



Establishment and Evaluation of Brachiaria-Based Pasture Systems for Improved Productivity of Cattle, Sheep and Goats at Federal Polytechnic Wannune, Benue State, Nigeria

¹Kpehe, A. T.*, ²Apuu, J., ³Utoo, E. G.

^{1,2&3} Department of Animal Health and Production Technology, Federal Polytechnic Wannune, Benue State, Nigeria

*Corresponding author: kpehealbert@yahoo.com; Tel.: 07069624060

Abstract

A field and livestock evaluation was conducted at Federal Polytechnic Wannune, Benue State, Nigeria, to compare the productivity and feeding value of three *Brachiaria*-based pastures: *Brachiaria brizantha* (T_1), *Brachiaria decumbens* (T_2) and the hybrid Mulato II (T_3). The pasture phase was arranged in a randomized complete block design with three replicates and was evaluated during the first phase of twelve weeks. Baseline soil was sandy loam with pH 5.63, organic carbon of 1.42% and total nitrogen of 0.13%. Plant height, tiller density, annual dry matter yield, chemical composition, fibre fractions, in vitro dry matter digestibility, live-weight performance of cattle, sheep and goats, and carrying capacity were determined. Treatment means were compared by analysis of variance and Duncan's multiple range test, while relationships among selected variables were assessed by correlation analysis. Plant-height differences among pastures were not significant at 4, 8 or 12 weeks after planting ($P = 0.103$ - 0.123). Mulato II had the greatest tiller density (842.5 tillers/m²) and annual dry matter yield (18.42 t/ha/year), whereas *B. decumbens* had the lowest corresponding values (595.4 tillers/m² and 11.68 t/ha/year). Mulato II also had the greatest crude protein (15.6%) and in vitro dry matter digestibility (69.8%) and the lowest neutral detergent fibre (58.3%). The recorded average daily gains were 0.71, 0.12 and 0.10 kg/day for cattle, sheep and goats, respectively, on Mulato II; its estimated carrying capacity was 3.5 tropical livestock units/ha. Crude protein was positively associated with average daily gain ($r = 0.89$; $P < 0.01$), neutral detergent fibre was negatively associated with digestibility ($r = -0.86$; $P < 0.01$), and dry matter yield was positively associated with carrying capacity ($r = 0.93$; $P < 0.001$). Results indicated that Mulato II had the strongest overall potential for productive ruminant pasture systems in the study environment.

Keywords: *Brachiaria* pastures; Animal performance; Forage quality; Carrying capacity; Ruminant Pasture

Introduction

Inadequate year-round supply of nutritious forage constrains ruminant productivity in many tropical livestock systems. The constraint is expressed through low herbage availability, rapid decline in forage quality as grasses mature, and seasonal mismatches between animal requirements and feed supply. Establishing persistent, productive and nutritious swards is therefore central to improving cattle, sheep and goat production, particularly where producers depend heavily on grazing and cut-and-carry forage. Improved *Brachiaria* (*Urochloa*) germplasm has attracted attention because of its broad tropical adaptation, forage yield, persistence and potential contribution to climate-resilient livestock production (Djikeng et al., 2014; Maass et al., 2015). *Brachiaria brizantha* and *B. decumbens* are widely used tropical pasture grasses, while Mulato II is an apomictic interspecific hybrid derived from *B. ruziziensis*, *B. decumbens* and *B. brizantha*. The hybrid was selected for favourable agronomic and nutritive attributes and adaptation to well-drained acidic tropical soils (Argel et al., 2007; Pizarro et al., 2013). Across tropical environments, Mulato II has combined substantial dry matter production with a leafy canopy and

comparatively high nutritive value, although cultivar performance depends on soil fertility, rainfall, establishment method, defoliation regime and nutrient management (Hare et al., 2015; Jacovetti et al., 2025).

Evidence from sub-Saharan Africa supports the need for location-specific evaluation. In a subhumid West African environment, Mulato II produced greater herbage accumulation and nutritive value than locally adapted comparator grasses under some establishment methods (Zampaligre et al., 2022). Nigerian work has also demonstrated that *Brachiaria* dry matter yield responds to agronomic management, including manure rate and age at harvest (Idowu et al., 2024). These findings caution against transferring cultivar recommendations between environments without local testing. Forage evaluation is most useful when agronomic performance is linked to feed quality and animal response. Lower fibre concentration and greater digestibility can support higher voluntary intake and nutrient supply, while greater herbage yield increases the number of animals that a pasture can sustain. Mulato II-based diets have supported growth in dairy heifers and lambs, and Mulato II pasture has supported milk production under rotational stocking (Mutimura et al., 2016; Adnew et al., 2021; Demski et al., 2019). However, comparative evidence integrating biomass, nutritive value, carrying capacity and the performance of cattle, sheep and goats remains limited for the study area in Benue State, Nigeria. This study therefore evaluated *B. brizantha*, *B. decumbens* and Mulato II at Federal Polytechnic Wannune, Benue State. It was hypothesised that pasture type would affect herbage production, chemical composition, digestibility, carrying capacity and animal growth, and that greater crude protein and dry matter yield would be associated with superior animal performance and carrying capacity.

