Growth and Yield of Three Brachiaria Cultivars from the Southern Highlands, Rungwe, Mbeya, Tanzania

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Abstract

Scarcity of grazing land in the Southern Highlands of Tanzania limits livestock production. Although high yielding pasture species such as Brachiaria are recommended in the areas where land is limiting factor, there is limited information on its growth and yield under humid climates. The experiments were conducted in Rungwe district to test performance of three cultivars of Brachiaria (Brachiaria brizantha cv. piata, Brachiaria brizantha cv. xaraes and Brachiaria decumbens cv. basilisk) against the local pasture species, Pennisetum purpureum. The study used the Complete Randomized Block Design where two experiments (on-station and on-farm) were considered as blocks, while Brachiaria cultivars were treated as main factors. Data on germination characteristics were recorded during the first two weeks after sowing whereas data on growth performance were collected at intervals of four weeks for three months consecutively. Farmers' performance evaluation and above ground biomass estimation was done at week 13rd of the experiment. Although, Pennisetum purpureum was consistently ranked higher by farmers in terms of growth attributes, the field data established little variations with other Brachiaria cultivars. Interestingly, B. decumbens cv. basilisk scored relatively higher values for germination rate, tiller number and biomass which imply its good growth and productive performance. The lower mean height of B. decumbens cv. basilisk probably optimises the accumulation of its biomass. The B. brizantha cv. xaraes exhibited lowest growth performance, and was relatively affected by insect and diseases. Therefore, the study recommended up-scaling of B. decumbens cv Basilisk in the Southern highlands and other areas with similar humid climate.

Keywords: Above-ground Biomass, Brachiaria Cultivars, Dairy Production, Growth Performance, Seed Germination

Introduction

Scarcity of forage is one of the most critical constraints for dairy production in Tanzania. Natural pastures are characterized by poor nutritive values with relatively lower digestibility because most of them are rapidly maturing perennial grasses (Mwilawa *et al.* 2008). The availability of natural pastures is also uncertain especially due to scarcity of land, the fact that is another major limitation for dairy production. Thus, in addition to natural forages, dairy cattle farmers in Mbeya and other regions in the Southern Highlands depend on crop residues (maize stover and rice straw) and banana leaves for animal feeding. These feeds, however, are characterized by low Crude Protein (3 to 4%) which is three times lower than the requirement for dairy cows (Mtengeti *et al.* 2008).

In Rungwe district, Mbeya region, cultivation of improved pastures and forages is minimally practiced. Therefore, dairy cattle farmers mostly depend on natural forages collected from fallow lands, road sides and river banks, and thus animals are normally undernourished. Most of these natural forages are undergoing process of degradation due to lack of proper management resulting to low milk yield ranging from 4 to 8 L per cow per day for dairy cows with genetic potential of producing at least 15 L per day (Mtengeti *et al.* 2018). Rungwe is one of the districts in the Southern highland with arable land and larger proportion of dairy cows (Kurwijila 2012) and hence improvement of animal feeds is imperative to achieve its productive potential. Currently, the district is estimated to have a total population of 339,157 people of which almost every household keeps a dairy cow (Kihoro *et al.* 2021). Although, high yielding fodder grasses such as Brachiaria have been recommended in highly populated areas, scarcity of land particularly in highland areas limits forage production (Mutimura and Everson 2012). Most studies on continental scale focused largely on availability and quality of different Brachiaria cultivars in low rainfall areas (Maia *et al.* 2014; Mutimura and Everson 2012; Paulino *et al.* 2011). There is lack of information on growth performance, climatic adaptability and yielding potential specifically for the three Brachiara cultivars; *Brachiaria brizantha cv. piata*, *Brachiaria brizantha cv. xaraes* and *Brachiaria decumbens cv. basilisk* when subjected to highland climatic conditions with high moisture contents and low temperature. Unfortunately, there is paucity of information on performance and productivity of Brachiaria cultivars in Rungwe district.

