 2015) observed a tremendous increase in the leaf area index of sorghum under fertilised treatment compared to the control (unfertilised treatments).

Figure 4: Effect of manure addition on Leaf Area index of Brachiaria grass



Effect of Manure on the Biomass yield of Mullato II grass in the Three Growth Cycles

The findings on the effect of manure fertilisation on the Biomass output of the *Brachiaria mullato* II are presented in *Figure 4*. The biomass peaked at the second Harvest i.e., 22 weeks and then declined tremendously when harvested at 28 weeks. Test of significance shows that the addition of farmyard manure had a significant effect on the biomass increase of the grass by 68% when harvested at 22 weeks ($p<0.05$). Nonetheless, the treatment i.e., manure fertilisation on the grass did not bring significant effect on the biomass production when harvested at 16 and 28 weeks. This is because the area received a low amount of rainfall at the beginning, i.e., first and at the end, i.e. third cut that was not enough for the area to have a sufficient amount of moisture for the plant to mineralise the available nutrients and yield more leaves to capture a sufficient amount of Sunlight.

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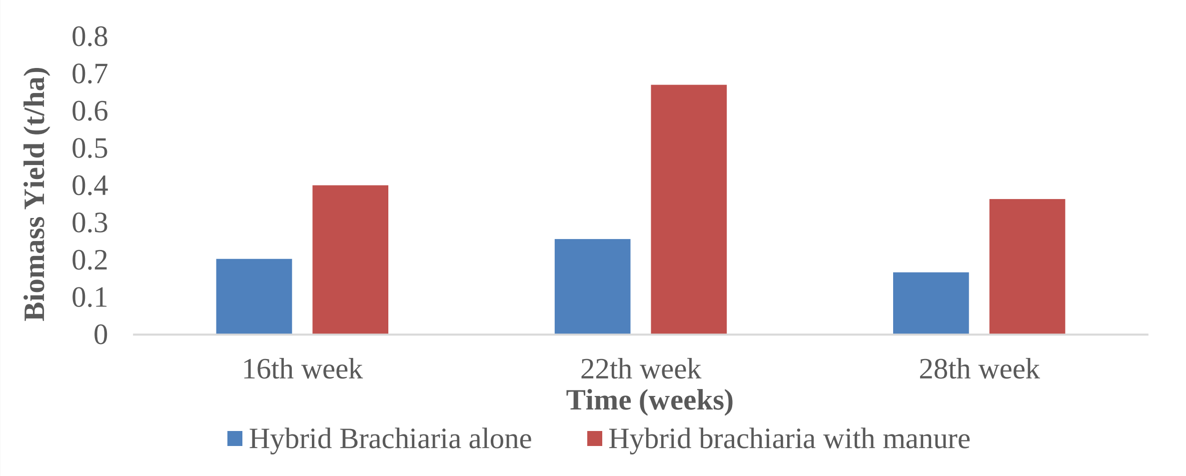
Figure 5: The effect of Farmyard manure addition on Biomass of hybrid Brachiaria grass



On the other hand, the significant increase in biomass yield at 22 weeks Harvest could be attributed to sufficient moisture available in the soil in the prolonged rain season. The availability of moisture content probably creates a favourable condition for the soil micro-organisms to mineralise the available nutrients from the soil that emanates from organic matter decomposition as well as farmyard manure addition and become readily available for the grass. The results of this study are consistent with those of Maleko (2015) in Morogoro-Tanzania, who revealed that, *Brachiaria ruziziensis* fertilisation with farmyard manure heightened the biomass yield by 1.3, 4.19 and 4.39 tha^{-1} when manure was added in the ratio of 5, 10 and 15 tha^{-1} respectively over the control. These findings conform with the results revealed by Selvie et al. (2019) from tropical climatic conditions in Indonesia, who reported that the addition of ruminant manure at the rate of 20 t/ha to *Brachiaria humidicola* raised its dry matter yield from 15.71 t/ha (control) to 18.51 t/ha.

CONCLUSIONS

Mullato grass is a prime forage source, which is suggested by its high content of the crude protein. The results revealed in the present study indicate immense potential for Brachiaria (Mullato II) production in agroecological conditions when fertilised with farmyard manure. The supplementation of Mulato grass with Farmyard manure significantly raised the plant tiller parameters i.e., height and number, leaf area index and biomass produced during the second cut (i.e. 22 weeks Harvests). We recommend that the integration of the Farmyard manure on the hybrid Brachiaria grass should be promoted to mitigate the shortage of livestock feeds in Lushoto and elsewhere in Tanzania. Moreover, technology like silage-making or hay should be emphasised to the smallholder farmers to ensure livestock food security, particularly when the weather conditions is unfavourable. Furthermore, a study should be conducted to find the nutritional value of Brachiaria (Mullato II) when farmyard manure is added during its production.

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