Morphological characteristics and yield of three Brachiaria cultivars subjected to different eco-climatic zones of Tanzania

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Abstract
Livestock production in Tanzania is limited by scarcity of forage resources, the situation acerbated by the effects of climate change. Replacement of high quality forages with low quality forages have resulted into low milk production in the country (4 to 5 L) which is below the potential of producing at least 15 L per cow per day. Although, high yield fodder grasses such as Brachiaria have been recommended as climate smart fodder grass, little information have been documented in Tanzania particularly the growth performance of these grasses across different eco-climatic zones. The current study tested the performance of three cultivars of Brachiaria (Brachiaria brizantha cv. Piata, Brachiaria brizantha cv. Xaraes and Brachiaria decumbens cv. Basilisk) at three different eco-climatic zones (Humid, sub-humid and semi-arid conditions). The study used the Factorial arrangement where interaction between eco-climatic zones and Brachiaria cultivars were subjected to Two Ways ANOVA. In cases where significant differences were found, the Post Hoc tests were performed using the Duncan Multiple Range Test of SAS 2014 to separate mean values. The study revealed that, sub-humid climate was superior in terms of all

growth attributes and biomass yield compared to semi-arid zone which was characterized with poor growth performance. Interestingly, B. decumbens cv. Basilisk was relatively shorter grass but scored the highest values for plant number and biomass yield. Surprisingly, B. brizantha cv Xaraes exhibited relatively higher number of tillers per plant in semi-arid condition besides its relatively poor performance. However, further studies on nutritive values and palatability are recommended for these Brachiaria cultivars.

***Keywords**: Above-ground Biomass, Brachiaria Cultivars, Eco-climatic Zones*

Introduction

Tanzania is a second country in Africa with largest livestock population with current estimated 30.5 million cattle and 18.9 million goats (TLMP, 2017). Besides, high population of livestock in the country, productivity is limited by scarcity of forage resources as a result of rangeland degradation and shrinkage of grazing lands (Kirui and Mirzabaev, 2014). Degradation of rangeland resources due to the effects of climate change and variability has become serious challenges bearing the negative impact to the pastoral livelihoods. About 99% of livestock sector in Tanzania belongs to traditional pastoralists and agro pastoralists who derive their livelihoods from rangelands which cover about 74% of total land area of Tanzania (Mwilawa et al., 2008). Unfortunately, these rangelands are characterized with poor natural pasture especially during dry season and hence livestock remain under-nourished for long period. During dry period, pastoralists and agro pastoralists, in addition to natural pasture, depend on available crop residues such as cereal crops

with low protein levels ranging from 3 to 4% (Mtengeti et al., 2008).

In many areas of Tanzania where land is not limiting, there are opportunities for improvement of livestock production through establishment of improved pasture such as Brachiaria with adequate biomass and nutritional value compared to the available less productive and nutritionally poor natural pasture. However, there have been fewer efforts of increasing quality and availability of forage through introduction of improved pasture. For that matter, in the Southern Highland and Eastern Zones of the country where there is limited grazing land, milk production have dropped up to 4 or 5 L for dairy cow with genetic potential of producing at least 15 L per cow per day (Mtengeti et al., 2008). Similarly in the Northern and Central Zones of the country characterized with semi-arid conditions, milk yield is below subsistence production of 5 L per cow/day. In the effort to improve forage availability and quality the InnovAfrica Project introduced the Brachiaria pilot project at different eco-climatic regions of Tanzania to test its growth performance and yield. Under this project, three Brachiaria cultivars (*Brachiaria brizantha* cv. Piata, *Brachiaria brizantha* cv. Xaraes and *Brachiaria decumbens* cv. Basilisk) were tested at three different eco-climatic zones (humid, sub-huimd and arid zones).

Material and methods

The study was conducted in three different eco-climatic regions namely; Southern Highland (Humid climate), Eastern Zone (sub-humid) and Northern Zone (Semi-arid). In the Southern Highland the pilot project was carried out in Rungwe district found in Mbeya region, South West Tanzania. The Rungwe district lies

between $9^0$00'S, and $9^0$30'S; and $33^0$30'E and $34^0$00'E in South-Western Tanzania (Mwakisunga and Majule 2012; Mweya et al. 2007). The district covers a total area of 2,211 km^2 of which 75% of the total area is arable land used for agriculture and the remaining land is covered by forest, mountainous and residential areas (Nyunza and Mwakaje 2012). Rungwe District is located between 770 metres and 2865 metres above the sea level and average rainfall ranges from approximately 900 mm in the lowland to 3300 mm in the highland zone (Nyunza and Mwakaje 2012).

