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Balancing Biomass Yield and Nutritional Quality of *Brachiaria ruziziensis* through NPK (20:10:10) Fertilization in Cameroon's Humid Tropics

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Abstract

The rising global demand for livestock products underscores the need to enhance forage quality and yield, particularly within tropical farming systems. This study evaluated the impact of five application rates of NPK 20:10:10 fertilizer (0, 150, 200, 300, and 400 kg/ha) on the growth performance, nutrient composition, and biomass yield of *Brachiaria ruziziensis* in Buea, Cameroon. A completely randomized block design (CRBD) was employed with four replications per treatment, maintaining a uniform plant density of 80,000 plants/ha across all plots. Data were collected over three harvest periods, assessing fresh and dry biomass as well as nutrient parameters. A non-destructive linear regression model was developed to estimate actual leaf area ($Y = 1.403X + 1.14$). Fertilizer application significantly improved plant height, leaf number, tiller count, and stem diameter compared to the control ($P \leq 0.01$). The treatment (400 kg/ha) had the highest plant height (86.8 cm), leaf number (463), tiller count (83), and dry biomass (34.7 tons/ha). Fertilizer treatments also significantly influenced nutrient concentrations of nitrogen, phosphorus, potassium, calcium, and magnesium ($P = 0.05$). Notably, the 300 kg/ha treatment optimized forage quality, producing the highest crude fibre (13.7%), crude protein (12.9%), nitrogen (2.2%), and phosphorus (2964.5 mg/kg) concentration and this was not significantly different from the treatment 400 kg/ha. The 400 kg/ha treatment recorded the highest potassium (2703 mg/kg), calcium (117.5 mg/kg) and ash content (8.6%). In conclusion, the 300 kg/ha gave the optimum biomass yield, the best balance between yield and nutritional quality. This rate is recommended for Brachiaria production and thereby enhancing sustainable livestock production in tropical humid regions such as Buea, Cameroon.

Keywords

Brachiaria Species, Fertilizer, Growth and Biomass, Actual Leaf Area Formula, Plant Nutrients

1. Introduction

The world's population is projected to be 9.6 billion by the year 2050 [1]. Thus, 70% more food would be required in 2050 than in the year 2000 [2]. Globally, livestock derives fodder from two-thirds (4.9 billion hectares) of all agricultural areas, comprising 3.4 billion hectares of grazing land and one-quarter of the area sown to crops [3]. Thus, the necessity to feed the increasing population in developing countries urges farmers to increasingly exploit land to the detriment of pastoral areas [4] [5], which lead to a considerable reduction in animal grazing land and low quality of forage [6]. Consequently, it is necessary to develop livestock farming to meet the nutritional needs of the animals [5]. Cultivation and use of *Brachiaria ruziziensis* in tropical countries would ensure availability both in the rainy season and dry season. Thus, production systems must evolve beyond meat and milk to include high-quality forage cultivation [7] [8]. *Brachiaria ruziziensis* is a Poaceae and a perennial grass native to Central Africa that adapts well in different regions. It has good nutritional value and is well-consumed by animals [9] [10]. The cultivation of *Brachiaria ruziziensis* and use can provide a solution to quality forage supplied in the animal production systems. It is recommended for the improvement of natural pasture but also silage [2] [7]. Its cultivation can also be an alternative to natural pasture [5]. This type of livestock farming allows for intensive and sustainable use of land resources, which is strategic given recent pressures on land use and climate variability [8]. Moreover, *Brachiaria* species are increasingly recognized for their ability to enhance soil carbon sequestration and improve pasture sustainability in tropical regions [11]. When cultivated, plants of the genus *Brachiaria* can extract all the few nutrients that remain in nutrient deficient soils [7] and as a result, their cultivation requires fertilization to improve their biomass and nutrient composition. In addition, key elements such as nitrogen, phosphorus, potassium and sulphur are often not available in sufficient quantities in the soil to allow optimal crop growth [7]. Given the critical role of *B. ruziziensis* in local livestock systems and the known nutrient limitations of the Mount Cameroon region soils, determining the precise NPK application rate is paramount for sustainable intensification of *Brachiaria* production. Previous studies emphasized the necessity of region-specific fertilization protocols to avoid economic waste and environmental impact [12]. However, the optimal NPK dosage that simultaneously maximizes biomass yield and enhances nutritional quality for *Brachiaria ruziziensis* under the specific edaphic and climatic conditions of Buea remains undefined. This investigation was therefore designed to establish the most effective fertilization strategy that enhances the growth, biomass yield and some nutrient concentration of *Brachiaria* grass production under different levels of fertilizer applications.

2. Materials and Methods

2.1. Description of Study Area

This study was carried out at the Department of Plant Science Research farm in the University of Buea (**Figure 1**). It is located between latitudes 4˚28′30″ N and 3˚54′26″N and longitudes 8˚57′10″ and 9˚30′49″E [12], and at an elevation of about 550 m above sea level. The area has a mean annual temperature 28˚C and a humidity of 86% [12]. It has a humid tropical climate with an annual rainfall of 2800 mm [13] [14]. The annual sunshine is about 900 - 1200 hours per annum, [14]. The upper elevations of the town tend to be cool and cloudy, while the lower elevations tend to be much warmer and less humid. Cameroon has five agro-ecological zones, with the South West Region located within the Humid Forest Zone with monomodal rainfall [15]. It is characterized by two seasons [16], a short dry season (about 3 months), and a wet season (about 9 months).