The current study funded by the InnovAfrica Project evaluated the growth performance, yielding potential and farmers' perceptions (on yield and perceived palatability) of the three Brachiaria cultivars against the selected best local pasture, elephant grass (*Pennisetum purpureum*) which was used as control experiment.

Materials and Methods

Study area

The study was carried out in Rungwe district found in Mbeya region, South West Tanzania (Fig. 1). The study area lies between 9000'S, and 9030'S; and 33030'E and 34000'E in South-Western Tanzania (Mwakisunga and

Figure 1: The map of Rungwe District showing study sites

Source: Modified from Mwakisunga and Majule (2012)

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).

Rungwe is divided into three agro-ecological zones, namely the upper, middle and lower zones. The upper/highlands zone is largely covered by Uporoto Mountains covering about 10% of the total area of the district with an altitude of 2865 meters above the sea level. Generally, the highlands zone is cold throughout the year with the average temperature of 16°C and rainfall ranging from 1500 mm to 2700 mm per annum (Mwakisunga and Majule 2012). Rungwe is one of the densely populated districts in the country with 339,157 people in 2012 census (URT 2013). The inhabitants of Rungwe are farmers engage in mixed farming (crop production and keeping of dairy cattle).

Experimental design and sampling procedure

The study used the Complete Randomized Block Design where two experimental plots; Ilenge Ward Resource Centre (IWRC) and Msigwa Private Farm (MPF) were treated as two blocks and Brachiaria cultivars were considered as main factors. The experimental plot at IWRC was treated as on-station experiment whereas the one at MPF was considered as on-farm experimental plot. Three Brachiaria cultivars (*Brachiaria brizantha cv. piata*, *Brachiaria brizantha cv. xaraes* and *Brachiaria decumbens cv. basilisk*) were randomly replicated four times in each experimental plot. Each cultivar was sown in four sub-plots of 4 x 5 m. The distance between sub-plots was one (1) metre 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 2017. Triple Super Phosphate fertilizer (250 kg/ha) was applied during sowing and Urea fertilizer was used as top-dressing fertilizer after 8 weeks of establishment. All sub-plots received similar agronomic management including manual weeding using hand hoe.

Growth performance of each variety was monitored throughout the growing period from sowing to harvesting by estimating number of plants germinated, seedling heights and number of tillers. Seed viability was determined in the field by comparing germination rate of tested cultivars. Growth characteristics were determined by counting number of tillers per plants, number of plants per square meter and average height of plants in the interval of two weeks for 13 weeks consecutively. 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 and green samples were collected from each cultivar within the 0.5 x 0.5 m quadrat and weighed. Thereafter, each sample was chopped and from it, fractions of samples were taken to the Department of Animal, Aquaculture and Range Sciences, Sokoine University of Agriculture for dry matter determination. In the laboratory, samples were forced-dried in oven at 105°C for 48h. After drying to the constant weight, samples were again weighed to determine DM (Dry matter) content and extrapolated to kg DM ha^{-1}. Incidences of pest and diseases were estimated synonymously by scoring their levels of prevalence.

Data analysis

Analysis of variance (ANOVA) was undertaken to determine the effect of different Brachiaria cultivars on the evaluated attributes. In cases where significant differences were determined in the ANOVA, Least Square Difference (LSD) was applied (at 5%) to discriminate the differences among the mean values. Analyses were performed following the Complete Randomized Block Design model according to Montgomery (2012), using the SAS software of 2014. The statistical model used was; Responses (growth attributes and yield)=General Mean+Cultivars (tested factor)+Location (Block)+Residual.