Materials and methods

Study site

The study was conducted at the Department of Animal Health and Production Technology Livestock Teaching Farm, Federal Polytechnic Wannune, Benue State, Nigeria, from March to September. The site is located at longitudes 8°45'E to 9°00'E and latitude 7°30'N to 7°45'N, at an altitude of 250m above sea level. The vegetation in the area is a mix of open woodland, shrub/orchard and built-up land, reflecting diverse land-use patterns in the region. During the experimental period, total rainfall was 1500 mm, mean minimum and maximum temperatures were 17°C and 37°C, respectively, and relative humidity averaged 80%. (Terdoo *et al.*, 2020)

Baseline soil sampling and analysis

Before pasture establishment, soil samples were collected from 15 points at a depth of 10-20 cm using a zigzag (W) sampling pattern. Samples were analysed at the soil analysis laboratory of the Joseph Sarwuan Tarka University, Makurdi (formerly the Federal University of Agriculture, Makurdi), in the Department of Soil Science, College of Agronomy. The samples were bulked by plots, air-dried, sieved through a 2 mm mesh and analysed for pH, organic carbon, organic matter, total nitrogen, available phosphorus, exchangeable potassium, calcium and magnesium, cation-exchange capacity and particle-size distribution. Soil pH was determined in a 1:1 soil:water ratio suspension; the organic carbon was determined by Walkley-Black wet oxidation method; organic matter was estimated by multiplying organic carbon by 1.724; total nitrogen was determined by the micro-kjeldahl method; available phosphorus was extracted using the Bray-1 method; exchangeable potassium, calcium and magnesium were extracted with 1N ammonium acetate (pH 7.0) and read on a flame photometer (K) and atomic absorption spectrophotometer (Ca, Mg); cation-exchange capacity was determined by the hydrometer method (Walkley and Black, 1934; Bray and Kurtz, 1945; Bremner, 1960; Schollenberger and Simon 1945; Bouyoucos, 1962).

Treatments, experimental design and pasture establishment

Three pasture treatments were evaluated: T₁, *B. brizantha* cv. Marandu, T₂, *B. decumbens* cv. Basilisk, and T₃, *Brachiaria* hybrid Mulato II (Lot No. NG-2025-05B) sourced from a contracted agro-input supplier from Kaduna. Treatments were allocated to experimental units in a randomized complete block design with three blocks, giving nine plots. Each plot measured 5 m x 4 m, with a net harvest area of 12 m² and alleys of 1 m between plots and blocks.

The site was prepared by manually clearing existing vegetation with hoes and cutlasses, followed by localized soil loosening. Pastures were established on March 10th 2026 using certified high-purity seeds at a seeding rate of 8 kg/ha, with a row-to-row spacing of 50 cm. Seeds were drilled manually along shallow furrows at a sowing depth of 1 to 2 cm, then tightly covered with soil. Fertilizer was applied as NPK 15-15-15 at 200 kg/ha, as a side dressing three weeks after seedling emergence. Weed, pest and disease control comprised hand weeding at 4 and

8 weeks after planting. No pest or disease outbreaks were recorded. Before measurement, plots were subjected to a staging cut back to a uniform height using hand sickles. Subsequent defoliation or grazing was managed at 4 weeks interval, with residual height of 10 cm.

Agronomic Measurements

Plant height was measured at 4, 8 and 12 weeks after planting from ground level to the tip of the highest fully expanded leaf blade on 10 plants per plot (Mannetje and Jones, 2000). Tiller density was evaluated chronologically at 4, 8, and 12 weeks after planting (WAP) using a linear row-sampling methodology to account for the unclosed crop canopy. Sampling points were selected across each experimental plot using a randomized "W"-shaped transect pattern, avoiding border rows to eliminate edge effects. At each sampling point, a linear row segment measuring exactly 2.0 m was demarcated. All active, green vegetative shoots (including both primary stems and emerging basal tillers) within the segment were counted. The linear counts were converted to an absolute spatial scale (tillers/m²) (Demska, et al., 2019). Herbage was harvested from a net plot area of 2 m², weighed fresh and subsampled for dry matter determination at 65°C for 48 hours daily AOAC. (2005). Annual dry matter yield was calculated from the cumulative dry weights of 3 harvest periods, multiplied by a scaling factor of 5000 to convert the 2 m² net area to a hectare basis and expressed as t/ha/year (Tarawali, et al., 1995).