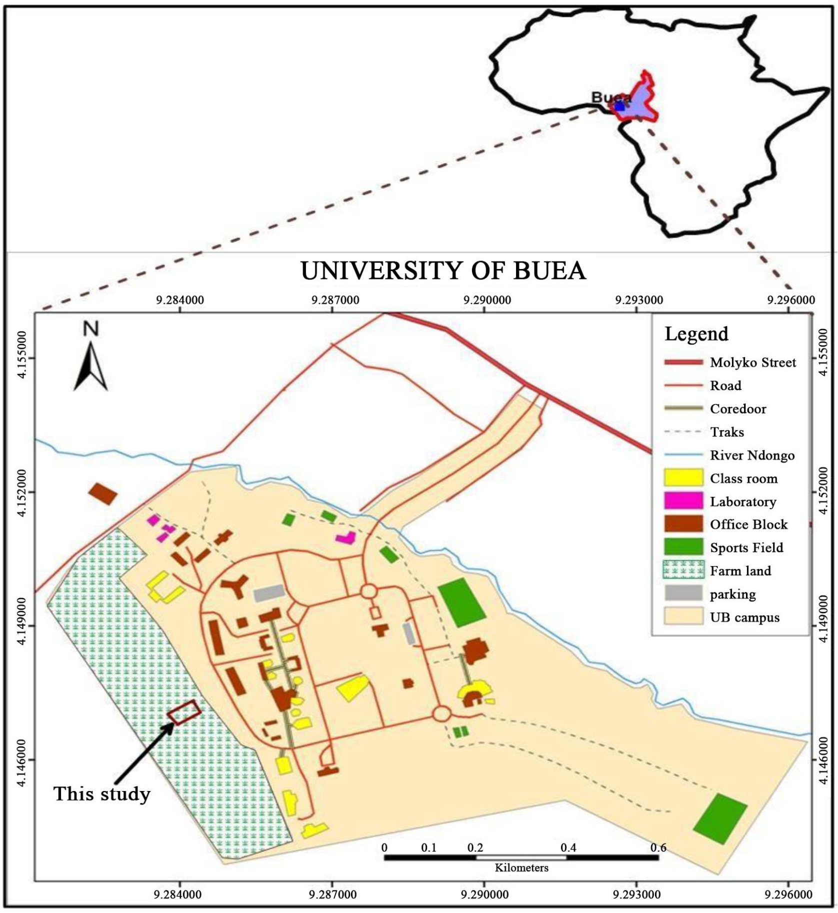

Figure 1. Location of the University of Buea, Cameroon.

2.2. Soil Sampling

A composite soil sample was collected from the experimental plots randomly using a soil auger at a depth of 0 - 10 cm, 10 - 20 cm and 20 - 30 cm, The soils were bulked according to each soil depth and homogenous samples were collected and labelled. The soil samples were air-dried and later sieved with a 2 mm sieve and stored in ziploc bags for routine chemical analysis. The samples were sent to the Plant and Soil laboratory of the University of Dschang for chemical analysis according to the method described by [17]. The soil samples were analyzed for nitrogen, phosphorus, potassium, magnesium, calcium, soil pH, organic carbon, exchange acidity and Cation Exchange Capacity (CEC).

2.3. Field Preparation and Experimental Design

A total area of 208 m^2 of land was cleared, raked and divided into 5 blocks with each block having 4 plots and each block separated from the other by a distance of 2 m. This gave a total of 20 plots with each plot measuring 3 × 3 m (9 m^2) with 1 m spacing between plots. The experimental design was a complete randomized block design (CRBD), five treatments and four replicates. The experiment was conducted across three successive harvest periods, spanning from October 29, 2020, to May 2, 2021. The specific harvest periods were:

1) **First Harvest:** October 29, 2020, to December 29, 2020 (60 days).
2) **Second Harvest:** December 30, 2020, to March 2, 2021 (60 days).
3) **Third Harvest:** March 3, 2021, to May 2, 2021 (60 days).

The stated fertilizer rates (e.g., 150, 200, 300, 400 kg/ha) represent the total annual amount (**Table 1**). This total was split equally across three application cycles: at the beginning of the growing season and immediately following the first and second harvests. Therefore, the quantity applied per individual application was one-third of the stated rate (e.g., 50, 66.7, 100, and 133.3 kg/ha per application, respectively).

Nursery and transplanting of seedlings of *Brachiaria ruziziensis*

Seeds of *Brachiaria ruziziensis* were obtained from the Institute of Agronomic Research for Development (IRAD) Bagante, Cameroon and the nursery medium were sand and topsoil in a ratio of 1:2. Seeds of *Brachiaria ruziziensis* were manually sown by broadcasting.

