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# Integration of Improved Forage Species in Mixed Farming System to Increase Feed Availability and Resiliency for Sustainable Productivity in Northern Ghana

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## ABSTRACT
***Ten accessions of forage seeds from Brachiaria and Panicum genome were evaluated at Council for Scientific and Industrial Research - Animal Research Institute's pasture experimental field in Nyankpala to determine the agronomic performance and biomass yield for integration into mixed farming system to increase feed availability and resiliency. The forage accessions were planted as a complete randomized design (CRD) with plot size of 5 x 2 m square as treatments units and replicated four times. The forage was left on the field after harvesting and sprouted at the on-set of rains in second year (2024). Data were taken on the second year's re-established forages. Panicum mun river was selected among the forage accessions and planted on-farm in three demonstration fields in different locations in the farmers' fields in Doku community. Agronomic and biomass yield data were collected both on-station and on-farm fields. Results of the on-station first harvest showed that DM yield was highest (P = 0.019) in Panicum mun river (2.14 tonnes/ha) and lowest in Brachiaria talisman (1.07 tonnes/ha). It further revealed that the Panicum varieties performed higher (P<0.001) than the Brachiaria varieties. The DM yield obtained from second on-station harvest data, Panicum varieties was 1.9 tonnes/ha higher (P=0.014) than 1.5 tonnes/ha in Brachiaria varieties. The on-farm results showed that mean plant height values of 104.3, 103.0 and 166.5 cm for fields I, II and III respectively. Dry matter yield obtained were 3.33, 3.34 and 4.89 tonnes/ha for fields I, II and III respectively with field III value being highest (P=0.015). The best performing forages among the 10 accessions were P. mun river., P. mombasa and B. Camello. These forages could be integrated into the mixed farming system to improve feed availability and resiliency.***

**Keywords**: *Dry matter, biomass yield, forage varieties, feed availability, farming system*

## INTRODUCTION
Feed availability is one of the major components in livestock production that hugely influences the success of the enterprise. In Ghana, common livestock feed resources utilized by farmers are natural pasture, crop residues and agro-industrial by-product (Konlan *et al.*, 2016: Larfarge and Loiseau, 2002; Yafetto *et al.,* 2023). In the dry season, the quality of the available grasses on the grazing lands reduces drastically due to senescence, high temperatures and low soil moisture (Thornton *et al.*, 2010). In the rainy season, the extensive cultivation of food crops limits animals' accessibility to pasture and makes grazing on natural pasture very limited (Lamy *et al.*, 2012). In this season, livestock farmers often placed their animals on restricted feeding regimes such as zero grazing (cut and carry feed-

ing) or tethering animals to prevent them from grazing other farmers' crops. This limited grazing and restricted feeding often lead to decreased in animals' weight gain and productivity (Anoh *et al.*, 2007: Pérez-Ramírez *et al*., 2008: Lamy *et al*., 2012). Also, the sources of forage and browse plants that are being cut for zero grazing are diminishing and are very difficult to obtain. This restricted feeding regime directly affects the overall productivity of animals and results in low animal performance that directly decreases farm output and farmers' income. This phenomenon has led to the search for alternative feed sources for sustainable production of farm animals. There is also very low adoption rate of improved forage cultivation as fodder for feeding ruminants in Ghana and need to be improved and encourage farmers to go into forage cultivation in their farming system as feed. It is therefore important to evaluate tropical forage species and integrate the high performing forages into the farming system to increase feed availability for livestock production and improve the resiliency of the farming system. This integration of forages into the farming system is one of the sustainable intensification pathways that is very relevant for improving livestock production and general productivity of the mixed farming system practiced by most farmers in northern Ghana.