In the Eastern Zone, the study was carried in the two institutions; Sokoine University of Agriculture (Morogoro) and Kibaha Education Centre (Coastal region). At Sokoine University of Agriculture (SUA), the study site was located at Magadu Farm situated at 37º 39E and 06º 5' S about 5 km from the centre of Morogoro Municipal. The average annual temperature in the Morogoro region is ranging from 18^{oC} to 30^{oC} (Pavola, 2004). The rainfall is bi-modal, ranging from 600-900mm per annum (Kizima et al., 2014; Selemani, 2018). In the Coastal region, the Kihaba Education Centre, located at 6º32' and 6º43' S and 38º48' and 39º02 E within the North Ruvu Forest Reserve. The area experience sub-humid type of climate and has irregular rainfall pattern with the mean annual precipitation ranging from 700 to 1000 mm and minimum to maximum temperature averages to 18ºC to 30ºC (Kindo et al. 2010).

In the semi-arid Northern zone, the study was conducted in Monduli district which is located in the North-East of the country between latitude 3º.29" South and longitude 36º.45" East (Kimaro et al. 2018). It is bordered to the North by Kenya, East by

Kilimanjaro region and Arumeru District, to the South by Manyara region and to the West by Ngorongoro and Karatu Districts. The district is largely inhabited by Maasai pastoralists whose livelihoods are mainly derived from livestock production. Most villages of Moduli districts are characterized by semi-arid condition with low amount and unpredictable rainfall.

Experimental design and sampling procedure

The study used the Factorial Experimental Design where climatic condition was treated a factor with three levels (humid, sub-humid and semi-arid climate) and Brachiaria cultivars were considered as another factor with three levels; three Brachiaria cultivars (*Brachiaria brizantha cv. piata, Brachiaria brizantha cv. xaraes and Brachiaria decumbens cv. basilisk).* Each of cultivar was randomly replicated four times in each ecological zones. Each cultivar was sown in four sub-plots of 4 x 5 m. The distance between sub-plots was 1 m apart. The seedbeds were prepared by using hand hoe and the pasture seeds were sown at the depth of 0.5 to 1 cm deep. The sowing rate was approximately 5 kg seeds/ha at specific rows maintained at 50 cm intervals between rows. The sowing in all experimental plots was done at the on-set of rainy season in November 2018. The Triple Super Phosphate (250 kg/ha) was applied during sowing and Urea (rate?) was used as top dressing fertilizer after 8 weeks of establishment. All sub-plots received similar agronomic management such as manual weeding using hand hoe.

Growth performance of each variety was monitored throughout the growing period from sowing to harvesting. Seed viability was determined in the field by comparing germination rate of tested cultivars. Growth characteristics were determined by observation

of growth attributes (number of tillers, number of plants and height of plant). Numbers of individual plants were counted randomly using 0.5 x 0.5 m quadrat. Within the quadrat, four individual plants were selected randomly for height measurement and counting number of tillers per plant. Yield in terms of above ground biomass of each cultivar was estimated through dry matter determination of collected samples in the laboratory. Fresh samples were collected from each cultivar within the 0.5 X 0.5 m quadrat and weighed. Thereafter, each sample was chopped mixed well before a sample was drawn, weighed and taken to the Department of Animal, Aquaculture and Range Sciences laboratory for dry matter determination. In the laboratory samples were forced-dried in oven at 105°C for 48h. After drying to constant weight, samples were again weighed to determine DM content used to calculate the yield in kg DM ha-1.

Data analysis

Analysis of variance (ANOVA) was undertaken to determine the effect of different Brachiaria cultivars on the evaluated attributes. In cases where significances were determined in the ANOVA, Least Square Difference (LSD) was applied (at 5%) and used to discriminate the differences among more than two means. Analyses were performed following the factorial arrangement according to Montgomery 2012, using the SAS software of 2014.

Results and Discussion

The main effects of Brachiaria cultivars regardless of eco-climatic zones are presented in Figure 1. Tiller number and plants height were two important growth attributes that were recorded and found to increase linearly with time (Figure 1). Although changes in plant heights over time indicated parallel patterns (Fig 1b) there

was significant difference among the three Brachiara cultivars in number of tillers (Fig 1a). The number of tillers increased with increasing time up to week 8 when *Brachiria decumbens* cv Balisisk indicated the highest value compared to others. Surprisingly, *Brachiaria brizantha* cv piata tended to increase exponentially from week 8 and attained the highest number of tillers at week 13. According to Yang et al. (2019), tillering is an important agronomic trait that determine the reproductive and productive performance of graminaceous plants. It has been noted that, the largest variation in tillering rate among different herbaceous vegetation to the large extent determined by plant's heritable characteristics coupled with environmental factors (Warringa and Creuser 1996). Therefore, the relatively higher number of tillers for *B. brazantha* cv piata and *B. decumbens* cv Balisisk implies higher growth potential for the two cultivars

compared to *B. brizantha* cv Xaraes and thus high probability of attaining higher biomass.