Seedlings of similar heights (average height of 10 cm with leaf numbers of 4 - 5 were selected from the nursery and transplanted into the various plots. Transplanting was carried out three weeks after seed germination. The seedlings were transplanted at 50 cm between rows and 25 cm within rows giving a plant density of 40 plants per plot and 80,000 plants/ha (modified from [18] [19].

Table 1. Treatment allocation.

Treatment (T)	Fertilizer levels (ha)	Annual Quantity of NPK per plot	Annual Quantity of NPK per plant
T1 (control)	0 Kg/ha	0 g	0 g

Continued

T2	150 Kg/ha	75 g	1.875 g
T3	200 Kg/ha	100 g	2.5 g
T4	300 Kg/ha	150 g	3.75 g
T5	400 Kg/ha	200 g	5.0 g

Note: The plant population was maintained at a uniform density of 40 plants per plot (equivalent to 80 000 plants per hectare) across all treatments. The quantity of fertilizer per plant used was calculated accordingly.

2.4. Growth Assessment

To assess growth**,** five plants were selected at random from the middle of each plot and tagged. Plant heights were measured from base to the crown using a graduated measuring rod. The diameters of the plants were measured at the height 5 cm of the base of the stem using a digital vernier caliper. The number of tillers of the tagged plants was counted and recorded. The total number of tillers per tuft for each measurement period was defined as the sum of total number of tillers at the previous measurement and the number of tillers formed after the previous measurement. The numbers of leaves per tagged plant were enumerated, and these measurements were conducted weekly over a span of eight weeks.

2.5. Biomass Assessment

The first harvesting was carried out 60 days after transplanting [18] and the plants were harvested at 10 cm above the ground level to facilitate regrowth. Fresh weights were determined using an electronic balance, followed by oven drying at 105˚C until a constant mass was achieved to obtain the dry weight. Three harvest cycles were conducted with a 60-day regrowth interval between each harvest period [12].

2.6. Determination of Actual Leaf Area Formula for *Brachiaria ruziziensis*

Fifty leaves were randomly sampled from each plot, giving a total of 200 leaves per treatment. This implied a total of 1000 leaves for the five treatments. The length and width of each leaf were measured in centimeters using a ruler to calculate the relative leaf area with the formula

$$\frac{1}{2} b \times L \tag{1}$$

was used where b and L represent the width and length of the leaf respectively. The actual leaf areas of these samples were determined using a leaf area meter (Orsenigo 121TM35). Subsequently, the actual leaf area was graphed against the relative leaf area using Excel software, and a regression line was fitted to depict the relationship between actual and relative leaf areas (Equation 2).

$$Y = MX + C \tag{2}$$

where M = gradient, X = Relative leaf area, C = constant.

The model generated from the regression analysis between actual leaf area and relative leaf area revealed that for every unit increase in the predictor variable (relative leaf area), the response variable (actual leaf area) increases by a factor of 1.403.

The regression equation is

$$Y = 1.403X + 1.138. \tag{3}$$

This non-destructive modelling approach is crucial for efficient field assessment of forage growth parameters [20]-[22].

2.7. Nutrients Assessment for *Brachiaria ruziziensis*

At each of the three harvest periods, 500g of leaves was harvested from each treatment oven dried at 65˚C for 48 hours, milled and sieved with a 2 mm sieve. The routine chemical analysis procedure was repeated for the milled plant materials for the nutrients (N, P, K, Mg, and Ca), ash content, crude protein and crude fibre content.

2.8. Statistical Analysis

Data collected on agronomic parameters and dry matter of forage samples was subjected to Analysis of Variance (ANOVA) procedure based on the model designed for a complete randomized block design (CRBD). The means were separated using the Dunnett method. All the analysis was done using MINITAB version 17 Statistical Software (2010).

3. Results

3.1. The Effects of Different Levels of NPK 20:10:10 on the Growth Parameters of *Brachiaria ruziziensis*

The initial chemical analyses of the experimental soil (Table 2) provided insightful context for interpreting the plant growth responses. The soil was characterized by low levels of key nutrients, particularly nitrogen (0.20%), potassium (0.28 Cmol/kg), and organic carbon (1.11%), while phosphorus was moderately available (19.57 mg/kg). The slightly acidic pH (pH-water 6.53) was generally favorable for nutrient availability. This baseline fertility profile, indicating a soil deficient in the primary nutrients supplied by the fertilizer, established the potential for a strong growth response to NPK 20:10:10 application.

Table 2. The chemical parameters of the soil prior to treatment application.

