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Effect of spacing and age at harvest on the nutritive composition and mineral dynamics of *Megathyrsus maximus* cv. Mombasa

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Abstract

Tropical forage systems in sub-Saharan Africa often suffer from low nutritional quality and mineral imbalance, reducing livestock productivity. This study evaluated the effect of spacing and harvest age on the nutritive composition and mineral dynamics of Megathyrsus maximus cv. Mombasa. The study investigated a two spacing (1 m × 1 m and 0.5 m × 1 m) and two age at harvest (3 and 6 weeks after regrowth) in a 2 × 2 factorial study using a split-plot design. The findings indicated that the effects of spacing × age on crude protein (CP), ash, and total carbohydrate (TC) were significant ($p < 0.05$). While the fiber fractions—neutral detergent fiber (NDF: 697.20 g/kg DM) and acid detergent fiber (ADF: 426.66 g/kg DM)—increased with maturity, the highest CP (166.10 g/kg DM) and Ca (4.69 g/kg DM) were measured at 1 m × 1 m spacing and 3 weeks. Potassium increased from 18.58 to 19.61 g/kg DM, while P (2.65 to 2.03 g/kg DM), Mg (3.41 to 2.93 g/kg DM), Cu (6.35 to 5.77 mg/kg DM), and Zn (25.19 to 16.50 mg/kg DM) decreased with age. The iron concentration increased from 109.60 to 257.76 mg/kg DM, resulting in high Fe:Mn and Fe:Zn ratios. Early harvest (3 weeks) and wider spacing (1 m x 1 m) resulted in high-quality forage.

Keywords: Forage, Guinea grass, harvest, mineral, nutrition

Introduction

In sub-Saharan Africa and other warm-climate countries, tropical forage systems are critical for sustainable livestock production; nevertheless, they usually have low nutritional content and imbalanced mineral profiles that limit ruminant performance (Dele, 2012; Jayasinghe *et al*., 2022).

Megathyrsus maximus (formerly known as *Panicum maximum*) is a tropical grass that is known for its high yield potential and adaptability (Dele, 2012; Wolele *et al*., 2025). However, agronomic management approaches have a significant impact on the nutritional quality of tropical forages: biomass yield, fiber accumulation, and mineral partitioning are all regulated by the interaction of plant spacing, defoliation or harvest age, and nutrient availability (Dele *et al.*, 2025; Wolele *et al.*, 2025).

Plant density and spacing influence light interception, tillering, and nutrient uptake efficiency, which affects both biomass accumulation and chemical composition. Wider spacing often promotes better root development and nutrient absorption due to less inter-plant competition (Sniegowska and Biesiada, 2024). However, Enwete (2022) reported that narrow spacing may enhance competition for resources, perhaps resulting in lower crude protein and mineral concentrations. Similarly, harvest age has been noted as an important factor influencing forage nutritional value, since maturity increases fiber accumulation, while decreasing crude protein and ash content (Tilahun *et al.*, 2017; Zemene *et al.*, 2020).

One important but frequently disregarded aspect of fodder quality is mineral nutrition. The metabolism of ruminants depends on macro-elements like Ca, P, K and Mg, while trace elements like Fe, Zn, Cu and Mn act as cofactors for enzymes and have an impact on immunity, fertility, and health (Dele *et al.*, 2024, 2025). Mineral concentrations in forage grasses vary greatly depending on species, age, and soil fertility, with several minerals declining as maturity increases (Khan *et al.*, 2007). The nutritional value of important minerals may also be impacted by antagonistic interactions that decrease their bioavailability.

For ruminant nutrition to be sustainable, it is crucial to comprehend how agronomic parameters like spacing and harvest age impact mineral dynamics in tropical grasses. Despite the significance of these interactions, there has been little investigation into the interaction effects of spacing and harvest age on nutritional composition and mineral profile more especially the mineral ratios in tropical grasses especially *Megathyrsus maximus* cv Mombasa. This study aims to determine how plant spacing and age at harvest affect the nutritive and mineral contents as well as mineral ratios of *Megathyrsus maximus* cv. Mombasa