In an intensive pasture production, the predominant genera are *Panicum* and *Brachiaria* (Fernandes *et al*., 2020). Livestock farmers have a preference for these plants due to their hardiness, wide adaptation to different environments, and are associated with high productive potential and good nutritional quality (Faye *et al*., 2023). In a study conducted with *Brachiaria decumbens* in an intensive production system, the researchers reported the accumulation of dry matter in the aerial part of plants as 3.26 and 5.94 tons per hectare, at 30 and 45 days after germination (Fernandes *et al.,* 2020). *Brachiaria* (*Urochloa* spp.) and *Panicum* (*Megathyrsus* spp.) are two important tropical forage species indigenous to Africa and are widely cultivated in Africa, South America, Australia and East Asia in an intensive forage production system (Faye *et al*., 2023; Fernandes *et al.,* 2020). These two forages have demonstrated success in transforming beef and dairy industries (Adnew *et al*., 2021). They are perennial, fast growing forages with high biomass production potential, palatable and nutritious for ruminants (Ba *et al*., 2023). Fernandes *et al.* (2020) reported crude protein (CP) content in B*rachiaria decumbens* at 60 days after plant emergence to be 6.3%, which is very good CP level for good forage as feed for ruminants. They possess large root systems, that accelerates carbon sequestration into the soils, and are adapted to drought and a wide variety of soils, tolerant to shade, water logging and to pests and diseases (Faye *et al*., 2023). *Brachiaria* and *Panicum* grasses are extensively used for grazing, cut-and-carry, and silage and hay production. Improved cultivars of these forages are high yielding, responsive to fertilizer applications, persistent and can remain green long into the dry season. The improved varieties of these forage grasses have not yet been tried in many locations in Sub-Saharan Africa. It is therefore appropriate to evaluate the forages as an on-station trial in Ghana in preparation to integrate the high yielding and palatable forages into the predominant crop-livestock production system in northern Ghana where most of the smallholder farmers cultivate crops and rear animals. The objective of this study was to screen the improved cultivars of *Brachiaria* and *Panicum* forage species in northern Ghana, and identify species with high agronomic and biomass yield for integration into the mixed farming system of smallholder farmers.

## MATERIALS AND METHODOLOGY

### Location and climate of experimental site

The forage species were screen in the pasture experimental field of Council for Scientific and Industrial Research - Animal Research Institute (CSIR-ARI) at Nyankpala station. It is located at latitude 9$^{o}$ 25' 41" N and longitude 0$^{o}$ 58' 42" W at an altitude of 183 m above sea level (GMS, 2017). One of the *Panicum* developed cultivars, (*Panicum mun river*) was planted in three demonstration fields at different locations in Doku community of Savelugu District of Northern Region in the farmers' fields as a way of integrating forage cultivation into the mixed farming system practice by most smallholder farmers. This on-farm integrative demonstration fields establishment was done after first year on-station screening and farmer evaluation of the

forages. Both experimental sites fall within the Guinea Savannah agro-ecological zone which has uni-modal rainfall pattern occurring between mid-April to November with an average annual rainfall of about 1200 mm, an annual mean temperature of 28.3°C and mean relative humidity of 54% (GMS, 2017).

Land area of about one hectare was allocated within the experimental fields for the on-station forage evaluation. This was sprayed with non-selective post-emergence herbicides (glyphosate) with the trade name Sunphosate 360 SL (Zhejiang Xinan chemical Industrial group Co. LTD, China) at a rate of 200 mls into 600 L of water for one hectare field (1 ml : 3 L of water) to kill annual and perennial weeds in the field after which the field was ploughed and harrowed with a tractor to break up the soil lumps and to level the field before planting. Further leveling of the field was done manually to get a very smooth surface before the experimental plots lay out was done.

At the on-station in year one, the design used was Complete Randomized Design (CRD) with 4 replications for each forage on the field. The main experimental field was divided into twenty sub plots and further divided each sub-plot into two to represent an experimental treatment in the field. The dimensions of each treatment plot were 5 x 2 m square and replicates and was replicated four times. A total of 40 treatment plots were laid for the 10 accessions of forage seeds and evaluated on-station in the first year of its establishment. The same forage experimental field second year re-established agronomic and biomass yield data was collected for assessment of the second year's regrowth.

The on-farm integrative demonstration fields established in Doku community was about 30 km away from the on-station field with similar agronomic and environmental factors. This were in the farmers' fields and management in a form of forage gardens during the 2024 cropping season. One of the high performing forages at on-station; *Panicum mun river* was used for planting in the on-farm integrative demonstration fields. The dimensions of the fields were 10 x 5 m square for each location with 1 m boarder distance in each farmer's field. A total of three fields were established in the Doku community. Field preparation was manually done and well leveled with hand hoe for the on-farm demonstration fields establishment.