Soil chemical parameters	Concentration
N_2 %	0.20
Calcium (Cmol/Kg)	3.39
Mg (Cmol/Kg)	4.62
Phosphurus (mg/kg)	19.57
K (Cmol/Kg)	0.28
Organic Carbon%	1.11
pH water	6.53

Continued

pH KCl	**5.60**
Exchange acidity (Cmol/Kg)	0.02
CEC (Cmol/Kg)	18.78

As anticipated from the soil analysis, significant enhancements in all growth parameters were observed in plants treated with fertilizers compared to the control group (Table 3, P = 0.05). Grouping information, indicated by superscript letters, was determined using the Dunnett Method at a 95% confidence level. Among the treatments, the application of 400 kg/ha of NPK resulted in the highest fresh weight (85.1 tons/ha), whereas the control group exhibited the lowest fresh weight (38.2 t/ha). Similarly, the treatment with 400 kg/ha also demonstrated the highest dry weight (34.7 tons/ha) and this was not significantly different from plants treated with 300 kg/ha NPK, while the control group recorded the lowest dry weight (15.3 t/ha) (Table 3).

Table 3. Effects of fertilizer levels on growth parameters of *Brachiaria ruziziensis.*

Treatment	Plant height (cm)	Number of leaves	Tiller number	Stem diameter (mm)	Leaf area	Fresh weight (tons/ha)	Dry weight (tons/ha)
T1 (Control)	34.40 ± 21.5a	200.6 ± 148.4a	44.40 ± 25.75a	1.86 ± 0.62a	39.76 ± 11.8a	**38.2 ± 12.5a**	**15.3 ± 5.2a**
T2 (150 kg/ha)	37.28 ± 22.53a	224.2 ± 173.8a	48.12 ± 28.29a	2.03 ± 0.80a	47.84 ± 14.8	**49.6 ± 14.8a**	**19.8 ± 6.1a**
T3 (200 kg/ha)	42.21 ± 42.2	255.0 ± 200.4	56.26 ± 31.27	2.19 ± 1.25	46.57 ± 12.3	**63.4 ± 18.2**	**25.6 ± 7.4**
T4 (300 kg/ha)	46.02 ± 28.5	291.0 ± 233.4	63.63 ± 38.22	2.23 ± 0.89	54.93 ± 16.4	**72.8 ± 20.3**	**29.4 ± 8.2**
T5 (400 kg/ha)	49.79 ± 28.8	307.8 ± 258.8	76.58 ± 78.1	2.44 ± 1.00	50.66 ± 14.8	**85.1 ± 22.6**	**34.7 ± 9.5**
Mean	41.9	255.7	57.8	2.15	48.0	**61.82**	**24.96**
P-value	<0.01	<0.01	<0.01	<0.01	<0.01	**<0.01**	**<0.01**
Significance	**	**	**	**	**	**	**

The values presented in the table represent the means of three planting regimes, accompanied by their respective standard errors. Grouping information, indicated by the letter "a" was determined using the Dunnett method at a 95% confidence level. Within each column, means not sharing the letter "a" are significantly different from the control treatment.

The regression analysis results revealed that 82.3% of variation in the response variable (actual leaf area) is explained by variations in the predictor variable (relative leaf area) as indicated by the coefficient of determination (Adj. R^2) of 0.823 in Table 4. The values for RMSE, MAE, AIC and BIC show how well the model fits the data, the lower these values the better the model.

The analysis of variance results further confirmed the existence of a significant ($P < 0.01$) relationship between the predictor (relative leaf area) and the response variable (actual leaf area) at the 5% level of significance. This implies that changes in actual leaf area significantly depend on changes in relative leaf area.

Table 4. Model evaluation metrics.

Metric	Value
R-squared (R^2)	0.823
Residual Standard Error (Sigma)	6.244
Root Mean Squared Error (RMSE)	6.238
Mean Absolute Error (MAE)	4.751
Akaike's Information Criteria (AIC)	6258.079
Bayesian Information Criteria (BIC)	6272.686

A scatter plot and regression line was used to graphically depict the relationship between actual leaf area and relative leaf area (Figure 2). Results revealed a positive slope indicating a positive relationship between actual leaf area and relative leaf area.

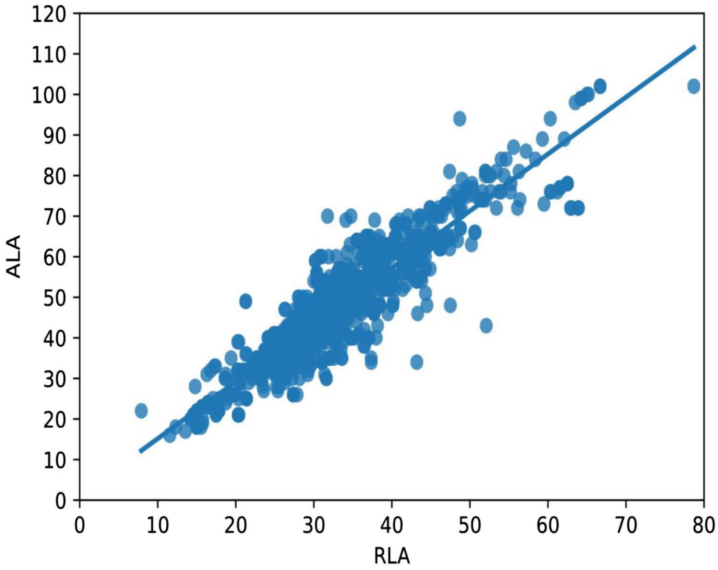

Figure 2. Scatter plot and regression line showing the relationship between the relative leaf area and the actual leaf area.