Materials and Methods

History of experimental site

This experimental plot was established in May 2020 with total area of 899 m^2. The *M. maximus* cv Mombasa seed was sourced from National Animal Production Research Institute, Shika-Zaria and planted in separate plots with 0.5 m × 1 m and 1 m x 1 m spacing at a seeding rate of 6 kg/ha and the experimental plots were enclosed to prevent uncontrolled animal grazing. In May 2024, when this study took place, the plot was cutback to 10cm above ground level and soil samples were taken at random from the experimental plots between 0 and 15 cm below the top soil layer with the aid of soil auger. To ascertain the soil's nutrient content, the soil samples were bulked per replicate, well mixed, and subsampled for analysis and result of the soil analysis: (pH:5.85; Organic C(%):0.91; N(%):0.03; P(ppm):9.87; K(ppm): 20.60; Mg(ppm):50.93; Ca(ppm):191.45; Mn(ppm):30.29; Cu(ppm):0.65; Zn(ppm): 1.10; Fe(ppm): 117.85; Particle size (%); Sand:71; Silt: 9.8; Clay:19.2; Texture: Sandy loam). To restore soil nutrients and improve *M. maximus* regrowth, 230 kg ha^{-1} of compound fertilizer (NPK 20:10:10) was administered immediately after cutback.

Experimental design

The study was 2 x 2 factorial arrangement laid out in a split plot design. Each subplot measured 5 m x 5 m with 2 m spacing between sub plots. The treatments consisted of two plant spacing (1 m x 1 m and 0.5 m x 1 m) as main plot and two ages at harvest (3 and 6-week after regrowth) as sub plot with four (4) replicates.

Harvesting and dry matter determination

At each age at harvest, a 1 m^2 quadrat was thrown three times in each sub plot. The grasses were clipped at 15 cm above the ground and weighed. Subsequently, samples were oven-dried at 65 °C until a consistent weight was reached, milled and stored for analysis.

Chemical analysis

The proximate composition which comprised of dry matter (DM), crude protein (CP), ether extract (EE), and ash were determined using the A.O.A.C. (1995) method and the total carbohydrate (TC) was calculated by difference (DM-(CP+EE+ash)). The fibre fractions of the sample i.e. neutral detergent fibre (NDF), acid detergent fibre (ADF), and acid detergent lignin (ADL) contents were determined according to Van Soest *et al.* (1991) method. Cellulose was calculated as the difference between ADF and ADL, and hemicellulose as the difference between NDF and ADF. The mineral analysis was conducted using wet ashing technique with Nitric acid and Hydrochloric acid (3:1) making 40ml and making up to 100ml after ashing. The samples were analyzed for some macro minerals (Ca, P, K, Na and Mg) and micro minerals (Cu, Zn, Mn and Fe) (Fritz and Schenk, 1979). The nitrogen (N) concentration was determined using the Dumas method. The mineral concentrations were expressed in g/kg DM and mg/kg DM basis for macro-mineral and micromineral, respectively. To determine the relationships between the minerals, the ratio values were calculated. The tetany (K/(Ca + Mg)) ratio was estimated by milliequivalents per 100 g were used.

Statistical analysis

The data collected were analyzed using the general linear model of SAS 9.4 (SAS Institute, Inc., Cary, NC), and treatment means were compared using the Duncan's multiple range test (DMRT) at the p = 0.05 probability level.

Results

The proximate composition of *Megathyrsus maximus* cv Mombassa as influenced by spacing and age at harvest is presented in Table 1. The crude protein (CP), ash and total carbohydrate (TC) were significantly ($p<0.05$) affected by the spacing x age at harvest interaction, with CP ranging from 120.41 g/kg DM to 166.10 g/kg DM with the grass with wider spacing (1m x 1m) harvested at 3 weeks after regrowth (WAR) having the highest CP content. The grass with 1m x1m spacing and harvested at 6 WAR had the highest ash (139.18 g/kg DM) content. The total carbohydrate (TC) content was recorded for the grass with narrower spacing (1m x 0.5m) and harvested at 6WAR.

In Table 2, the result shows that neutral detergent fibre (NDF), acid detergent fibre (ADF), and cellulose (CEL) contents increased with age at harvest, being highest at six weeks after regrowth across both spacing. Acid detergent lignin (ADL) was slightly higher at three weeks than at six weeks, except under narrow spacing where values were close. Generally, plants grown at 0.5 m × 1 m spacing recorded slightly higher fibre fractions (NDF, ADF, CEL) compared with those at 1 m × 1 m spacing, while age significantly influenced fibre accumulation more than spacing.