On the forage planting, a total of 10 accession of forage seeds made up of *Brachiaria and Panicum* species were acquired from ALLIANCE for Biodiversity & CIAT (International Center for Tropical Agriculture) for the evaluation. The detailed list of the seeds is presented in Table 1. The seeds of each forage specie were randomly allocated to a treatment plot and replicated four times within the field. The treatments (each forage specie) were arranged in a complete randomized design. The on-station experimental field had no differences in soil characteristics and topography.

**Table 1: List of forage accessions evaluated in northern Ghana**

| S/N | Scientific name of forage accession | Varietal name |
|---|---|---|
| 1 | *Brachiaria mestizo* | Urochloa hybrid "Mestizo" |
| 2 | *Brachiaria hybrid GP3025 "Camello"* | Urochloa hybrid GP3025 "Camello" |
| 3 | *Brachiaria hybrid GP0423* | Urochloa hybrid GP0423 |
| 4 | *Brachiaria hybrid GP1794 "Cobra"* | Urochloa hybrid GP1794 "Cobra" |
| 5 | *Brachiaria hybrid "*Talisman" | Urochloa hybrid CIATGP1005BR "Talisman" |
| 6 | *Brachiaria basilisk* | Urochloa decumbens "Basilisk" |
| 7 | *Brachiaria marandu* | Urochloa brizantha "Marandu" |
| 8 | *Panicum mombasa* | Megathyrsus maximus "Mombasa" |
| 9 | *Panicum maasai* | Megathyrsus maximus "Maasai" |
| 10 | *Panicum mun river* | Megathyrsus maximus "Mun River" |

The planting of the forage seeds was done in July, 2023 within a period of three days. Using drilling as a sowing method, the seeds were sown in 10 rows per plot with planting distance of 50 cm between rows, at an average seeding rate of (42.5 kg/ha). Germination was observed within 3-8 days after planting in the first year of on-station forage experimental field establishment in 2023. Over 90% of the forages in the on -station experimental field survived the five months long dry season in the Savannah ecological zone and sprouted well at the on-set of rainfall in April, 2024.

At the on-farm integrative demonstration fields in Doku, the *Panicum mun river* was planted in August, 2024 due to the dry spell that occurred in the Northern Ghana during 2024 rainy season. The planting dimensions used for the *Panicum mun river* was 50 x 50 cm between rows and within rows. The seeding rate used for planting of the forage was 15 kg/ha. The forage seeds were mixed with rice husk uniformly at a ratio of 1 part of seed to 3 parts of rice husk before planting.

Weeds control was done on the 3$^{rd}$ week and 6$^{th}$ week after planting using a hand hoe and by occasional manual hand removal of weeds especially within rows in the field during the first year (2023) in the on-station experimental field. A basal application of IDISAL$^{TM}$ fertilizer (NPK 25-10-10) was also done at a rate of 100 kg/ha in first year (2023). In the second year (2024), the weed control was done during the first week of June and in the last week of August, 2024. In the on-farm demonstration fields at Doku, weeds control was done manually with hand hoe once at third week after planting.

Four plants in each plot within one square meter were randomly selected, and each plant height measured with tape measure. Samples of each forage specie was harvested within one metre square per plot. The first data collection on plant height and biomass sampling was done at 15$^{th}$ July and second same data collection done on 8$^{th}$ November, 2024 in the second year of the on-station forage experimental field. The data collection was deemed ready when the forage attained closed canopy growth after sprouting at the on-set of rainfall in the second year. The second data collection was taken on the re-growth after the first data collection and general harvesting, leaving a stubble height of 5 cm above ground level.

The on-farm *Panicum mun river* demonstration fields data collection was done at two different ages of the forage growth. First agronomic and biomass yield data collection was done at 7 weeks after planting when the forage formed closed canopy in its growth. Specifically, on 9$^{th}$ October, 2024 and that was 52 days of the plant age and the second same data collection was done at 10 weeks after planting, specifically on 30$^{th}$ October, 2024, 73 days of plant age. Re-growth biomass harvest was done 3 weeks after the first harvest to determine the re-establishment rate of the *Panicum mun river* in the farmers' fields. The harvesting was done leaving a stubble height of 5 cm above ground level.