3.2. The Effects of Different Levels of NPK 20:10:10 on Nutrients Concentration of *Brachiaria ruziziensis*

The results of the effects of fertilizer on nutrient concentrations are presented in Table 5. For all nutrients studied, plant supplied with fertilizer had a significant effect ($P = 0.05$) except ash content on plant nutrient concentrations.

For nitrogen concentration, plants treated with 300 kg/ha fertilizer recorded the highest percentage of nitrogen was 2.2% and was not significantly different from the amount recorded in the 400 kg/ha B (2.1%) while the control exhibited the lowest N concentration (0.7%). Similar trends were observed for phosphorus and potassium, with the 300 kg/ha fertilizer treatment showing the highest concentrations of phosphorus (2964 mg/kg) and potassium (2510 mg/kg), whereas the control had the lowest concentrations for all nutrients analysed except ash. In the case of calcium and magnesium, plants treated with 400 kg/ha of NPK recorded the highest concentrations—1280 mg/kg and 117 mg/kg, respectively—while the control had the lowest concentrations, at 77.6 mg/kg for calcium and 17.0 mg/kg for magnesium. Plants treated with 300 kg/ha NPK fertilizer had the highest crude protein (CP) (14.9%), crude fibre (13.7%) while plants in the control plots had 12.8% and 5.4 % respectively (Table 5).

Table 5. Nutrient concentration of *Brachiaria ruziziensis* under different treatments.

Treatment	T1 (Control)	T2 (150 kg/ha)	T3 (200 kg/ha)	T4 (300 kg/ha)	T5 (400 kg/ha)	Mean	F-value	P-value
N (%)	0.7 ± 0.1^{B}	1.5 ± 0.0^{AB}	1.7 ± 0.2^{A}	2.2 ± 0.3^{A}	2.1 ± 0.2^{A}	1.6	10.13	≤0.01
P (mg/kg)	694.1 ± 31.8^{B}	1937.5 ± 1^{AB}	1889.0 ± 17.2^{AB}	2964.5 ± 315.0^{A}	2783.1 ± 145.0^{A}	2036.5	5.67	≤0.01
K (mg/kg)	5.8 ± 0.0^{C}	1337.9 ± 43.4^{B}	1677.1 ± 88.7^{B}	2369.2 ± 52.2^{A}	2510.2 ± 222.0^{A}	1550.1	62.19	≤0.001
Ca (mg/kg)	77.6 ± 43^{C}	774 ± 110^{ABC}	903.3 ± 91.7^{AB}	1089.3 ± 129.0^{AB}	1280.0 ± 72.1^{A}	818.1	21.25	≤0.001
Mg (mg/kg)	17.0 ± 1.4^{B}	51.4 ± 1.31^{AB}	80 ± 13.5^{AB}	113.0 ± 28.6^{A}	117.5 ± 20.1^{A}	75.6	4.62	≤0.05
Crude protein (%)	12.8 ± 0.3^{B}	12.9 ± 0.5^{B}	13.6 ± 0.3^{AB}	14.9 ± 0.3^{A}	14.8 ± 0.3^{A}	13.6	8.66	≤ 0.01
Crude fibre (%)	5.4 ± 0.1^{B}	9.2 ± 0.1^{AB}	10.7 ± 1.0^{AB}	13.7 ± 1.7^{A}	13.4 ± 1.2^{A}	10.7	8.04	≤0.01
Ash Content (%)	6.8 ± 0.1^{A}	8.5 ± 0.9^{A}	7.6 ± 0.7^{A}	8.0 ± 0.6^{A}	8.6 ± 0.1^{A}	7.8	1.94	0.18

Table values represent the means of three cutting regimes, presented alongside their corresponding standard errors. Superscript letters (A, B, C, etc.) across rows indicate statistical grouping; means sharing the same letter are not significantly different. Higher numerical values reflect more favorable outcomes except for ash, F- and P-values apply to comparisons across row.

4. Discussion

The observed differences in plant height can be attributed primarily to the low soil nutrients contained in the control treatment. The baseline soil nutrient levels of 0.2% nitrogen, 19.57 mg/kg phosphorus, and 0.28 Cmol/kg potassium were insufficient to support optimal vegetative growth. This limitation likely contributed to the significantly lower mean height recorded in the control plots compared to the plots supplied with NPK fertilization.

The improved height performance of plants treated with nitrogen fertilizer which promotes vigorous vegetative growth, phosphorus is essential for meristematic activity and root development, and potassium enhances cell expansion and turgor maintenance, all of which contribute to improved overall phytomorphogenesis. These findings align with previous reports [23], who demonstrated that NPK application significantly increased plant height due to enhanced nutrient uptake. Some authors such as [24] also noted that plant height is closely linked to internodal elongation, which is further influenced by water availability and nutrient levels. Moreover, [25] emphasized nitrogen as a key limiting factor in plant growth and biomass production. This further supports the association between soil nitrogen deficiency and reduced plant height in the control plots.