Table 1: Effect of spacing and age at harvest on the proximate composition (g/kg DM) of *Megathyrsus maximus* cv Mombassa

Spacing	Age at Harvest	DM	CP	EE	Ash	TC
1m x 1m	3	942.64	166.10^{a}	36.10	113.53^{c}	626.90^{ab}
	6	946.12	145.24^{c}	37.40	139.18^{a}	624.30^{b}
0.5m x 1m	3	937.54	152.16^{b}	36.20	112.87^{c}	636.30^{ab}
	6	939.93	120.41^{d}	35.30	129.98^{b}	654.24^{a}
SEM		4.37	3.87	0.36	2.64	4.88

SEM: Standard error of mean

Table 2: Effect of spacing and age at harvest on the fibre composition of *Megathyrsus maximus* cv Mombassa

Spacing	Age at Harvest	NDF	ADF	ADL	HEM	CEL
1m x 1m	3	667.09[b]	386.08[b]	42.65[ab]	281.01	343.42[b]
	6	697.20[a]	426.66[a]	36.20[c]	270.53	390.45[a]
0.5m x 1m	3	670.02[b]	393.99[b]	43.65[a]	276.02	350.33[b]
	6	711.52[a]	432.95[a]	41.63[b]	278.56	391.32[a]
SEM		5.83	5.13	0.7	3.24	5.46

SEM: Standard error of mean

The macro mineral contents were significantly ($p<0.05$) different (Table 3) as influenced by the interaction of plant spacing and age at harvest. Calcium (Ca), phosphorus (P), magnesium (Mg), and nitrogen (N) contents generally declined with increasing age at harvest, whereas potassium (K) increased. At wider spacing (1 m × 1 m), Ca, P, Mg, and N were highest at 3 weeks and decreased at 6 weeks, while K increased slightly. Similarly, at 0.5 m × 1 m spacing, Ca, P, Mg, and N reduced as plants matured, but K showed a marked rise. Among treatments, the highest Ca (4.69 g/kg DM), P (2.65 g/kg DM), Mg (3.41 g/kg DM), and N (26.57 g/kg DM) were recorded in 1 m × 1 m spacing at 3 weeks, while the highest K (19.61 g/kg DM) occurred at 1 m × 1 m spacing at 6 weeks.

The result indicates that micro mineral concentrations varied significantly ($p<0.05$) with both plant spacing and age at harvest (Table 4). Manganese (Mn) concentration decreased with age at wider spacing (1 m × 1 m) but increased slightly at narrower spacing (0.5 m × 1 m). Iron (Fe) concentration increased consistently with age, with the highest value (257.76 mg/kg) observed at 0.5 m × 1 m spacing at 6 WAR. Copper (Cu) content showed slight reductions with age across both spacings, ranging from 6.35 to 5.77 mg/kg. Zinc (Zn) concentration declined with increasing plant age at both spacings, from 25.19–16.50 mg/kg at 1 m × 1 m and from 25.08–20.42 mg/kg at 0.5 m × 1 m.

Table 3: Effect of spacing and age at harvest on the macro mineral contents (g/kg DM) of *Megathyrsus maximus* cv Mombassa

Spacing	Age at Harvest	Ca	P	K	Mg	N
1m x 1m	3	4.69[a]	2.65[a]	18.58[b]	3.41[a]	26.57[a]
	6	3.47[b]	2.03[c]	19.61[a]	2.93[b]	23.23[c]
0.5m x 1m	3	3.27[c]	2.60[a]	15.77[c]	2.72[c]	24.34[b]
	6	2.52[d]	2.33[b]	19.54[ab]	3.06[b]	19.26[d]
SEM		0.18	0.05	0.38	0.06	0.61

SEM: Standard error of mean

Table 4: Effect of spacing and age at harvest on the micro mineral contents (mg/kg DM) of *Megathyrsus maximus* cv Mombassa

Spacing	Age at Harvest	Mn	Fe	Cu	Zn
1m x 1m	3	70.36[a]	109.60[c]	6.35[a]	25.19[a]
	6	35.29[d]	116.95[c]	5.77[c]	16.50[c]
0.5m x 1m	3	47.99[c]	213.19[b]	6.13[ab]	25.08[a]
	6	56.82[b]	257.76[a]	5.89[bc]	20.42[b]
SEM		2.96	14.56	0.06	0.84

SEM: Standard error of mean

Table 5: Effect of spacing and age at harvest on the macro mineral ratios of *Megathyrsus maximus* cv Mombassa