Results

The results of seed viability monitored in the first two weeks are presented in Figure 2. Although, no significant differences in germination rate were noted between on-station (Ilenge Ward Resource Center) and on-farm plots (Msigwa Farm), it was observed that, in all plots the germination rate was significantly higher for *B. decumbens cv basilisk* compared to other cultivars. Its germination rate was almost twice as much as those recorded from *B. brizantha cv xaraes* and more than 25% of those observed from *B. brizantha cv piata*. The viability of elephant grass was constant across all subplots as it was based on cuttings (4 plants per meter square) rather than seeds.

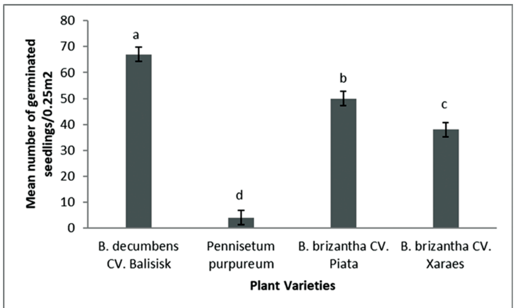

Figure 2: The mean number of germinated seedlings per quadrat (0.5x0.5) recorded in the first two weeks

Temporal variation in mean numbers of plant recorded was also observed between the cultivars. Generally, there was exponential increase in the individual numbers of Brachiaria plants recorded with time (Fig. 3) which implies less seedlings mortality. The mean number of Brachiaria plants recorded per square metre (m^2) in the current study increased linearly with time starting from week two (2) (51 plants/m^2) to week 13 (151 plants/m^2). Generally, there were relatively higher densities of plants per unit area particularly for *B. decumbens cv basilisk* which exhibited significantly higher number plants throughout the experimental period. The significant higher number of *B. decumbens cv basilisk* could probably be attributed to its relatively higher viability potential. Nevertheless, slight variation between *B. brizantha cv piata* and *B. brizantha cv xaraes* was only observed at the first four weeks and the rest of time none significant was observed between them. As noted earlier, the number of *Pennisetum purpureum* remained constant across subplots over time.

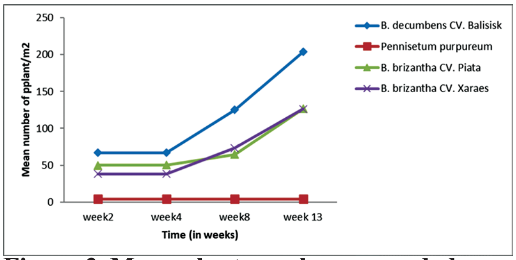

Figure 3: Mean plant numbers recorded over time

The growth and productive performances of experimental plants were visually evaluated by farmers and their average scores were presented in Table 1. Generally, most of attributes scored between 3 (good) to 4 (very good). The

Tablel 1: Farmers' performance evaluation by ranking different plants' attributes

Variety	Growth rate	Yield	Height	Greenish	Disease	Pest
B. ducumbens CV. Balisisk	2.0±022b	2.5±0.38b	2.0±0.2c	2.75±0.41	3.25±0.3	3.0±0.41
B. brizantha CV. Piata	2.5±022b	2.75±0.38ab	2.25±0.2b	2.25±0.41	3.5±0.3	3.25±0.41
B. brizantha CV. Xarases	2.75±022ab	2.75±0.38ab	2.5±0.2b	2.75±0.41	3.5±0.3	3.0±0.41
Pennisetum purpureum	4.0±022a	3.5±0.38a	4.0±0.2a	2.5±0.41	3.25±0.3	3.25±0.41
Significance at 5%	**	*	**	NS	NS	NS

*Scores range from 1 = poor, 2 = fair, 3= good and 4 =very good. * =significant, ** highly significant and NS= none significant*

Pennisetum purpureum was consistently ranked higher by farmers in terms of growth habit, yield and height (Table 1). On the other hand, the *B. decumbens cv basilisk* was ranked the least by farmers in terms of height, which was also confirmed to be relatively shorter plant from the field data (Fig. 5). Other attributes such as greenish color of plants and ability to resist pest and diseases were found to have less significant differences across the tested varieties.