In terms of leaf production, the highest number of leaves were observed in plants treated with 400 kg/ha NPK and this can be attributed to the availability of essential nutrients that support rapid cell division and expansion at growing points. Potassium and nitrogen, in particular, are known to play pivotal roles in leaf initiation and expansion. [26] reported that nitrogen application accelerates leaf emergence due to its effect on meristematic tissue activity. Accordingly, fertilized plants are more likely to reach their maximum leaf count earlier than unfertilized ones.

The pattern of tiller development observed in this study also supports the positive influence of fertilization on vegetative growth. The highest tiller number was recorded in the 400 kg/ha treatment and this increase in tillering with fertilizer application is consistent with the findings of [27], who reported enhanced tiller production in *Brachiaria brizantha* treated with NPK. [28] further explained that nitrogen stimulates the activation of dormant buds and increases tiller turnover, thereby promoting forage productivity. However, the observed decline in tiller number after the fifth week mirrors the trend reported by [24] who found that tiller numbers tend to peak during early growth stages and decline as plants approach maturity.

A linear regression equation was developed to estimate the leaf area of *Brachiaria ruziziensis* ensured non-destructive measurements. This model is comparable to that proposed by [29] for hazelnut leaf area estimation. The coefficient of determination (R^2 = 82.4%) aligns with similar studies, such as that of [29], who reported comparable values when modeling leaf area in maize.

All fertilizer treatments resulted in significantly ($P = 0.05$) higher macronutrient concentrations in the plant tissues compared to plants in the control plots. The trend of potassium may reflect a plateau in tissue potassium levels, a phenomenon often attributed to luxury consumption in tropical forages such as *Brachiaria*, where potassium uptake exceeds physiological requirements [30]. This behaviour is consistent with previous findings [23] [24] [27], that reported increased nutrient accumulation with increasing NPK levels. However, the absence of significant differences at higher application rates suggests a possible saturation point in the soils such as that of Buea beyond which nutrient uptake does not proportionally increase in productivity [24].

The trend of increasing macronutrient concentration with fertilizer application in this study contrasts with the findings of [6], who observed that increasing NPK levels decreased both magnesium and phosphorus in *Tripsacum laxum*. Conversely, the current findings also differ from those of [31].

Crude protein (CP) content across all fertilized treatments exceeded the minimum threshold of 7% required for ruminant nutrition, indicating the suitability of the forage for livestock feeding. The enhanced CP levels are likely due to increased nitrogen availability, as nitrogen is a fundamental component of amino acids and proteins synthesis. These results support previous studies by [15], who found elevated CP levels in *Brachiaria ruziziensis* following NPK application. Similarly, [9] [10] demonstrated that nitrogen supplementation via poultry manure significantly improved CP content. [25] also reported a direct correlation between nitrogen doses and CP concentration in *Brachiaria* species.

The relatively low crude fibre (CF) content observed suggests improved forage digestibility and palatability. This finding is consistent with the results of [32], who reported a decline in CF from 38% to 27.77% with increased fertilization. [10] also observed similar trends. Although CF values in this study (12.8 - 14.9%) are lower than those reported in the aforementioned studies, they suggest that forage from all treatments would be well-accepted by ruminants.

Ash content increased with fertilization, although differences were not statistically significant (P = 0.18). The higher ash content in fertilized treatments indicates improved mineral accumulation, consistent with the findings of [32], who observed increased ash content in forages treated with ammonia fertilizer. [15] also noted that the inclusion of nutrient-rich plant residues can enhance the mineral composition of forage. In contrast, [6] and [15] reported a decrease in ash content with increasing nitrogen levels, highlighting the variability of this parameter depending on fertilizer type and soil conditions.

5. Conclusion

The results of this study showed that fertilizer positively influenced the heights, leaf number, and number of tillers, stem diameter and biomass of *Brachiaria ruziziensis*. Increased fertilizer levels increased biomass production of *Brachiaria ruziziensis*. Plants supplied with 300 kg/ha and 400 kg/ha gave the best results and the two were not significantly different. Therefore, 300 kg/ha NPK is recommended for the production of Brachiaria in the Cameroon's humid tropics such as Buea and environs. In terms of nutrients, fertilization increases the macronutrients concentrations of *Brachiaria ruziziensis*, the crude protein concentrations and the ash content of the treatments. The equation developed can be used to calculate the actual leaf area of *Brachiaria ruziziensis* using the non-destructive method.

Author Contributions

Egbe Enow Andrew conceptualized and designed the study and reviewed the manuscript. MBUH Marie Chantal Wirbe collected field data, and drafted the initial manuscript. Soupi Nkeutcha Marietta Solange contributed in literature review, and assisted in field data collection and reviewed the draft manuscript. Forkwa Etienne Yong, Ojong Agbor Ntane and Feh Ashley Anjoh assisted in data analysis and references, tables and figures, and reviewed the draft manuscript. All authors reviewed and approved the final version of the manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] United Nations, Department of Economic and Social Affairs, Population Division (2017) World Population Prospects: The 2017 Revision, Key Findings and Advanced Work-

ing Tables. *Uganda Journal of Agricultural Science*, **9**, 656-662.