The fresh weight of the samples of the harvested forages was taken with digital weighing scale and then sent to laboratory for determination of dry matter weight of the samples. This was done by putting the samples in an oven at a temperature of 60 $^{\circ}$C for 48 hours. These samples dry matter content was then used and determined the dry matter weight of the one metre square biomass yield of each forage replicate plot harvested. The data was extrapolated to obtained the forage dry matter yield per hectare.

The data collected was analyzed by ANOVA using GenStat (12th edition). The forage varieties and harvesting periods served as fixed factors and the measured parameters such as plant height, forage fresh and dry matter yield were the dependent variables for on-station data. The on-farm data; the field location in each farmer plot and harvesting age were the independent factors and measured parameters as mentioned above formed the dependent variables. Differences of means were determined using LSD at $P<0.05$ probability level.

## RESULTS AND DISCUSSION

The second-year regrowth of the on-station forages established for screening *Panicum* and *Brachiaria* accessions for integration into mixed farming system, agronomic and biomass yield parameters results have been categorized into

first and second harvest. The results represent the re-establishment growth of the forages after the on-set of rainfall. The comparative growth height of both *Brachiaria* and *Panicum* forage accessions at first harvest data collection showed that *Panicum mun river* had the superior growth and was the highest (P<0.001) forage (147 cm) but not significantly higher than *Panicum mombasa* with a height value 146 cm. *Brachiaria talisman* was the shortest forage (52.1 cm) among all the 10 forages accessions (Table 2). The differences in the forage heights were associated to forage resiliency to survive the dry season and its regenerative ability to sprout and grow faster after the on-set of rains. It was also attributed to the genotypic makeup of the forages since the two grass forages are of different genetic makeup. Over 90% of the forage survived the dry season and were physically looking very good and more greenish after the first harvest. The fresh forage biomass yields mean values did not show statistical differences but significant differences were observed in the dry matter (DM) yield among the 10 forage accessions. The DM yield obtained was highest (P = 0.019) in *Panicum mun river* (2.14 tonnes/ha) and lowest in *Brachiaria talisman* (1.07 tonnes/ha). The *Panicum mun river* DM yield mean value was similar to that of other *Panicum* varieties tested but higher than the *Brachiaria* varieties. This indicated superior DM yield performance of *Panicum varieties* over that of the *Brachiaria* in this study within this environment. The similarity of the mean fresh forage biomass yield values but significant differences in DM yields suggested differences in moisture contents of the forages harvested fresh, that might have accounted for the DM yield differences in values.

**Table 2: On-station second year forage agronomic and dry matter yield during first harvest**

| Forage specie | Plant height (cm) | Fresh yield (tonnes/ha) | Dry matter yield (tonnes/ha) |
|---|---|---|---|
| *B. talisman* | 52.1$^{ga}$ | 7.00 | 1.07$^{e}$ |
| *B.H GP0423* | 75.2$^{f}$ | 18.00 | 1.41$^{bcde}$ |
| *B. mestizo* | 84.2$^{ef}$ | 17.75 | 1.84$^{abcd}$ |
| *B. basilisk* | 85.9$^{ef}$ | 12.25 | 1.29$^{de}$ |
| *B. marandu* | 97.9$^{de}$ | 15.75 | 2.03$^{ab}$ |
| *B. cobra* | 102.9$^{cd}$ | 16.00 | 1.30$^{cde}$ |
| *B. camello* | 114.1$^{c}$ | 20.25 | 1.67$^{abcde}$ |
| *P. massai* | 129.8$^{b}$ | 20.75 | 1.77$^{abcd}$ |
| *P. mombasa* | 145.6$^{a}$ | 17.00 | 1.92$^{abc}$ |
| *P. mun river* | 147.1$^{a}$ | 14.75 | 2.14$^{a}$ |
| SED | 7.08 | 5.548 | 0.3082 |
| p-value | 0.001 | 0.426 | 0.019 |

*Means with different superscripts in the same column are statistically different at p<0.05; B= Brachiaria, P= Panicum, SED=Standard Error of Differences of means*