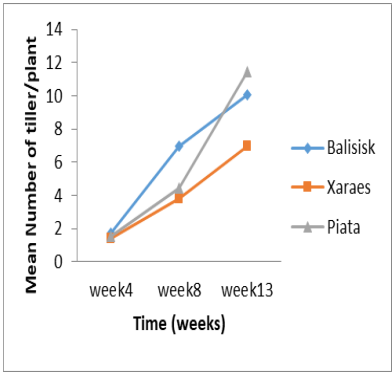

Figure 1a: Mean tiller production per time

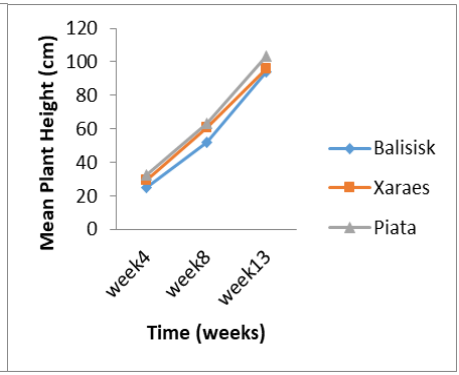

Figure 1b: Change in mean height per time

The findings from this study suggest that climatic condition has varying significant influences on growth performance and yield of

Brachiairia cultivars. Generally, the results indicated that, the highest number of plants, number of tillers per plant and plant heights were recorded at sub-humid eco-climatic zones (Table 1). Similar results were recorded by Wassie et al. (2018), who established maximum growth rates of Brachiaria cultivars in mid-attitude of Ethiopia with moderate rainfall. This implies that, Brachiaria growth optimally in moderate rainfall ranging from 600 to 1000 mm per annum. Although, Brachiaria is one of drought tolerance grasses recommended in tropics, Skerman and Rivers (1990), pointed out that, it grows well in rainfall exceeding 500 mm per annum. Nevertheless, the relatively reduced growth rate recorded in humid eco-climate zones of the Southern Highlands with the highest amount of rainfall (up to 3000 mm) compared to those from sub-humid zones could be associated with its poor flooding tolerance (Skerman and Rivers 1990). Flooding normally alter the morphological structure of plants particularly the erect-stem grasses such as *B. brizantha* and *B. decumbens* (Skerman and River 1990), with little effect of stoloniferous grasses such as *Brachiaria mutica* (Baruch and Merida 1995).

Interestingly, the tested Brachiaria cultivars had variable growth characteristics across different eco-climatic zones. For example, *B. brizantha* cv Xaraes exhibited lowest numbers of tillers in sub-humid zone but comparatively, it had the highest to moderate number of tiller per plant within semi-arid and humid zones respectively. Wassie e al. (2018) reported that the growth performance and morphological characteristics of Brachiaria cultivars are highly influenced by area of origin including humidity, temperature and rainfall. These differences enable individual cultivars to respond to variations in soil and

environment conditions through adjustment of their morphological structure and physiology for survival.

Table 1: Growth attributes of Brachiaria cultivars at different eco-climatic zones for three months.

Eco-climatic zone	Brachiaria Cutlivar	No. of plants/0.25m2	No. of tiller/plant	Plant height (cm)
Humid	B. decumbens cv Balisisk	134.16 ± 8.24b	3.22 ± 0.89c	63.47 ± 5.71b
	B. brizantha cv Xaraes	71.66 ± 8.24c	2.58 ± 0.89c	63.82 ± 5.71b
	B. brizantha cv Piata	77.33 ± 8.24c	2.89 ± 0.89c	69.73 ± 5.71b
sub-humid	B. decumbens cv Balisisk	167.69 ± 6.23a	10.22 ± 0.68a	75.61 ± 4.31a
	B. brizantha cv Xaraes	66.40 ± 6.23c	5.98 ± 0.68b	85.78 ± 4.31a
	B. brizantha cv Piata	103.16 ± 6.23b	9.54 ± 0.68a	91.50 ± 4.31a
Semi-arid	B. decumbens cv Balisisk	18.19 ± 8.24d	1.97 ± 0.91cd	14.50 ± 5.83c
	B. brizantha cv Xaraes	18.41 ± 8.24d	2.16 ± 0.89c	18.66 ± 5.71c
	B. brizantha cv Piata	16.69 ± 8.24d	1.76 ± 0.91d	15.53 ± 5.83c