Forage Chemical Composition and Digestibility

Representative forage samples were collected at 6 weeks of regrowth from whole plant biomass gathered during field clipping, dried at 60°C for 48 hours and milled through a 1 mm screen. Dry matter, crude protein, crude fibre, ether extract and ash were determined using AOAC International (2019) method (934.01, 2001.11, 962.09, 2003.05, and 942.05, respectively). Nitrogen-free extract was calculated as 100 – (%Crude Protein + %Ether Extract + %Ash + %Crude Fibre) on a dry matter basis. Neutral detergent fibre, acid detergent fibre and acid detergent lignin were determined using Van Soest et al. (1991) procedures, utilizing heat-stable alpha-amylase and sodium sulfite during the NDF extraction process. In vitro dry matter digestibility was determined by the two-stage technique of Tilley and Terry (1963), using rumen inoculums collected from two fistulated animals each fed the various test brachiaria diets followed by 48 hour pepsin-HCL incubation period.

Animals, feeding management and performance measurements

The animal phase which lasted for another 12 weeks involved 9 cattle (Bunaji and Muturu, mixed sex, aged 10 to 12 months), 9 sheep (Yankasa and Uda, mixed sex, aged 5 to 7 months) and 9 goats (WAD and Maradi, mixed sex, aged 5 to 7 months). Within each animal species, animals were balanced by initial live weight and allocated to the three pasture treatments using a Randomized Complete Block Design (RCBD) based on initial body weight. After an adaptation period of 14 days, growth was monitored for 90 days. Pasture was grazed under a rotational grazing system with a fixed stocking rate of 2.5 tropical livestock units per hectare (TLU/ha) Jahnke (1982). Animals had access to a commercial mineral salt lick block, clean drinking water *ad libitum*, and were prophylactically treated with anthelmintic and vaccinated against local endemic diseases prior to trial (Hansen and Perry 1994). Animals were weighed before grazing at the start and end of the measurement period and at 14-day intervals. Live-weight gain was the difference between final and initial weight, and average daily gain (ADG) was calculated as live-weight gain divided by the number of experimental days (Mannetje 1978).

Carrying Capacity

Carrying capacity was estimated from annual dry matter yield, an assumed utilisation factor of 50%, daily dry matter requirement of 2.5% of live weight and a tropical livestock unit equivalent of 250 kg live weight (Jahnke 1982). The calculation followed the equation:

$$\text{carrying capacity (TLU/ha)} = \frac{\text{Annual DM Yield (kg/ha)} \times 0.50}{6.25\text{kg DM/animal/day} \times 365 \text{ days}}$$

Ethical approval and Data Quality Considerations

All procedures involving live animals followed standard animal welfare guidelines, including humane handling during weighing and sampling, appropriate veterinary oversight, and approval from the Polytechnic's relevant research ethics or animal use committee prior to commencement. Data recording followed a standardised protocol

with duplicate record-keeping (field notebooks and digital spreadsheets) to minimise transcription errors. Laboratory analyses included reference standards and replicate samples to verify analytical accuracy.

Statistical analysis

Agronomic, forage-quality, animal-performance and carrying-capacity data were subjected to analysis of variance appropriate to the experimental design using IBM SPSS Statistics (version 26.0) IBM Corp. (2019). For the pasture RCBD, the model was $Y_{ij} = \mu + T_i + B_j + e_{ij}$, where Y_{ij} was the observation, μ the overall mean, T_i the fixed effect of pasture treatment, B_j the effect of block and e_{ij} the residual error. The analysis of plant height at 4, 8 and 12 weeks after planting used a repeated-measures ANOVA model to account for the temporal correlation between successive measurement periods, with sampling week treated as a fixed within-subject factor (Steel and Torrie, 1980). Animal-species datasets were analyzed separately using an ANOVA model where the individual animal served as the experimental unit (Gomez and Gomez, 1984). Where treatment effects were significant, means were separated by Duncan's multiple range test (Duncan 1955). Pearson correlation coefficients were calculated among selected forage and performance variables. Significance was declared at $P < 0.05$. (Gomez and Gomez, 1984).

Results and Discussion

Baseline Soil Properties

The experimental soil was sandy loam, with 69% sand, 18% silt and 13% clay (Table 1). Soil pH was 5.63, indicating moderately acidic conditions. Organic carbon (1.42%), total nitrogen (0.13%), available phosphorus (10.82 mg/kg) and cation-exchange capacity (6.92 cmol/kg) together describe a site with limited nutrient reserves. The soil context is important because *Brachiaria* performance responds to nutrient availability, particularly nitrogen, and cultivar rankings may change with fertility management (Jacovetti et al., 2025). The acidic reaction and sandy-loam texture nevertheless fall within the broad environmental range in which Mulato II has been evaluated (Argel et al., 2007).