**Table 3: Comparative agronomic and dry matter yield of second-year on-station Brachiaria and *Panicum* forage accessions at first harvest**

| Parameters | Brachiaria | Panicum | SED | P value |
|---|---|---|---|---|
| Plant height (cm) | 87.5$^{b}$ | 140.8$^{a}$ | 4.4 | 0.001 |
| Fresh biomass yield (tonnes/ha) | 15.29 | 17.50 | 2.734 | 0.423 |
| Dry matter yield (tonnes/ha) | 1.52$^{b}$ | 1.94$^{a}$ | 0.166 | 0.014 |

The results of plant height and biomass yield of the *Brachiaria* and *Panicum* varieties were compared and it revealed that the *Panicum* varieties performed higher (P<0.05) than the *Brachiaria* varieties (Table 3). In terms of plant height, *Panicum* varieties mean value was 140.8 cm versus 87.5 cm in *Brachiaria*. The *Panicum* varieties DM yield value obtained was 1.9 tonnes/ha and significantly higher (P=0.014) than 1.5 tonnes/ha in *Brachiaria* varieties. The higher performance of the *Panicum* varieties in the second year is in line with same performance of the forages in similar experiment in the same area reported by Ansah *et al.* (2023).

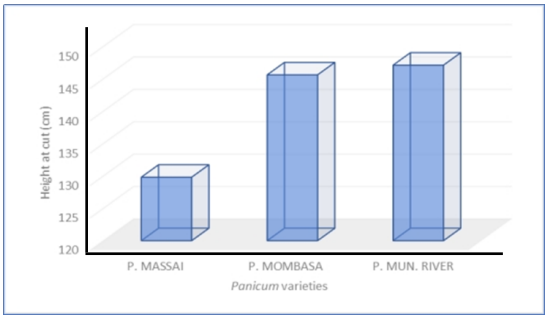



**Figure 1: *Panicum* forages comparative height at first cut in second year**

The three varieties of the *Panicum (P.)* were compared to determine the best performing variety in terms of plant height and dry matter yield. The results of plant height showed *P. mun river* as highest but similar to that of *P. mombasa* with *P. massai* being shortest among them (figure 1).

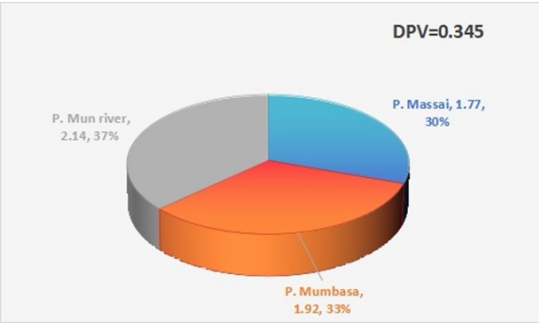



**Figure 2: Comparative dry matter yield (tonnes/ha) of 3 *Panicum* varieties at first harvest in second**

Figure 2 illustrates the comparison of the dry matter yield of the three forages. This also followed the same trend as in the plant height with *P. mun rive*r contributing 37% (2.14 tonnes/ha) being the highest of the total dry matter yield of the three forages combined whereas the *P. massai* contributed 33% (1.8 tonnes/ha) the least DM yield.

Table 4 presents the plant height and biomass yield of the *Brachiaria* varieties in the second year of establishment at first harvest. The result showed significant differences in plant height among the B*rachiaria* varieties with *B. camello* recording highest height (114 cm) and *B. talisman* with the shortest mean plant height. The fresh biomass and dry matter yield did not show statistical differences (P>0.05) among all the *Brachiaria* varieties. The values obtained in this study are lower than a mean of 6.53 tonnes/ha of dry matter yield for 4 weeks regrowth reported in *Brachiaria decumbens* and *Ruziziensis* under heavy fertilizer application before and after leveling cut (Asis *et al.,* 2023). The differences of the values emanate from the fertilizer application that was done in this particular study.

The results of forage height and biomass yield in November at second year of forage establishment at the on-station of both *Brachiaria and Panicum* accessions are presented in Table 5. This regrowth after the first harvest in July represent the measure of the forage growth and biomass accumulation in the second year. The highest (P<0.001) mean plant height was observed in *P. massai* (117.06 cm) and the shortest plant height recorded in *B talisman* (50.44 cm). Fresh biomass and dry matter yield did not show difference (P>0.05) at the second harvest of the second year of forage regrowth (Table 5). The low dry matter yield values could be associated with inadequate moisture due to the erratic rainfall the was experienced during the 2024 growing season in the area.