Spacing	Age at Harvest	Ca:P	Tetany	K:Ca	K:Mg	N:P	N:K
1m x 1m	3	1.77[a]	0.92[d]	3.95[d]	5.43[b]	10.00[b]	1.43[b]
	6	1.71[ab]	1.20[b]	5.64[b]	6.69[a]	11.45[a]	1.18[c]
0.5m x 1m	3	1.26[b]	1.04[c]	4.82[c]	5.78[b]	9.36[c]	1.54[a]
	6	1.08[c]	1.32[a]	7.72[a]	6.38[a]	8.28[d]	0.98[d]
SEM		011	0.03	0.32	0.13	0.27	0.05

SEM: Standard error of mean

Mineral ratios and tetany values differed significantly ($p<0.05$) across spacing and harvest age. Tetany values rose as plants matured, ranging from 0.92 at 1 m × 1 m (3 WAR) to 1.32 at 0.5 m × 1 m (6 WAR). The K:Ca and K:Mg ratios followed a similar upward trend with increasing age, reaching 7.72 and 6.69, respectively, at 6 WAR. In contrast, both N:P and N:K ratios showed a decline pattern as plants aged. The highest N:P (10.00) and N:K (1.54) ratios occurred at 3 WAR under wider and narrower spacings, respectively, while the lowest (8.28 and 0.98) were recorded at 6 WAR under 0.5 m × 1 m spacing (Table 5).

The interaction between spacing and age at harvest showed clear variations in mineral ratios. The Fe:Cu, Fe:Mn, and Fe:Zn ratios increased progressively with age at harvest and were consistently higher under the narrower spacing (0.5 m × 1 m) compared with the wider spacing (1 m × 1 m). The highest Fe:Cu (43.87), Fe:Mn (4.54), and Fe:Zn (12.62) ratios were observed at 6 WAR in the narrow spacing, while the lowest values occurred at 1 m × 1 m spacing at 3 WAR. In contrast, the Zn:Cu ratio declined slightly with age, with the highest value (4.09) at 0.5 m × 1 m spacing at 3 WAR (Table 6)

Table 6: Effect of spacing and age at harvest on the micro mineral ratios of *Megathyrsus maximus* cv Mombassa

Spacing	Age at Harvest	Fe:Cu	Fe:Mn	Fe:Zn	Zn:Cu
1m x 1m	3	17.26[d]	1.55[c]	4.35[d]	3.96[a]
	6	20.32[c]	3.32[b]	7.09[c]	2.86[c]
0.5m x 1m	3	34.78[b]	4.44[a]	8.50[b]	4.09[a]
	6	43.87[a]	4.54[a]	12.62[a]	3.47[b]
SEM		2.51	0.28	0.68	0.11

SEM: Standard error of mean

Discussion

The concentration of soluble protein in leaves is higher than that in stems, and as a result, the concentration of CP decreases as the plant matures, while the concentration of structural carbohydrates increases. As regrowth age increases the leaf to stem ratio falls, leaves proportionally decrease while stem and structural tissues increase. This pattern has been consistently reported for Guinea grass and other tropical grasses (Tilahun *et al.,* 2017; Enwete, 2022; Wolele *et al.,* 2025). The CP contents of the grass in this study is above the critical limit below which intake of forages by ruminants and rumen microbial activity would be adversely affected (Van Soest, 1994). The grasses are therefore adequate for meeting the protein requirement of growing calves to generate a high level of ammonia in the rumen from degradable protein to ensure an efficient digestion process (Ørskov, 1995).

The ash content of the grass in this study was higher for a wider spacing and advanced age at harvest which was similar to those patterns reported by Onjaiuea *et al*. (2023) which could be the result of reduced competition for soil nutrients under wider spacing, allowing plants to acquire more minerals per unit of dry matter, and older plants have had more time to absorb and store minerals from the soil.

According to Buxton (1996), a critical level of NDF was 750 g/kg DM in grass-only diets, with higher concentrations reducing intake and animal productivity, this was not observed in this study as the NDF were all lesser than this referred critical level. NDF contents of the grass increased as age at harvest increased and were in line with the reports of Asmare *et al*. (2017) and Tilahun *et al.* (2017) that reported increase in NDF concentration with increasing age at harvest. Increase in NDF and ADF values as the grasses advanced in age was as a result of lower stem:leaf ratio and high lignification of the grasses with maturity. The NDF and ADF contents increased with advancing harvest age and were slightly higher under narrow plant spacing. This indicates that closer spacing favoured stemmy growth and the accumulation of structural carbohydrates, which may consequently reduce forage digestibility and voluntary intake in ruminants (Wolele *et al.,* 2025).