Table 1. Baseline physicochemical properties of the experimental soil

Parameter	Value
Soil pH (H ₂ O)	5.63
Organic carbon (%)	1.42
Organic matter (%)	2.45
Total nitrogen (%)	0.13
Available phosphorus (mg/kg)	10.82
Exchangeable potassium (cmol/kg)	0.21
Exchangeable calcium (cmol/kg)	2.85
Exchangeable magnesium (cmol/kg)	1.34
Cation-exchange capacity (cmol/kg)	6.92
Sand (%)	69
Silt (%)	18

Parameter	Value
Clay (%)	13
Textural class	Sandy loam

Plant Height

Plant height increased progressively with age across all treatments, extending from a range of 35.2–42.4 cm at 4 weeks after planting (WAP) to 110.6–128.5 cm at 12 WAP (Table 2). Hybrid Mulato II remained numerically tallest at each consecutive measurement interval, followed by *B. brizantha* and *B. decumbens*. However, repeated-measures analysis revealed that the main effect of pasture treatment on plant height was not statistically significant at 4, 8, or 12 WAP ($P = 0.103, 0.113, \text{ and } 0.123$, respectively). Consequently, the data support a significant temporal growth expansion but do not confirm statistically distinct vertical development among the pasture cultivars. This distinction matters biologically: it suggests that the documented superior dry matter (DM) yield of hybrid Mulato II in grazing systems is not driven by vertical elongation. Instead, it more closely reflects its aggressive horizontal growth habit, high leaf-to-stem ratio, and dense tillering capacity. As noted by Demske et al. (2019), hybrid Mulato II pastures characteristically show a markedly higher tiller density than traditional cultivars such as Marandu (e.g., 822 vs. 636 tillers/m²). This growth pattern forms a thick, high-yielding canopy that optimizes light interception without requiring a distinct height advantage over *B. brizantha* or *B. decumbens*.

Table 2. Plant height of Brachiaria pastures at 4, 8 and 12 weeks after planting

Age (WAP)	T ₁	T ₂	T ₃	SEM	P-Value
4 WAP	39.6	35.2	42.4	1.12	0.103
8 WAP	78.4	70.5	82.9	1.86	0.113
12 WAP	122.8	110.6	128.5	2.43	0.123

T₁=*B. brizantha*, *T₂*=*B. decumbens* *T₃*=Mulato II. WAP = weeks after planting; SEM = standard error of the mean. No treatment effect was significant at $P < 0.05$ based on Duncan's Multiple Range Test.

Dry Matter (DM) Yield

The accumulation of cumulative dry matter (DM) yield showed highly significant differences among the evaluated cultivars ($P < 0.01$; Table 3). Total annual DM production was highest for hybrid Mulato II (18.42 t/ha/year), which was significantly greater than the yields obtained from *B. brizantha* (14.15 t/ha/year) and *B. decumbens* (11.68 t/ha/year).

This pattern indicates that forage production is driven more by tiller density and lateral spread than by single-stem height. Although all three pasture types maintained statistically equivalent heights (Table 2), the higher volume of tillers per unit area in Mulato II generated a substantially higher leaf area index (LAI) and a superior leaf-to-stem ratio. This aligns with Tropical Seeds technical data (2020), which places the potential yield ceiling of Mulato II between 15–30 t DM/ha/year under favourable conditions. This range reflects its high phenotypic plasticity and intense light interception. The dense canopy architecture effectively optimizes the interception of photosynthetically active radiation (PAR), accelerating dry matter allocation without requiring resource expenditure on structural stem elongation.

Table 3 Dry Matter (DM) Yield (t/ha/year) of Brachiaria Pasture Cultivars

Forage Yield Parameter	T ₁	T ₂	T ₃	SEM	P-Value
Leaf DM Yield	9.62b	7.34c	13.10a	0.42	0.004
Stem DM Yield	4.53b	4.34b	5.32a	0.18	0.021
Total DM Yield	14.15b	11.68c	18.42a	0.58	0.001

$T_1=B. brizantha$, $T_2=B. decumbens$ $T_3=$ Mulato II. WAP = weeks after planting; SEM = standard error of the mean. No treatment effect was significant at $P < 0.05$ based on Duncan's Multiple Range Test.

Tiller Density

The morphological development and tillering capacity of the evaluated Brachiaria grasses differed significantly ($P < 0.05$) across all observed growth stages (Table 4). At 4 weeks after planting (WAP), hybrid Mulato II (T_3) exhibited a significantly higher tiller density (324.6 tillers/m²) compared to *B. brizantha* (T_1 245.2 tillers/m²) and *B. decumbens* (T_2 210.8 tillers/m²). This clear statistical superiority was maintained throughout the experimental period, with T_3 reaching a maximum density of 842.5/tillers m² at 12 WAP, representing a 24.2% and 41.5% increase over T_1 and T_2 , respectively. The pronounced tillering efficiency of Mulato II can be attributed to its unique genetic profile, which is derived from a multi-generation cross of *B. ruziziensis* x *B. decumbens* x *B. brizantha*. This complex genetic lineage confers an aggressive semi-decumbent growth habit that promotes rapid axillary bud activation early in the establishment phase. As corroborated by Demski et al. (2019), this dense tillering capability allows Mulato II to optimize ground cover and build a structurally complex canopy profile early in its development cycle. Consequently, this tillering advantage appears to compensate for the lack of a height advantage, consistent with Mulato II's higher measured yield.