Above ground biomass was significantly higher in *Pennisetum purpureum* and *B. decumbens* cv basilisk compared to *B. brizantha cv piata* and *B. brizantha cv xaraes*. The average above ground biomass for *Pennisetum purpureum* and *B. decumbens cv basilisk* were 7721.97 kg/ha and 6441.6 kg/ha respectively (Fig. 4).

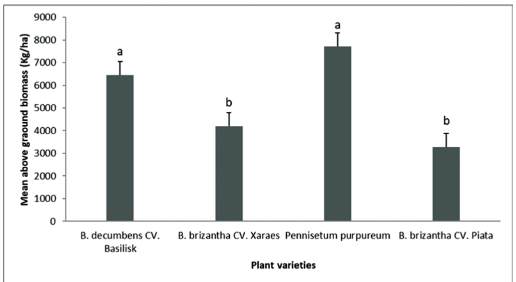

Figure 4: The above ground biomass of different tested grass varieties

The average heights of tested grass cultivars recorded for the period of three months are presented in Figure 5. The *Pennisetum purpureum* exhibited significant higher mean height throughout the experimental period. On the contrary, the *B. decumbens cv basilisk* had significantly low average height compared to other varieties. Interestingly, the height attributes from field data had similar trend as those scored by farmers during field day.

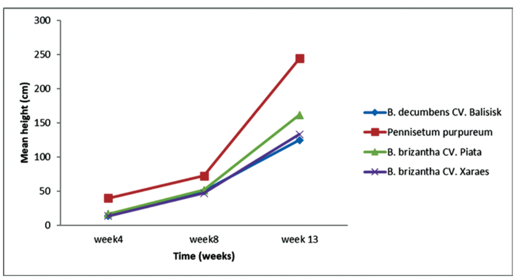

Figure 5: Growth performance of tested plant cultivar over time

The current study established linear relationship between number of tillers and biomass production. Correlation analysis established strong positive correlation co-efficiency (0.69) between number of tillers and above ground biomass. In particular, the higher number of tillers found in *Pennisetum Purpureum* and *B. decumbens cv basilisk* were closely correlated with their respective higher above-ground biomass production (Fig. 4&7). The number of tillers for these two grasses increased exponentially with time, starting with an average of 2 tillers per plant at week four to 8 and 10 tillers per individual *B. decumbens cv basilisk* and *Pennisetum Purpureum* respectively (Fig. 7).

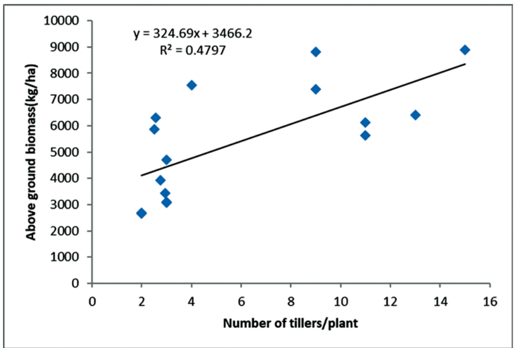

Figure 6: The correlation of above ground biomass and number of tillers per plant

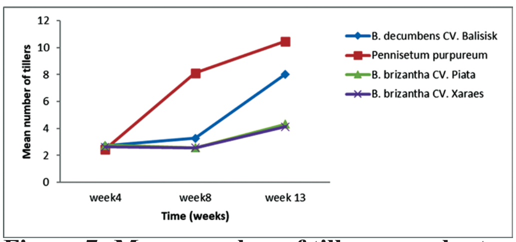

Figure 7: Mean number of tillers per plant

Almost all tested grass cultivars found to have good ability to resist pest and disease as rated by farmers during field day. However, the field data taken over the period of three months indicated slight variation in ability to resist pest and diseases whereas *B. brizantha cv xaraes* found to have relatively less ability to resist pest and diseases (Table 2). Nevertheless, no variation was noted between on-station and on-farm plots in terms of pest and disease resistance.