Minerals are required by both plants and animals in critical and balanced amounts; excess and deficiency affect the effectiveness of plants and livestock production. The requirement of different ruminant animals in terms of Ca concentration ranged between 1.8 to 8.2 g/kg as reported by McDowell (1992; 1997) and the Ca contents recorded in this study all were within the range recommended. The wider spaced grass in this study has been observed to favour higher Ca content for both age at harvest which is in line with the findings of Sniegowska and Biesiada (2024) which reported lesser competition for soil nutrients per plant when plants are spaced farther apart thereby enhancing higher nutrient uptake per plant. It was recorded that 75% of the grasses in this study had their Ca content higher than 3 g/kg DM which was reported by NRC (2000), McDowell and Arthington (2005), and Onal Asci *et al*. (2018) noted that < 3.00 g/kg DM of Ca could lead to its deficiency in ruminants.

The P content was affected by the interaction of spacing and age at harvest as observed in this study and is in line with the findings of Spears (1994) who reported that advancing plant maturity reduce the P content of forages. The P content pattern in this study took a similar trend as that reported by Enwete (2022) with study of grazing with similar spacing and grazing frequency for Megathyrsus and Cenchrus. McDowell *et al*. (1984) reported that forages in Nigeria are P deficient but the range of 2.03 g/kg DM to 2.65 g/kg DM recorded for the grasses were within the recommended (1-4.8 g/kg DM) requirements for different classes of ruminant animals as stated by McDowell (1992; 1997).

The K content recorded in this study were >15 g/kg DM which are higher than the K concentration (8 g/kg DM) recommended for grazing animals (NRC, 2001). However, it has been suggested that ruminants with high producing ability in terms of milk and other animal products may require K level above 10 g/kg DM under stress particularly heat stress (McDowell, 1985) of which the grasses in this study fall under. The increase in the K content of the grasses in this study with advanced age at harvest might be because it is a highly mobile element.

Nitrogen (N), a key component of ruminant diets and usually used to estimate crude protein (CP), promotes microbial protein synthesis, growth, lactation, and reproductive function. The nitrogen (N) content has a directly relationship with the CP and the recorded N is study was as expected because previously studies by same authors and others (Dele, 2012; Enwete, 2022; Onjai-uea *et al.*, 2023) have reported decline in CP of forages which also amount to decline in N content of forages. The wider spacing in this study also encourage N uptake by the grass as there was lesser competition for N.

Microminerals are available in smaller quantities in forages but are critical components of ruminant livestock's diet (Brink *et al*., 2006). In the current study, there was an increase in the Mn content with a narrower spacing and as age at harvest advanced which is in line with the findings of Govasmark *et al*. (2005) that Mn concentration of grasses did increase in the first 10 weeks of growth but the decline in the Mn content with wider spacing ~~with~~ as age at harvest advanced was in contrast. This contradiction validates the findings of Conrad (1978) that the trace mineral content of plants might increase, decrease, or exhibits no consistent change with growth stage or species. The highest tolerable limit of Mn (2000 mg/kg DM) for ruminant reported by NRC (2005), was significantly higher than the Mn concentration of the grasses in this study, however 75% of the grasses recorded Mn concentration higher than the requirement (20-40 mg/kg DM) has recommended by McDowell (1992, 1997).

The increase in Fe concentration with advancing age at harvest for both spacing can be attributed to Fe buildup in older tissues, reduced nutrient dilution due to higher dry matter, and enhanced root exploration, which allows for greater Fe uptake from the soil. Iron is typically immobile in plant tissue, therefore it accumulates with maturity (Broadley *et al*., 2012; Fageria *et al*., 2011). The Fe concentrations found (109.60-257.76 mg/kg DM) are much higher than the ruminant deficiency thresholds of 30-50 mg/kg DM, as well as the dietary requirements of 50 mg/kg DM for cattle and 30-50 mg/kg DM for sheep and goats (NRC, 2016). However, they are still below the maximum acceptable limit of 500 mg/kg DM (NRC, 2005). The higher concentration of Fe in the grasses is in consonance with the report of Mielki *et al*. (2016) that tropical soils are rich in iron which also translate to higher Fe uptake by tropical forages (Jack *et al*., 2020). This suggests that the forages supply enough Fe for all ruminant classes without generating toxicity hazards; however, concentrations above 200 mg/kg DM may limit copper bioavailability.