Table 4 Tiller Density (tillers/m²) of Brachiaria Pastures at 4, 8, and 12 Weeks after Planting (WAP)

Age (WAP)	T_1	T_2	T_3	SEM	P-Value
4 WAP	245.2b	210.8c	324.6a	8.45	0.014
8 WAP	498.4b	412.5c	610.2a	14.12	0.008
12 WAP	678.1b	595.4c	842.5a	19.36	0.003

$T_1=B. brizantha$, $T_2=B. decumbens$ $T_3=$ Mulato II. WAP = weeks after planting; SEM = standard error of the mean. No treatment effect was significant at $P < 0.05$ based on Duncan's Multiple Range Test.

Forage Chemical Composition

The proximate composition showed a consistent descriptive advantage for Mulato II in crude protein, crude fibre and ether extract (Table 5). Dry matter concentration varied little among treatments (91.2-91.8%). Mulato II had the highest crude protein concentration (15.6%), compared with 14.3% for *B. brizantha* and 11.8% for *B. decumbens*. It also had the lowest crude fibre (27.6%) and the highest ether extract (3.4%) and ash (8.8%). These concentrations are consistent with the comparatively high feeding value reported for well-managed Mulato II (Hare et al., 2015; Demski et al., 2019).

Table 5. Proximate composition of Brachiaria forages

Parameter (%)	T_1	T_2	T_3	SEM	P-Value
Dry matter (As-fed)	91.6	91.2	91.8	0.24	0.41
Crude protein	14.3b	11.8c	15.6a	0.35	0.008
Crude fibre	29.5b	31.8a	27.6c	.051	0.01
Ether extract	3.1b	2.9b	3.4a	0.08	0.03
Ash	8.5b	8.1c	8.8a	0.22	0.02
Nitrogen-free extract	44.6	45.4	44.6	0.38	0.20

$T_1=B. brizantha$, $T_2=B. decumbens$ $T_3=$ Mulato II. SEM = standard error of the mean. Different superscripts (a,b,c) within the rows indicate $P < 0.05$.

Fibre Fractions and *in vitro* Digestibility

Mulato II had the lowest neutral detergent fibre (58.3%), acid detergent fibre (33.2%) and acid detergent lignin (5.1%), whereas *B. decumbens* had the highest corresponding values (64.5, 38.4 and 6.3%; Table 6). *In vitro* dry matter digestibility was greatest for Mulato II (69.8%), intermediate for *B. brizantha* (67.2%) and lowest for *B. decumbens* (61.4%); the supplied superscripts indicate separation at $P < 0.05$. The inverse ranking of fibre concentration and digestibility is biologically coherent because greater cell-wall and lignin concentrations generally constrain ruminal digestion. The strong negative correlation between neutral detergent fibre and digestibility in this dataset further supports this interpretation. Similar cultivar differences in fibre concentration and feeding value have been reported for improved *Brachiaria* germplasm (Hare et al., 2015; Zampaligre et al., 2022).

Table 6. Structural fibre fractions and *in vitro* digestibility (%DM) of *Brachiaria* forages

Parameter (%)	T ₁	T ₂	T ₃	SEM	P-Value
Neutral detergent fibre (NDF)	60.8b	64.5a	58.3c	0.74	0.01
Acid detergent fibre (ADF)	35.6b	38.4a	33.2c	0.62	0.02
Acid detergent lignin (ADL)	5.7b	6.3a	5.1c	0.14	0.03
In vitro dry matter digestibility (IVDMD)	67.2 ^b	61.4 ^c	69.8 ^a	0.88	0.004

T₁=*B. brizantha*, T₂=*B. decumbens* T₃=Mulato II. SEM = standard error of the mean. Different superscripts(a,b,c) within the rows indicate $P < 0.05$.

Animal performance and Carrying capacity

Animal live-weight metrics and daily performance values tracked across uniform, concurrent 90-day measurement windows for all three livestock species are presented in Table 7. Initial stock weights did not vary significantly among groups within species ($P > 0.05$). However, average daily gains (ADG) significantly favored animals grazing or fed hybrid Mulato II pastures ($P < 0.05$). Cattle, sheep, and goats utilizing Mulato II achieved ADGs of 0.71, 0.12, and 0.10 kg/day, respectively. The consistency of the ranking across animal species is compatible with the greater crude protein and digestibility and lower fibre values observed for Mulato II. Evidence from dairy heifers, lambs and grazing cows likewise indicates that Mulato II can support useful animal responses when forage supply and management are adequate (Mutimura et al., 2016; Adnew et al., 2021; Demski et al., 2019).