The comparative regrowth results of the *Brachiaria* and *Panicum* forage varieties showed higher (P<0.001) plant height in *Panicum* than the *Brachiaria* varieties (109.1 versus 70.4 cm) as presented in Table 6. The fresh biomass and dry matter yield of the two improved forages did not show statistical differences (P>0.05). The dry matter yield within the *Panicum* varieties

showed *P. mun river* recording the highest (P=0.008) value of 2.27 tonnes/ha and *P. massai* with lowest dry matter yield value of 1.53 tonnes/ha (Figure 3). This followed the same trend as in the first harvest dry matter yield values in figure 2. The dry matter yield values obtained in this work are comparatively lower to the work of Shadrack *et al.* (2019), who reported a mean dry matter yield of 3 tonnes/ha in local varieties of Napier Grass (*Pennisetum purpureum*) at 12 weeks after planting in an on-farm trial in the same Guinea Savannah ecological zone. The lower values in this work are attributable to erratic rainfall with long dry spell in this years' rainy season.

**Table 4: Height and biomass yield of *Bachiaria (B.)* varieties in second-year at first harvest**

| Brachiaria varieties | Plant height (m) | Fresh yield (tonnes/ha) | Dry matter yield (tonnes/ha) |
|---|---|---|---|
| *B. basilisk* | 85.94$^{cd}$ | 12.25 | 1.29 |
| *B. camello* | 114.12$^{a}$ | 20.25 | 1.67 |
| *B. cobra* | 102.94$^{ab}$ | 16.00 | 1.30 |
| *HGP0423* | 75.19$^{d}$ | 18.00 | 1.41 |
| *B. mestizo* | 84.19$^{d}$ | 17.75 | 1.84 |
| *B. marandu* | 97.88$^{bc}$ | 15.75 | 2.03 |
| *B. talisman* | 52.12$^{e}$ | 7.00 | 1.07 |
| SED | 6.87 | 5.8858 | 0.33 |
| p-value | 0.001 | 0.383 | 0.095 |

**Table 5: On-station second year's forage agronomic and biomass yield at second harvest**

| Forage name | Plant height (cm) | Fresh yield (tonnes/ha) | Dry matter yield (tonnes/ha) |
|---|---|---|---|
| *B. talisman* | 50.44$^{e}$ | 17.75 | 1.52 |
| *B. mestizo* | 64.81$^{d}$ | 15.50 | 1.89 |
| *B. bailisk* | 66.25$^{d}$ | 12.75 | 1.76 |
| *B.H GP0423* | 67.31$^{d}$ | 16.00 | 1.55 |
| *B. camello* | 73.62$^{d}$ | 12.00 | 1.79 |
| *B. marandu* | 84.31$^{c}$ | 17.25 | 1.86 |
| *B. cobra* | 86.06$^{c}$ | 11.25 | 1.69 |
| *P. mun. river* | 100.19$^{b}$ | 14.25 | 1.53 |
| *P. mombasa* | 110.19$^{a}$ | 10.50 | 1.99 |
| *P. massai* | 117.06$^{a}$ | 15.50 | 2.27 |
| SED | 4.75 | 3.670 | 2.287 |
| p-value | 0.001 | 0.496 | 0.061 |

*Means with the different superscripts in the same column are statistically different.*
*B= Brachiaria; P= Panicum*

**Table 6: Comparative plant height, fresh biomass and dry matter yield of *Brachiaria* and *Panicum* varieties of year two on-station established forages at second harvest in November, 2024**

| Parameter | *Brachiaria* | *Panicum* | SED | p-values |
|---|---|---|---|---|
| Plant heihgt (cm) | 70.4[b] | 109.1[a] | 2.87 | 0.001 |
| Fresh yield (tonnes/ha) | 14.643 | 13.42 | 1.794 | 0.498 |
| Dry matter yield (tonnes/ha) | 1.722 | 1.93 | 0.122 | 0.098 |