[2] Bekele, K., Jabessa, T. and Tesfaye, G. (2022) Evaluation of Bracharia Grass Cultivars for Their Agronomic Performance in Midland. *International Journal of Advanced Research in Biological Sciences*, **9**, 13-20.

[3] Foley, J.A., Ramankutty, N., Brauman, K.A., Cassidy, E.S., Gerber, J.S., Johnston, M., *et al.* (2011) Solutions for a Cultivated Planet. *Nature*, **478**, 337-342. https://doi.org/10.1038/nature10452

[4] Tendonkeng, F., Boukila, B., Pamo, T.E., Mboko, A.V., Matumuini, N.E.F. and Fogang, Z.B. (2009) Effect of Different Levels of Nitrogen Fertilization and the Phenological Stage on the Growth and Yield of *Brachiaria ruziziensis* in West Cameroon. *International Journal of Biological and Chemical Science*, **3**, 7257.

[5] Jabessa, T., Bekele, K., Tesfaye, G. and Amare, Z. (2022) Evaluation of Elephant Grass (*Pennisetum purpureum* L.) Accessions for Their Agronomic Performances in Lowland Areas of Guji Zone, Southern Oromia, Ethiopia. *American Journal of Biological and Environmental Statistics*, **8**, 31-35. https://doi.org/10.11648/j.ajbes.20220801.14

[6] Guenni, O., Seiter, S. and Figueroa, R. (2008) Growth Responses of Three Brachiaria Species to Light Intensity. *Tropical Grasslands*, **42**, 75-87.

[7] Bekele, K., Jabessa, T. and Tesfaye, G. (2025) Evaluation of Brachiaria Grass Varieties for Their Agronomic Performance in Midland Areas of East Guji Zone, Southern Oromia, Ethiopia. *Austin Journal of Plant Biology*, **11**, 1063.

[8] Food and Agriculture Organization (2023) The State of Food and Agriculture 2023: Livestock Transformation and Sustainable Development. FAO. https://www.fao.org/agrifood-economics/publications/detail/en/c/1661488/

[9] Cheruiyot, D., Midega, C.A.O., Pittchar, J.O., Pickett, J.A. and Khan, Z.R. (2020) Farmers' Perception and Evaluation of Brachiaria Grass (Brachiaria Spp.) Genotypes for Smallholder Cereal-Livestock Production in East Africa. *Agriculture*, **10**, Article No. 268. https://doi.org/10.3390/agriculture10070268

[10] Alemu, T., Desalegn, A., Eyaya Gashaw, K.A. and Gondar (2023) Forage Yield and Quality Traits of Brachiaria spp. Grass Species at Central Gondar Zone, Ethiopia. *Journal of Rangeland Science*, **13**, 1-9.

[11] Kamara, A.Y. and Bello, A. (2022) Role of Brachiaria Grasses in Enhancing Soil Carbon Sequestration and Pasture Sustainability in Sub-Saharan Africa. *Journal of Sustainable Agriculture and Environment*, **1**, 1-15.

[12] Sarkar, D., Rakshit, A., Al-Turki, A.I., Sayyed, R.Z. and Datta, R. (2021) Connecting Bio-Priming Approach with Integrated Nutrient Management for Improved Nutrient Use Efficiency in Crop Species. *Agriculture*, **11**, Article No. 372. https://doi.org/10.3390/agriculture11040372

[13] Jaliya, M.M., Falaki, A.M., Mahmud, M. and Sani, Y.A. (2008) Effect of Sowing Date and NPK Fertilizer Rate of Yield and Yield Components of Quality Protein Maize (*Zea mays* L.). *ARPN Journal of Agricultural and Biological Science*, **3**, 23-29.

[14] Forkwa, E.Y., Bechem, E.E.T. and Egbe, E.A. (2024) Elucidation of *Ralstonia solanacearum* Phylotypes Causing Bacterial wilt in *Solanum lycopersicum* (Cobra Tomatoes) through Modified Agar Medium (MAM) and Multiplex-PCR. *International Journal of Agriculture and Biological Sciences*, **8**, 15-34. https://doi.org/10.5281/zenodo.14795035

[15] Egbe, A.E., Soupi, M.S.N., Nkede, F. and Ndogho, A.P. (2023) Growth, Yield and Yield Characteristics of Three Pepper Cultivars to Fertilizers Application in the Mount Cameroon Region. *Journal of Agricultural Chemistry and Environment*, **12**, 188-205.

https://doi.org/10.4236/jacen.2023.122015

[16] Essougong, K.P.U. (2017) Urban and Peri-Urban Agriculture in Cameroon: Status and Perspectives for Development. *International Journal of Agronomy and Agricultural Research*, **11**, 116-127.

[17] Pauwels, J.M., Van Ranst, E., Verloo, M. and Mvondo, Z.A. (1992) Method of Soil and Plant Analysis, Stock Management of Glassware and Chemicals. Manual of Pedology Laboratory. Agricultural Publications.

