

Growth Performance and Nutrient Composition of Stem Cutting-Propagated Napier Grass (*Pennisetum purpureum* Schumach.) as Influenced by Poultry Litter Application and Harvest Maturity

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Abstract: A 4 × 4 factorial experiment arranged in a completely randomized block design (CRBD) was conducted to evaluate the effects of poultry litter (PL) application rates (0, 5, 10, and 15 t/ha) and harvest age (45, 60, 75, and 90 days after cutback, DAC) on the growth performance, dry matter yield, and nutrient composition of stem cutting-propagated Napier grass (*Pennisetum purpureum* Schumach.). Forty-eight plots of 3.5 m × 3.0 m were established at 1 m × 0.5 m plant spacing. Results showed that poultry litter application significantly ($p < 0.05$) improved plant height, leaf dimensions, stool circumference, number of tillers, and dry matter yield, with the 10 t/ha rate producing the highest yield (27.09 t/ha DM). Harvest age significantly influenced all growth and compositional parameters. Dry matter yield was greater at 90 DAC (30.24 t/ha) than at 45 DAC (13.57 t/ha), while crude protein declined progressively from 13.96% at 45 DAC to 11.07% at 75 DAC. The interaction of 10 t/ha PL with harvest at 90 DAC produced the highest dry matter yield (38.24 t/ha), whereas quality parameters (crude protein, nitrogen-free extract) were best preserved at younger harvest stages combined with moderate PL rates. These findings demonstrate that optimum management of stem cutting-propagated Napier grass in sub-humid tropical environments can be achieved by applying poultry litter at 10 t/ha and harvesting between 45 and 60 DAC to balance forage yield and nutritive value for ruminant livestock.

Keywords: *Pennisetum purpureum*; Organic Fertilizer; Harvest Interval; Forage Quality; Dry Matter Yield.

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I. INTRODUCTION

Napier grass (*Pennisetum purpureum* Schumach.), also known as elephant grass, is among the most productive tropical perennial grasses globally and plays a central role in supplying basal roughage for smallholder dairy and beef cattle production

systems across sub-Saharan Africa, South and Southeast Asia, and Latin America (Islam *et al.*, 2024). Its C4 photosynthetic pathway, extensive root system penetrating to 4.5 m depth, and clump-forming growth habit confer outstanding biomass productivity and drought resilience (Islam *et al.*, 2023). Napier grass constitutes up to 80% of forage ingested by cows in

numerous tropical and subtropical countries, yet its nutritive value under conventional management remains a persistent challenge to ruminant productivity (Islam *et al.*, 2024).

The grass propagates vegetatively through stem cuttings, root splits, or crown divisions. Stem cutting propagation is the most widely adopted approach because of its simplicity, rapid establishment, and low cost (Ashvani and Priyanka, 2023; Aleme *et al.*, 2024). Despite these advantages, the productivity and nutritional value of stem cutting-established stands are strongly modulated by soil fertility management and defoliation frequency, two management levers that smallholder farmers can meaningfully adjust (Islam *et al.*, 2023).

Soil fertility is a primary determinant of Napier grass yield and quality. Being a high-biomass C4 grass, Napier has substantial nitrogen demand, requiring up to 600 kg N/ha or more to sustain maximum production (Islam *et al.*, 2023). Inorganic nitrogen fertilizers are often inaccessible or economically prohibitive for smallholder producers in tropical Africa, making organic amendments an attractive alternative. Poultry litter, which is generated in large quantities by the expanding poultry industry, supplies nitrogen, phosphorus, potassium, calcium, magnesium, and micronutrients, and simultaneously improves soil physical structure and microbial activity (Rambau *et al.*, 2022). However, the optimum application rate for Napier grass established from stem cuttings in sub-humid tropical agroecologies has not been systematically characterized, most especially in Wukari.

Harvest age is equally critical. Younger Napier grass harvested at shorter intervals (30-45 days) tends to have higher crude protein (CP), lower neutral detergent fiber (NDF), and greater digestibility, while older material (75-90 days) accumulates greater biomass but with reduced CP, elevated structural carbohydrates, and increased acid detergent lignin (ADL), limiting rumen fermentation and intake (Babu *et al.*, 2025; Islam *et al.*, 2025). Optimal harvest timing therefore involves a trade-off between yield quantity and nutritive quality, a balance that is further conditioned by fertilizer inputs. The interactive effects of organic manure rate and harvest maturity on both morpho-agronomic traits and proximate and cell wall composition of stem cutting-propagated Napier grass remain insufficiently documented in the literature.