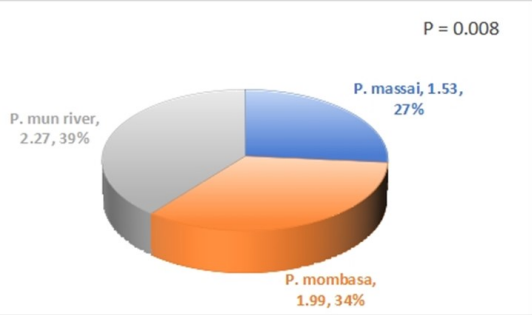



**Figure 3. On-station comparative dry matter yield (tonnes/ha) of *Panicum* varieties in Nov. 2024**

The results on plant height and Biomass yield within *Brachiaria* varieties at the second harvest of the on-station established forages in the second year are presented in Table 7. There were differences (P<0.001) in plant height among the forages. The highest mean regrowth plant height was observed in *B. camello* (86.06 cm) and lowest mean plant height was recorded in *B. talisman* (50.44 cm). The difference in plant height was attributed to plant varietal differences as the plant were in similar environment and received the same conditions needed for plant growth. The fresh biomass and dry matter yield of the *Brachiaria* forage varieties followed the same trend as was observed in the first harvest in July as presented in Table 4 and so, did not show differences (P>0.05) among the *Brachiaria* varieties. Although there were differences in plant height among the *Brachiaria* varieties but it did not affect the plants biomass yield. This could be attributed to smaller leaf size among the taller varieties as in *B. camello*. This is contrary to the general impression and in many situations in herbaceous plants, where taller plants often influence plant biomass production and tend to be

**Table 7: Height and biomass yield of on-station *Bachiaria* varieties in November 2024**

| *Bachiaria* varieties | Plant height (cm) | Fresh yield (tonnes/ha) | DM yield (tonnes /ha) |
|---|---|---|---|
| *B. basilik* | 66.25[b] | 12.750 | 1.76 |
| *B. camello* | 73.62[b] | 12.00 | 1.79 |
| *B. cobra* | 86.06[a] | 11.25 | 1.69 |
| *B. HGP0423* | 67.31[b] | 16.00 | 1.56 |
| *B. mestizo* | 64.81[b] | 15.50 | 1.89 |
| *B. murandu* | 84.31[a] | 17.25 | 1.86 |
| *B. talisman* | 50.44[c] | 17.75 | 1.52 |
| SED | 4.78 | 37.591 | 3.759 |
| p-value | 0.001 | 0.469 | 0.649 |

*Means with the different superscripts in the same column are statistically different. B= Brachiaria; DM= Dry matter*

higher than shorter plants (Sun and Frelich, 2011).

**On- farm agronomic and biomass yield of *Panicum mun river* in the farmers' fields**

The results obtained from the agronomic parameters of on-farm demonstration fields showed that there were no differences (P>0.05) in mean tiller numbers of *Panicum mun river* from three different fields that the forage was planted at 10 weeks after planting (Table 8). The mean plant height values were 104.3, 103.0 and 166.5 cm for fields I, II and III respectively in Doku community with field III value being the highest (P<0.001) compared to fields I and II. Fresh biomass and dry matter yield of the forage showed the same trend. The mean dry matter yield values obtained were 3.33, 3.34 and 4.89 tonnes/ha respectively, for fields I, II and III respectively with field III value being the highest (P=0.015).

The result of *P. mun river* dry matter yield at first harvest (3.28 tons /ha) at 7 weeks after planting was significantly lower (P=0.007) compared to the second harvest at 10 weeks after planting that recorded 6.22 tonnes/ha as presented in Table 9. The regrowth dry matter yield value of 2.33 tonnes/ha was not different from that of the first harvest. The plant height and tiller number data collected during the two harvesting ages showed the same trend as that of the dry matter yield data. The high values of biomass yield observed at second harvest at 10$^{th}$ week after planting was attributable to the increased in plant growth and biomass accumulation in plant tissues in relation to longer days it stayed in the field before harvesting.

There was significant interaction (P<0.001) between field and harvesting age of the forage on fresh biomass and dry matter yield of the forage demonstrated in the mixed farming system (Table 10). This interaction observed suggested that the soil fertility of the three different fields in the same community could be different or the differences in farmers' management practices of the fields might have led to the differences observed.