[18] Batista, K., Aparecida Giacomini, A., Gerdes, L., Teixeira de Mattos, W., Tereza Colozza, M. and Pozar Otsuk, I. (2014) Influence of Nitrogen on the Production Characteristics of Ruzi Grass. *African Journal of Agricultural Research*, **9**, 533-538. https://doi.org/10.5897/ajar2013.7302

[19] Akpensuen, T.T., Pyalson, N.E., Cooke, A.S., Lee, M.R.F. and Rivero, M.J. (2025) A Comparison of Biomass Production and Quality of Congo and Rhodes Grasses in Nigeria. *Grasses*, **4**, Article No. 45. https://doi.org/10.3390/grasses4040045

[20] Fernandes, P.B., Santos, C.A.d., Gurgel, A.L.C., Gonçalves, L.F., Fonseca, N.N., Moura, R.B., *et al.* (2023) Non-Destructive Methods Used to Determine Forage Mass and Nutritional Condition in Tropical Pastures. *AgriEngineering*, **5**, 1614-1629. https://doi.org/10.3390/agriengineering5030100

[21] Khan, F.A., Banday, F.A., Narayan, S., Khan, F.U. and Bhat, S.A. (2016) Use of Models as Non-Destructive Method for Leaf Area Estimation in Horticultural Crops. *IRA-International Journal of Applied Sciences*, **4**, 162-180. https://doi.org/10.21013/jas.v4.n1.p19

[22] Kaushik, P., Pati, P.K., Khan, M.L. and Khare, P.K. (2021) A Quick and Simple Method for Estimating Leaf Area by Leaf Weight. *International Journal of Botany Studies*, **6**, 1286-1288. https://www.botanyjournals.com

[23] Costa, K.A.d.P., Severiano, E.d.C., Simon, G.A., Epifanio, P.S., Silva, A.G.d., Costa, R.R.G.F., *et al.* (2014) Nutritional Characteristics of *Brachiaria brizantha* Cultivars Subjected to Different Intensities Cutting. *American Journal of Plant Sciences*, **5**, 1961-1972. https://doi.org/10.4236/ajps.2014.513210

[24] Ahmed, S.A. (2019) Effects of NPK 15:15:15 Rates on Forage Yield, Quality of *Brachiaria ruziziensis* and Performance of Yankasa Rams Fed on Brachiaria: Concentrate Ration. Dissertation, Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, 118 p.

[25] Tendonkeng, F., Boukila, B., Pamo, T.E., Mboko, A.V. and Matumuini, N.E.F. (2011) Direct and Residual Effect of Different Levels of Nitrogen Fertilization on the Growth and Yield of *Brachiaria ruziziensis* at Different Phenological Stages. *Tropicultura*, **29**, 197-204.

[26] Pamo, T.E., Boukila, B., Meduke, C.N. and Tendonkeng, F. (2008) Effect of Nitrogen Fertilization and Cutting Frequency on the Yield and Regrowth of *Panicum Maximum* Jacq. in West Cameroon. In: Xie, H. and Huang, J., Eds., *XXI International Grassland Congress/ VIII International Rangeland Congress*, 354.

[27] Umami, N., Kusuma, A.H.I. and Noviandi, C.T. (2018) Growth, Production and Seed Quality of *Brachiaria brizantha* cv. Mg 5 under Different Planting Space. *Buletin Peternakan*, **42**, 210-214. https://doi.org/10.21059/buletinpeternak.v42i3.12803

[28] Li, X., Xia, K., Liang, Z., Chen, K., Gao, C. and Zhang, M. (2016) MicroRNA393 Is Involved in Nitrogen-Promoted Rice Tillering through Regulation of Auxin Signal Transduction in Axillary Buds. Nature Publishing Group, 1-12.

[29] Kabas, O., Kayakus, M. and Moiceanu, G. (2023) Nondestructive Estimation of Ha-

zelnut (*Corylus avellana* L.) Terminal Velocity and Drag Coefficient Based on Some Fruit Physical Properties Using Machine Learning Algorithms. *Foods*, **12**, Article No. 2879. https://doi.org/10.3390/foods12152879

[30] Sardans, J. and Peñuelas, J. (2021) Potassium Control of Plant Functions: Ecological and Agricultural Implications. *Plants*, **10**, Article No. 419. https://doi.org/10.3390/plants10020419

[31] Yolcu, H., Gunes, A., Dasci, M., Turan, M. and Serin, Y. (2010) The Effects of Solid, Liquid and Combined Cattle Manure Applications on the Yield, Quality and Mineral Contents of Common Vetch and Barley Intercropping Mixture. *Ekoloji*, **19**, 71-81. https://doi.org/10.5053/ekoloji.2010.7510

[32] Al-Arif, M.A., Suwanti, L.T., Estoepangestie, A.S. and Lamid, M. (2017) The Nutrients Contents, Dry Matter Digestibility, Organic Matter Digestibility, Total Digestible Nutrient, and NH_3 Rumen Production of Three Kinds of Cattle Feeding Models. *KnE Life Sciences*, **3**, 338-343. https://doi.org/10.18502/kls.v3i6.1142