NB: The different superscript within the column show significant different at 5%

The above ground biomass productions for the three Brachiaria cultivars pooled from all eco-climatic zones (Figure 2) were within the range to those recorded by Maia et al. (2014). Significant higher yield was recorded from *B. decumbens* cv. Balisisk with mean value of 6608.54kg/ha. On the other hands, no significant difference was established between the two cultivars of *B. brizantha* (piata and xaraes) which implies that, the variability in yielding capacity was due to species difference. Low (2015)

pointed out that; *B. decumbens* has widely been adopted as preferable pasture for ruminant grazing due to its ability to produce abundant biomass and aggressive growth habit. Its ability to grow over the wide range of eco-climatic zones made it being recommended as the most important pasture for sustainable livestock production in semi-arid condition.

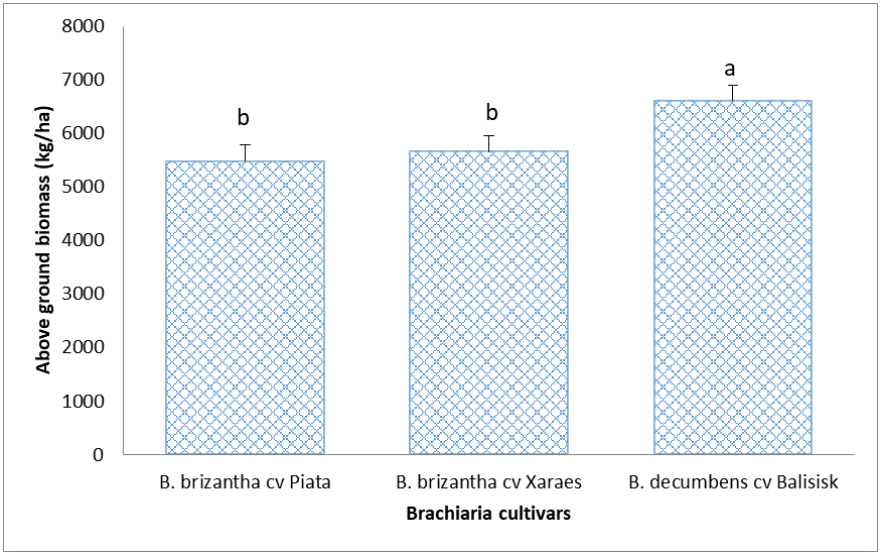

Figure 2: The main effect of cultvars on the mean above ground biomass production

Although, little significant variations was noted across different eco-climatic zones in terms of biomass yield, the *B. decumbens* cv Balisisk consistently scored higher values in all eco-climatic regions compared to other cultivars (Table 2). Surprisingly, in semi-arid eco-climatic zone significant low yield was noted for *B. brizantha* cv Piata and *B. brizantha* cv Xaraes, but the yield for *B. decumbens* cv Balisisk from semi-arid zone does not differ

significantly from other eco-climatic zones. This implies that, *B. decumbens* is drought tolerant and can grow to wide range of soil types and climate ranging from tropical to sub-tropical (Bryden, 2015).

Table 2: Interactive effects of eco-climatic zones and B. cultivars on biomass (kg/ha) production

Eco-climatic zone	Brachiaria Cutlivar	Biomass yield (Kg/ha)
Humid	B. brizantha cv Piata	5614.23 ± 427.90a
	B. brizantha cv Xaraes	5748.50 ± 427.90a
	B. decumbens cv Balisisk	6171.12 ± 417.90a
sub-humid	B. brizantha cv Piata	7545.20 ± 427.90a
	B. brizantha cv Xaraes	7049.17 ± 427.90a
	B. decumbens cv Balisisk	7212.90 ± 427.90a
Semi-arid	B. brizantha cv Piata	3281.46 ± 427.90b
	B. brizantha cv Xaraes	4191.91 ± 427.90b
	B. decumbens cv Balisisk	6441.60 ± 427.90a

Conclusion and Recommendations

The study examined the growth habits and yield of three Brachiaria cultivars subjected to different eco-climatic zones of Tanzania. The results revealed that, sub-humid climate was superior in terms of all growth attributes and biomass yield against the semi-arid zone characterized with poor growth performance and low yield. Interestingly, *B. decumbens* cv. Basilisk was relatively shorter grass but scored the highest values for plant number and biomass yield and hence recommended to all the three climatic conditions. Surprisingly, *B. brizantha* cv Xaraes exhibited relatively higher number of tillers per plant in semi-arid condition besides their relatively poor growth

performance. The study further, recommend for further studies on nutritive values and palatability for these Brachiaria cultivars.

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