The *Panicum mun river* agronomic performance and biomass yield data obtained at the on-farm level was comparable to the on-station data and also showed good regenerative ability when harvested for stall feeding or grazed in the field. The higher performance of field III than the other fields (I and II) was further confirming the earlier assumption that the fields' soil fertility and farmer agronomic practices might have differed.

## CONCLUSION AND RECOMMENDATIONS

*Panicum mun river* had the superior growth ability and was the tallest forage among the ten forage accessions at first harvest in July whereas *Brachiaria talisman* was the shortest forage. The DM yield obtained was highest in *Panicum mun river* and lowest in *Brachiaria talisman*. Generally, the *Panicum* varieties performed higher

**Table 8: Agronomic performance and biomass yield of *Panicum mun river* in 3 different demonstration fields at 10 weeks**

| Item | Demonstration fields | | | SED | P-value |
|---|---|---|---|---|---|
| | I | II | III | | |
| Tiller number | 21.46 | 18.96 | 22.96 | 2.094 | 0.163 |
| Plant height | 104.3$^{a}$ | 103.0$^{a}$ | 166.5$^{b}$ | 3.220 | <0.001 |
| Fresh biomass yield (kg/ha) | 10.78$^{a}$ | 10.79$^{a}$ | 25.56$^{b}$ | 0.315 | <0.001 |
| Dry mater yield (kg/ha) | 3.33$^{a}$ | 3.34$^{a}$ | 4.89$^{b}$ | 0.562 | 0.015 |

*Means with the different superscripts in the same row are statistically different at p<0.05*

**Table 9: Agronomic and biomass yield of *Panicum mun river* at two different harvesting ages**

| Forage age | Fresh yield (kg/ha) | Dry mater yield (kg/ha) | Tiller number | Plant height (cm) |
|---|---|---|---|---|
| 7 weeks | 15.33[ab] | 3.78.0[a] | 17.25 | 102.8 |
| 10 weeks | 24.11[b] | 6.22.0[b] | 25 | 146.8 |
| 3 weeks regrowth | 8.11[a] | 2.33[a] | - | - |
| SED | 4.566 | 0.650 | 1.730 | 7.54 |
| P-value | 0.007 | <0.001 | <0.001 | <0.001 |

*Means with the different superscripts in the same column are statistically different at p<0.05*

**Table 10: Interaction effect of harvesting age and fields on biomass yield of *Panicun mun river***

| Demonstration fields | Forage ages (weeks) | Fresh yield (tonnes/ha) | Dry matter yield (tonnes/ha) |
|---|---|---|---|
| Field I | 7 | 9.00 | 2.82 |
| | 10 | 16.67 | 5.33 |
| | 3 regrowth | 8.00 | 2.33 |
| Field II | 7 | 7.33 | 2.33 |
| | 10 | 16.00 | 4.67 |
| | 3 regrowth | 9.00 | 3.00 |
| Field III | 7 | 29.67 | 4.67 |
| | 10 | 39.67 | 8.67 |
| | 3 regrowth | 7.33 | 1.67 |
| SED | | 2.914 | 0.689 |
| P-values | Field | <0.001 | <0.001 |
| | Harvesting age | <0.001 | <0.001 |
| | Field * harvesting age | <0.001 | <0.001 |

than the *Brachiraria* varieties in most of the parameters measured. In terms of plant height, *Panicum* varieties mean value was higher than *Brachiaria*. The on-farm *Panicum mun river* tiller number was similar across the fields but plant height and biomass yield had differences in the different field locations within the same community and suggests field differences in soil fertility and farmer field management practices. The high preforming forages such as *Panicum mun river, P. mombasa and Brachiaria camello* agronomic performance and biomass yield data were very good and also showed good regenerative ability when harvested as feed. Farmers are encouraged to integrate *Panicum mun river* and the other good forages species reported here into their mixed farming system to increase high quality feed availability and improve system resiliency. There are challenges in acquisition of forage planting materials and efforts are needed to train personnel on forage seed production and processing and vegetative propagation technologies for transfer and easy adoption by farmers.

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