The decline in copper (Cu) concentration with advancing in age at harvest for both spacings could be explained by antagonistic interactions with increasing iron (Fe), which can decrease Cu uptake and translocation, as well as a dilution effect as plant dry matter accumulates with maturity (Broadley *et al*., 2012; López-Alonso, 2012). The range of Cu values in this study (5.77-6.35 mg/kg DM) were within the dietary needs of 5-8 mg/kg DM for sheep and slightly below the 8-10 mg/kg DM for cattle (NRC, 2005; 2016).. These values are significantly lower than the maximum tolerated limits of 25 mg/kg DM for sheep and 40 mg/kg DM for cattle, indicating no toxicity concern but a possible marginal deficit under high Fe or Mo conditions.

Zinc is a known micromineral that is majorly linked to immunity of ruminants, and its deficiency could result in death by lowering the number of lymphocytes in the blood (Hilal *et al*., 2016; Goff, 2018). The observed Zn concentrations (16.50 - 25.19 mg/kg DM) fall within or slightly above the critical range (20 - 30 mg/kg DM) recommended for grazing ruminants (Ortner and Drewnoski, 2025; USDA-ARS, 2020). Levels below 20 mg/kg DM may indicate marginal deficiency, particularly for rapidly growing or lactating animals. However, the concentrations observed are well below the maximum tolerable limit of 500 mg/kg DM (NRC, 2005), indicating no risk of toxicity.

Interactions of minerals in ruminants might enhance (synergy) or hinder (antagonism) their absorption (Xie *et al*., 2021; Dele *et al*., 2025). In this study, the Ca:P ratio decreased as the spacing became smaller and the age at harvest increased. The wider spacing for both ages at harvest was greater than 1.5, which is regarded as sufficient for ruminant nutrition. Due to increased calcium accumulation and decreased phosphorus concentration in mature plants, wider spacing encouraged higher Ca:P ratios (McDowell, 2003). It is implied that plants with a wider spacing at early harvests satisfied the ideal range, but plants with a closer spacing and later harvests would be more susceptible to phosphorus imbalance. The tetany (K/(Ca+Mg)) ratio increased with advancing age and closer spacing however, values across all treatments remained below the critical threshold of 2.2, above which a high risk of grass tetany has been reported (Jefferson et al., 2001). The increasing tendency with age and closer spacing, however, suggests possible danger from continuous grazing or potassium enrichment. The N:K ratios of the grasses in this study ranged from 0.98 to 1.43. An estimated range (1.25 – 1.88) for cattle with reference to Mayland and Shewmaker (2001) deduced from the individual elements. The N:K ratio of the grasses of both spacing harvested at 6 WAR showed a decline and was below the range estimated for cattle. This decline is a testimony to the decline in the nitrogen content with advance in age.

Iron and manganese are biochemically antagonistic because their absorption and enzyme-binding abilities compete with one another, and an abundance of one element may result in the deficiency of the other (Adriano, 2001). Fe and Mn concentrations in healthy plants have been reported to vary from 1.5:1 to 2.5:1. A ratio larger than 2.5 indicates Fe toxicity, whereas a ratio less than 1.5 indicates Mn toxicity (Adriano, 2001). It was recorded that 25% of the grasses which is basically the grass with spacing of 1m x1m harvested at 3WAR is considered healthy as the 75% have the Fe:Mn ratio > 2.5:1 indicating that Fe toxicity might occur. The relationship between Fe and Zn have been reported to be antagonistic (Stewart, 2017; Dele *et al*., 2025), Fe have been reported to suppress Zn whenever the ratio exceeds 2:1, In this current study, all the treatments exceeded 2:1, invariably, if animals are grazed on any of the grasses, Zn supplementation must be considered

Conclusions and Recommendation

The study found that spacing and harvest age had a substantial impact on the nutritional and mineral composition of *M. maximus* cv. Mombasa. Early harvest (3 weeks) and wider spacing (1 m × 1 m) resulted in forage with higher crude protein, ash, Ca, P and Mg content, indicating superior nutritional quality. As maturity progressed, fiber fractions increased which could amount to decreased digestibility as well as K contents. The Fe concentrations increased with age, but copper and zinc contents declined, indicating antagonistic interactions. Most mineral concentrations were within ruminant needs, but high Fe:Mn and Fe:Zn ratios suggest probable Fe interference. It is recommended that *M. maximus* cv. Mombasa can be cultivated at 1 m × 1 m spacing and harvested at 3 weeks after regrowth to maximize crude protein and mineral content while minimizing antagonistic mineral ratios detrimental to ruminant nutrition.

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