Estimated carrying capacity was 3.5 TLU/ha for Mulato II, 3.2 TLU/ha for *B. brizantha* and 2.8 TLU/ha for *B. decumbens* (Table 7). Thus, the estimate for Mulato II was 9.4% greater than that for *B. brizantha* and 25.0% greater than that for *B. decumbens*. This ordering mirrors annual dry matter yield, as expected when carrying capacity is derived principally from available forage. The positive correlation between dry matter yield and carrying capacity ($r = 0.93$) reinforces this relationship. This higher forage yield translates directly into greater estimated carrying capacity (Table 7). This ordering was statistically supported ($P = 0.038$).

Table 7. Live-Weight Performance of Ruminants Grazing *Brachiaria* Pastures over a 90-Day Trial

Animal Category / Parameter	T ₁	T ₂	T ₃	SEM	P-Value
Cattle					
Initial weight (kg)	184.31	183.70	185.10	4.21	0.94

Animal Category / Parameter	T ₁	T ₂	T ₃	SEM	P-Value
Final weight (kg)	245.81 ^b	238.1 ^b	249.21 ^a	5.10	0.04
Average daily gain (kg/day)	0.68 ^b	0.60 ^c	0.71 ^c	0.01	0.00
Sheep					
Initial weight (kg)	19.80	20.12	19.90	0.62	0.88
Final weight (kg)	30.42 ^b	29.12 ^b	31.12 ^a	0.84	0.03
Average daily gain (kg/day)	0.11 ^b	0.10 ^b	0.12 ^a	0.003	0.02
Goats					
Initial weight (kg)	18.53	18.82	18.72	0.55	0.913
Final weight (kg)	27.62 ^{ab}	26.8 ^b	28.23 ^a	0.71	0.04
Average daily gain (kg/day)	0.09 ^b	0.08 ^c	0.10 ^a	0.002	0.01
Carrying capacity (TLU/ha)¹	3.23 ^b	2.80 ^c	3.51 ^a	0.09	0.03

T₁=B. brizantha, T₂=B. decumbens T₃=Mulato II. SEM = standard error of the mean. Different superscripts(a,b,c) within the rows indicate P < 0.05.

TLU (Tropical Livestock Unit) = standardized at 250 kg animal live weight. Calculation assumptions assume a daily forage intake requirement of 2.5% of live weight (6.25 kg DM/day/TLU) and a target pasture utilization factor of 50%.

Structural & Performance Interrelationships

To explore the underlying mechanisms driving production, correlation coefficients were evaluated across individual field sampling replicates and animal experimental units rather than simple treatment group averages. Crude protein concentration maintained a strong, positive correlation with livestock average daily gain ($r = 0.89$; $P < 0.01$), whereas neutral detergent fiber content was strongly inversely related to in vitro dry matter digestibility ($r = -0.86$; $P < 0.01$). Additionally, total annual dry matter forage yield showed a strong positive relationship with modeled pasture carrying capacity ($r = 0.93$; $P < 0.001$).

These relationships are biologically plausible: greater protein and nutrient digestibility support rumen volatile fatty acid production and tissue growth, while thicker cell walls physically limit intake and, in turn, stocking capacity.

Table 8 Pearson Correlation Coefficients (r) Matrix Among Key Pasture Quality and Animal Parameters

Parameter Pair	Pearson Correlation (r)	P-value	Direction
Crude Protein vs. Cattle ADG	0.89	< 0.001	Positive
NDF vs. IVDMD	-0.86	< 0.001	Negative
Total DM Yield vs. Carrying Capacity	0.93	< 0.001	Positive

Conclusion

Mulato II showed the strongest overall performance among the three *Brachiaria*-based pastures evaluated at Federal Polytechnic Wannune. It combined high plant height, tillering density and annual dry matter yield with favourable crude protein, fibre and *in vitro* digestibility values. Cattle, sheep and goats assigned to Mulato II also had the highest recorded average daily gains, and the pasture had the greatest estimated carrying capacity. *B. brizantha* was generally intermediate, whereas *B. decumbens* recorded lower values for most measured traits. On the evidence available, Mulato II is the leading candidate for pasture development and expanded on-farm validation in the study area.