Table 2: Pest and disease resistance

	Insect incidences	Diseases incidences
Ilenge VKC	0.94 ± 0.06	0.34 ± 0.14
Msigwa Farm	0.83 ± 0.06	0.39 ± 0.14
Significance at 5%	NS	NS
B. decumbens CV. Balisisk	0.87 ± 0.08b	0.04 ± 0.19b
B. brizantha CV. Xaraes	1.13 ± 0.09a	0.81 ± 0.20a
Pennisetum purpureum	0.79 ± 0.08b	0.29 ± 0.19b
B. brizantha CV. Piata	0.76 ± 0.08b	0.32 ± 0.20b
Significance at 5%	**	**

The scores ranges from 0-5 where 0=no insect pest, 1=few plants have diseases and 5=75% of plants have diseases

Discussion

Viability of seeds is one of the important factors determining pasture productivity. Significantly higher germination rate for *B. decumbens cv basilisk* compared to other cultivars may be attributed to variation in seed viability. Although no controlled germination test was done in laboratory prior to sowing, its germination rate on-farm was almost twice as much as those of *B. brizantha cv xaraes* and more than 25% of those observed from *B. brizantha cv piata*. The differences in germination observed among the Brachiaria cultivars may probably due to variations in their intrinsic properties such as seed dormancy, hardness of seed coat, impermeability to water and gases as well as external factors such as sensitivity to sunlight and temperature. Prudente and Paiva (2017) explained that germination of some seeds is positively or negatively affected by external factors such as sunlight. For example, Erasmo *et al.* (2017) found that, the germination rate of *B. brizantha cv piata* was significantly reduced due to low light intensity which could be the case in Rungwe district where the area is characterized by cloudy and humid conditions all year around. Nevertheless, the significantly lower number of *Pennisetum purpureum* per unit area was expected because of the nature and size of planting materials. Unlike Brachiaria cultivars, where seeds were sown, the *Pennisetum purpureum* was planted using cuttings which are relatively large in size (40 cm) and hence occupied large area per single planting material.

The exponential increase in the individual numbers of Brachiaria recorded with time implies less seedling mortality for Brachiaria cultivars. The current findings confirmed by Oliveira *et al.* (2016) who attributed the low seedling mortality of Brachiaria to its rapid reproductive cycle, high photosynthetic and nutrient use efficiency as well as high growth rates. Nevertheless, the temporal increased in plant population per time was similar to the study done by Nguku *et al.* 2015, who established positive changes in number of plants per time. Surprisingly, the noted higher density of *B. decumbens* cv basilisk throughout the experimental period did not affected its growth attributes and biomass yield as would be expected. Normally, as plant population become denser, it results into the stiff competition for necessary resources for growth such as light, nutrients and water (Erasmo *et al.* 2017) and subsequently reduces its productive performance which was not the case for *B. decumbens* cv basilisk.

The similarity of the farmers' perception and field data on growth attributes of tested Brachiaria indicated the rich indigenous / local knowledge farmers possessed. Most of attributes rated by farmers during farmers' field day were closely related to the field measurements taken for three months of experimentation. For example, the elephant grass was ranked higher in terms of growth habit, height and yield, of which the similar trend was recorded from the field data. Similarly, the *B. decumbens cv basilisk* was ranked the least by farmers in terms of height, which was also confirmed by measurement in the field. Therefore, involvement of farmers in the field trials is not only important for performance appraisal, but also facilitates use of local knowledge and easy adaption of tested technology. Farmers' participation provides sense of ownership and great amount of experience and insights for planning, implementation, monitoring and evaluation of targeted projects (Iddi and Nuhu 2018). This in turn will ensure sustainability and easy up-scaling of innovative technologies to farmers.