This study was therefore conducted to: (i) determine the effects of graded poultry litter application rates on the growth performance, dry matter yield, and nutrient composition of stem cutting-propagated Napier grass; (ii) evaluate the influence of harvest age on these parameters; and (iii) characterize interaction effects between poultry litter rate and harvest interval. The outcomes are expected to guide evidence-based recommendations for Napier grass agronomy under organic soil fertility management in tropical environments.

II. MATERIALS AND METHODS

➤ *Experimental Site and Treatments*

The experiment was conducted at the Federal University Wukari Livestock Teaching and Research Farm during the raining season of 2025. Forty-eight plots measuring 3.5 m × 3.0 m were established with a 1.0 m alley between plots. Stem cuttings were planted at 1.0 m × 0.5 m spacing. A 4 × 4 factorial arrangement in a completely randomized block design (CRBD) was used. The first factor comprised four poultry litter (PL) application rates: 0 (T₁, control), 5 (T₂), 10 (T₃), and 15 (T₄) t/ha. The second factor was harvest age at 45, 60, 75, and 90 days after cutback (DAC). Dry matter yield was measured only at 45 and 90 DAC for practical logistical reasons, while growth and compositional parameters were recorded at all four harvest stages.

➤ *Data Collection*

Agro-morphological measurements including plant height (cm), leaf length (cm), leaf width (cm), stool circumference (cm), number of leaves per stool, and number of tillers per stool were recorded at each harvest age using measuring tape and Vernier calipers where applicable. For yield determination at 45 and 90 DAC, all plants per designated plots were harvested, weighed per plot using 50 Kg sensitive hanging scale and the weights recorded. The harvested forages were subsampled and immediately conveyed to the laboratory and oven-dried at 65 °C for 72 hours to determine their moisture content which were used subsequently to determine the dry matter yield of the harvested forages. The yield per plot area was then extrapolated to tons/ha. Dried and milled samples were analyzed for proximate composition (DM, crude protein, ether extract, crude fiber, ash, and nitrogen-free extract) following AOAC (2019) methods. Neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), cellulose, and hemicellulose were determined using the Van Soest *et al.* (1991) sequential detergent fiber procedure.

➤ *Statistical Analysis and Model*

All data were subjected to two-way analysis of variance (ANOVA) using the following linear model: $Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \rho_k + \epsilon_{ijk}$, where Y_{ijk} is the observed value; μ is the overall mean; α_i is the effect of poultry litter rate i ($i = 0, 5, 10, 15$ t/ha); β_j is the effect of harvest age j ($j = 45, 60, 75, 90$ DAC); $(\alpha\beta)_{ij}$ is the interaction effect; ρ_k is the block effect; and ϵ_{ijk} is the random error. Means were separated using Tukey's Honestly Significant Difference (HSD) test at $p < 0.05$. All analyses were performed using JMP Clinical 18 (SAS Institute, 2022).

III. RESULTS AND DISCUSSION

➤ Effect of Poultry Litter Application Rates on Growth Performance and Dry Matter Yield

The effect of poultry litter application on morpho-agronomic traits and dry matter yield of stem cutting-propagated Napier grass is presented in Table 1. Poultry litter significantly ($p < 0.05$) influenced all growth parameters and yield. Plant height was significantly lower in the unfertilized control (T1: 292.53 cm) compared to all PL-amended treatments, which did not differ significantly ($P > 0.05$) from one another (316.71–326.69 cm). This growth-promoting effect of poultry litter is consistent with its role as a slow-release source of nitrogen, phosphorus, and potassium, nutrients that directly stimulate meristematic activity, chlorophyll synthesis, and photosynthate accumulation in tall tropical grasses (Rambau *et al.*, 2022; Islam *et al.*, 2023).

Leaf length and leaf width followed similar trends: the control was significantly inferior to fertilized treatments (121.36 vs. 126.14–126.80 cm leaf length; 4.28 vs. 4.64–4.88 cm leaf width). Wider and longer leaves increase the photosynthetically active surface area per unit land area, translating into greater canopy light interception and carbon assimilation. These results align with those reported for Napier grass varieties receiving organic amendments at similar rates in Ethiopia (Aleme *et al.*, 2024) and South Africa (Rambau *et al.*, 2022).