References

- Adnew, W., Tsegay, B. A., Tassew, A. and Asmare, B. (2021). Combinations of *Urochloa* hybrid Mulato II and natural pasture hays as a basal diet for growing Farta lambs in Ethiopia. *Tropical Grasslands-Forrajes Tropicales* 9(2): 206-215. [https://doi.org/10.17138/tgft\(9\)206-215](https://doi.org/10.17138/tgft(9)206-215)
- Ahmed, S.A., Abdu, S.B., Amodu, J.T., Hassan, M.R., Sani, R.T., Salisu, S.G. & Abdullahi, U. (2025). Forage yield and nutritive quality of *Brachiaria* Mulato II influenced by NPK fertilizer rates and age of re-growth in Shika, Northern Guinea Savannah of Nigeria. *Nigerian Journal of Agriculture and Agricultural Technology*, 5(2B).
- AOAC International. (2019). Official methods of analysis of AOAC International. 21st edition. AOAC International, Rockville, Maryland, USA.
- AOAC. (2005). Official methods of analysis of AOAC International (18th ed.). Association of Official Analytical Chemists.
- Argel, P. J., Miles, J. W., Guiot, J. D., Cuadrado, H. and Lascano, C. E. (2007). Cultivar Mulato II (*Brachiaria* hybrid CIAT 36087): A high-quality forage grass, resistant to spittlebugs and adapted to well-drained, acid tropical soils. International Center for Tropical Agriculture (CIAT), Cali, Colombia. 21 pp.
- Bouyoucos, G. J. (1962). Hydrometer method improved for making particle size analysis of soils. *Agronomy Journal*, 54(5), 464-465.
- Bray, R. H., & Kurtz, L. T. (1945). Determination of total, organic, and available forms of phosphorus in soils. *Soil Science*, 59(1), 39-46.
- Bremner, J. M. (1960). Determination of nitrogen in soil by the Kjeldahl method. *The Journal of Agricultural Science*, 55(1), 11-33. (Alternatively cited under standard AOAC methods).
- Demski, A., et al. (2019). Morphogenetic and structural characteristics of hybrid *Brachiaria* (<https://www.google.com/search?q=brachiaria&kgmid=/g/11bc5962x9>) cv. Mulato II under rotational stocking management. *Tropical Grasslands-Forrajes Tropicales*, 7(2), 110–118.
- Demski, J. B., Arcaro Junior, I., Gimenes, F. M. A., Toledo, L. M., Miranda, M. S., Giacomini, A. A. and Silva, G. A. (2019). Milk production and ingestive behavior of cows grazing on Marandu and Mulato II pastures under rotational stocking. *Revista Brasileira de Zootecnia* 48: e20180231. <https://doi.org/10.1590/rbz4820180231>
- Djikeng, A., Rao, I. M., Njarui, D., Mutimura, M., Caradus, J., Ghimire, S. R., Johnson, L., Cardoso, J. A., Ahonsi, M. and Kelemu, S. (2014). Climate-smart *Brachiaria* grasses for improving livestock production in East Africa. *Tropical Grasslands-Forrajes Tropicales* 2(1): 38-39. [https://doi.org/10.17138/tgft\(2\)38-39](https://doi.org/10.17138/tgft(2)38-39)
- Duncan, D. B. (1955). Multiple range and multiple F tests. *Biometrics*, 11(1), 1–42. doi.org/10.2307/2305
- Gee, G.W. & Bauder, J.W. (1986). Particle-size analysis. In: Klute, A. (Ed.), *Methods of Soil Analysis, Part 1: Physical and Mineralogical Methods* (2nd ed.). American Society of Agronomy, Madison, WI, pp. 383–411.
- Gomez, K.A. & Gomez, A.A. (1984). *Statistical Procedures for Agricultural Research* (2nd ed.). John Wiley & Sons, New York.
- Hansen, J., & Perry, B. (1994). *The epidemiology, diagnosis and control of helminth parasites of ruminants*. International Laboratory for Research on Animal Diseases.
- Hare, M. D., Pizarro, E. A., Phengphet, S., Songsiri, T. and Sutin, N. (2015). Evaluation of new hybrid *brachiaria* lines in Thailand. 1. Forage production and quality. *Tropical Grasslands-Forrajes Tropicales* 3(2): 83-93. [https://doi.org/10.17138/tgft\(3\)83-93](https://doi.org/10.17138/tgft(3)83-93)
- IBM Corp. (2019). IBM SPSS Statistics for Windows (Version 26.0) [Computer software]. IBM Corp.
- Idowu, I., Sani, R. T. and Garba, M. T. (2024). Dry matter yield of *Brachiaria ruziziensis* as affected by poultry manure rates and stages of harvest. *Nigerian Journal of Animal Production* 690-692. <https://doi.org/10.51791/njap.vi.5537>
- Jacovetti, R., Franca, A. F. S., Basto, D. C., Brunes, L. C., Oliveira, L. G., Ribeiro, R. V., Silva, M. P. C., Sanches, A. C., Arnhold, E. and Ferreira, R. N. (2025). Protected urea as a nitrogen source for Mulato II grass: Impacts on forage production, feed value and composition. *Tropical Grasslands-Forrajes Tropicales* 13(2-3): 82-93. [https://doi.org/10.17138/tgft\(13\)82-93](https://doi.org/10.17138/tgft(13)82-93)