Although plant height is considered as one of the factors determining forage yield, it was contrary to *B. decumbens cv basilisk* which found to have the least mean plant height but had significantly higher above ground biomass yield. This is most likely explained by other factors such as plant density per unity area, nature and number of leaves as well as number of tillers.

The current study established significantly higher plants number per unit area coupled with substantial increase in tiller number for *B. decumbens cv basilisk* which did not differ much with that of elephant grass. Nguku (2015) established that, the genus decumbens is one of the C4 plants with high productivity, tolerance to low fertility, good growth performance and good quality forage. Although *Pennisetum purpureum* was also ranked higher by farmers in terms of growth habit, yield and height but the field data indicated that its yielding potential in terms of above-ground biomass (kg/ha) did not differ significantly with *B. decumbens cv basilisk*. Neither variation in biomass production nor tillering habits favour utilization of *Pennisetum purpureum*, against *B. decumbens cv basilisk* due to their variations in digestibility. Rocha *et al*. (2019) established low biomass digestibility of *Pennisetum purpureum* which reduces its utilization potential. On the contrary, Guerra *et al.* (2019) reported high digestibility of Brachiaria cultivars under different soil conditions.

Tillering is an important attribute of forage plants because of its influence on leaf-area production and dry matter yield. The number of tillers produced by grasses allows them to attain maximum growth at early age and recover fast after defoliation (Machogu 2013). The current study noted close correlation between the number of tillers and biomass production. The positive correlation between number of tillers and biomass production of different Brachiaria cultivars was also reported by Mustaring *et al.* (2014). According to the authors, the higher number of tillers reflects higher biomass production per unit area. Indeed, the productivity and longevity of Brachiaria forages is determined by its tillering behavior (Araújo *et al.* (2020). The number of tillers for these two grasses increased exponentially with time, from an average of 2 tillers per plant to 10 tillers per plants.

Dairy cattle keepers are in favour of high yielding pasture species which are tolerant to drought and pest/diseases. All tested grasses were ranked to be good to very good in terms of resisting pests and diseases of which similar trend was also noted from field data. The field data indicated no variations in the incidences of pest and diseases for all tested cultivars except for *B. brizantha cv xaraes* which exhibited relatively less resistance to pest and diseases. Although it was not clear which pest infected grasses, the few affected plants had indication of leaf spot diseases which could have biological implication on plant growth if not well managed. Unfortunately, it was not well established whether the poor performance of *B. brizantha cv xaraes* was associated with its inability to resist pests and diseases or its genetic potential.

Conclusion

The study showed that Brachiaria cultivars performed well in terms of growth and yield in the Southern Highlands of Tanzania particularly Rungwe District which is the ideal area for dairy farming. Most of tested Brachiaria cultivars were characterized by fast growth, high yielding potential and high resistance to pests and diseases. In particular, the *B. decumbens cv basilisk* found to have relatively higher growth and productive performance in terms of tillering and above ground biomass yield. Interestingly, performance evaluation by farmers in terms of growth attributes and yielding potential did not vary significantly with findings from field data which informed the rich indigenous/local knowledge possessed by farmers. Although the growth and productivity of local elephant grass (*Pennisetum purpureum*) did not differ significantly with improved Brachiaria cultivars, yet the utilization potential can be complemented by using alternative and best performing forage materials. It is therefore anticipated that, the production level of dairy cow in Rungwe will increase through promotion and utilization of improved Brachiria cultivars particularly the *B. decumbens cv Basilisk* with the highest yielding potential.

More studies are, therefore, recommended to investigate the underlying factors affecting growth performance particularly of *B. brizantha cv xaraes* taking into account both pull (internal) and push (external) factors. Although, the current study provided the insights on growth performance and yielding potential of tested grasses, further studies are recommended to examine the nutritive values, digestibility and the nutritional impacts to dairy cow production which is among the core livelihood activities in the Southern Highland of Tanzania.

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