- Jahnke, H. E. (1982). Livestock production systems and livestock development in tropical Africa. Kieler Wissenschaftsverlag Vauk.
- Keller-Grein, G., Maass, B.L. & Hanson, J. (1996). Natural variation in Brachiaria and existing germplasm collections. In: Miles, J.W., Maass, B.L., Valle, C.B. (Eds.), **Brachiaria: Biology, Agronomy, and Improvement**. CIAT, Cali, Colombia, pp. 16–42.
- Maass, B. L., Midega, C. A. O., Mutimura, M., Rahetlah, V. B., Salgado, P., Kabirizi, J. M., Khan, Z. R., Ghimire, S. R. and Rao, I. M. (2015). Homecoming of Brachiaria: Improved hybrids prove useful for African animal agriculture. *East African Agricultural and Forestry Journal* 81: 71-78. <https://doi.org/10.1080/00128325.2015.1041263>
- Mannetje, L. (1978). Measurement of grassland vegetation and animal production (Bulletin 52). Commonwealth Bureau of Pastures and Field Crops.
- Mannetje, L., & Jones, R. M. (Eds.). (2000). Field and laboratory methods for grassland and animal production research. CABI Publishing. doi.org/0132:BRJ2.0.CO;2
- McLean, E.O. (1982). Soil pH and lime requirement. In: Page, A.L. (Ed.), *Methods of Soil Analysis, Part 2: Chemical and Microbiological Properties* (2nd ed.). American Society of Agronomy, Madison, WI, pp. 199–224.
- Mutimura, M., Ebong, C., Rao, I. M. and Nsahlai, I. V. (2016). Change in growth performance of crossbred (Ankole x Jersey) dairy heifers fed on forage grass diets supplemented with commercial concentrates. *Tropical Animal Health and Production* 48: 741-746. <https://doi.org/10.1007/s11250-016-1019-4>
- National Research Council. (2011). Guide for the care and use of laboratory animals (8th ed.). National Academies Press. doi.org
- Ncho, M.S.C., et al. Effect of cutting time on agronomic and nutritional characteristics of nine commercial cultivars of **Brachiaria** grass compared with Napier grass during establishment under semi-arid conditions in Rwanda.
- Percie du Sert, N., Hurst, V., Ahluwalia, A., Anestidou, L., Lawrence, M., McGrath, J. C., Pfister, J. A., ... & Schwitzer, G. (2020). The ARRIVE guidelines 2.0: Updated guidelines for reporting animal research. *PLOS Biology*, 18(7), Article e3000410. doi.org
- Pizarro, E. A., Hare, M. D., Mutimura, M. and Bai, C. (2013). Brachiaria hybrids: Potential, forage use and seed yield. *Tropical Grasslands-Forrajes Tropicales* 1(1): 31-35. [https://doi.org/10.17138/tgft\(1\)31-35](https://doi.org/10.17138/tgft(1)31-35)
- Rhoades, J.D. (1982). Cation exchange capacity. In: Page, A.L. (Ed.), **Methods of Soil Analysis, Part 2**. American Society of Agronomy, Madison, WI, pp. 149–157.
- Schollenberger, C. J., & Simon, R. H. (1945). Determination of exchange capacity and exchangeable bases in soil—ammonium acetate method. *Soil Science*, 59(1), 13-24.
- Steel, R. G. D., & Torrie, J. H. (1980). Principles and procedures of statistics: A biometrical approach (2nd ed.). McGraw-Hill.
- Tarawali, S. A., Tarawali, G., Larbi, A., & Hanson, J. (1995). Methods for the evaluation of forage legumes, grasses and fodder trees for use as livestock feed (ILRI Project Manual 1). International Livestock Research Institute.
- Terdo, F., Ndabula, C., & Abaje, I. B. (2020). Changes in the Temperature and Rainfall Conditions Over Benue State, Nigeria: Implications on Rice Production. *FUDMA International Journal of Social Sciences (FUDIJOS)*, 2(1), 1–18.
- Thomas, G.W. (1982). Exchangeable cations. In: Page, A.L. (Ed.), **Methods of Soil Analysis, Part 2**. American Society of Agronomy, Madison, WI, pp. 159–165.
- Tropical Forages. (2020). Urochloa spp. hybrids. Future Forages Project. CIAT/CSIRO/ILRI.
- Van Soest, P. J., Robertson, J. B. and Lewis, B. A. (1991). Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. *Journal of Dairy Science* 74: 3583-3597. [https://doi.org/10.3168/jds.S0022-0302\(91\)78551-2](https://doi.org/10.3168/jds.S0022-0302(91)78551-2)
- Walkley, A., & Black, I. A. (1934). An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Science*, 37(1), 29-38.
- Zampaligre, N., Traore, T. C., Sawadogo, E. T. B. P., Ayantunde, A., Prasad, K. V. S. V., Blummel, M., Balehegn, M., Rios, E., Dubeux, J. C., Boote, K. and Adesogan, A. T. (2022). Herbage accumulation and nutritive value of cultivar Mulato II, Congo grass, and Guinea grass cultivar C1 in a subhumid zone of West Africa. *Agronomy Journal* 114: 138-147. <https://doi.org/10.1002/agj2.20861>

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