Stool circumference, an indicator of stand vigor and root development, was significantly greatest at 10 t/ha (74.10 cm)

and lowest in the control (64.71 cm), with 15 t/ha (69.85 cm) being intermediate. The superior stool development at moderate PL rates likely reflects optimal nitrogen-phosphorus-potassium balance, as excessive potassium at 15 t/ha may interfere with calcium and magnesium uptake, slightly constraining root expansion. The number of tillers per stool was highest at 10 t/ha PL (21.07) and comparable between the control and the 15 t/ha rate (16.24 and 16.58, respectively). This non-linear response in tillering might be suggesting that above a threshold PL rate, luxury nitrogen consumption may redirect assimilates toward vegetative extension rather than lateral shoot initiation, a phenomenon noted in high-biomass tropical grasses (Monte & Marcos, 2024).

Dry matter yield responded strongly and significantly to poultry litter ($p < 0.0001$). The control yielded only 15.10 t/ha DM, while 10 t/ha PL produced the highest yield (27.09 t/ha DM), followed by 5 t/ha (25.77 t/ha) and 15 t/ha (19.65 t/ha). This quadratic-type response, where 10 t/ha outperformed 15 t/ha, indicates a point of diminishing returns beyond which higher PL inputs may cause physiological inefficiencies, soil salinity effects, or nitrogen volatilization losses which is consistent with findings from Pakchong Napier grass evaluations (Monte & Marcos, 2024). The DM yields observed at the 5 and 10 t/ha levels (25.77 and 27.09 t/ha) compare favorably to the 20.93 t/ha recorded by Aleme *et al.* (2024) for the highest-yielding Napier variety in Ethiopia, suggesting that poultry litter at moderate rates effectively compensates for inorganic fertility inputs.

Table 1. Effect of Poultry Litter Application Rates on Growth Performance and Yield of Napier Grass Propagated with Stem Cuttings

Parameters	Poultry Litter Application Rate				SEM	p – value
	0 ton/Ha	5 tons/Ha	10 ton/Ha	15 tons/Ha		
Plant height	292.53 ^b	316.71 ^a	326.69 ^a	321.93 ^a	4.210	<0.0001
Leaf length	121.36 ^b	126.72 ^a	126.80 ^a	126.14 ^a	1.214	0.0035
Leaf width	4.28 ^b	4.64 ^a	4.88 ^a	4.644 ^a	0.069	<0.0001
Stool circumference	64.71 ^b	73.18 ^a	74.10 ^a	69.85 ^{ab}	2.091	0.0069
Number of leaves	23.50 ^a	20.58 ^b	23.19 ^{ab}	21.46 ^{ab}	0.781	0.024
Number of tillers	16.24 ^b	19.5 ^{ab}	21.07 ^a	16.583 ^b	0.898	0.0002
Yield (t /ha DM)	15.10 ^c	25.77 ^a	27.09 ^a	19.65 ^{bc}	1.890	< 0.0001

Means within rows with different superscripts differ significantly ($p < 0.05$). T1 = 0 t/ha, T2 = 5 t/ha, T3 = 10 t/ha, T4 = 15 t/ha. SEM = Standard Error of Mean.

➤ Effect of Harvesting Age on Growth Performance and Dry Matter Yield

The effect of harvest age on growth and yield traits is summarized in Table 2. All parameters differed significantly ($p < 0.0001$) across harvest dates. Plant height increased progressively and significantly with advancing maturity (267.79 cm at 45 DAC to 369.52 cm at 90 DAC), consistent with the indeterminate vegetative growth pattern characteristic of Napier grass under tropical conditions. Comparable height trajectories have been reported for Napier varieties evaluated in Ethiopia (Aleme *et al.*, 2024) and Thailand (Islam *et al.*, 2025).

Leaf length was paradoxically highest at 45 DAC (135.93 cm) and declined thereafter to 113.03 cm at 75 DAC before partially recovering at 90 DAC (121.93 cm). This pattern may reflect the increasing proportion of stem to leaf tissue as the canopy develops and lower leaves senesce, altering the population of leaves measured. In contrast, stool circumference (52.86 to 86.91 cm) and number of tillers (14.67 to 22.08) increased consistently with age, reflecting progressive root system enlargement and clump expansion, traits that contribute to long-term stand productivity. The number of leaves per stool increased substantially from 15.94 at 45 DAC to 29.88 at 90

DAC, a pattern that supports the accumulation of greater leaf biomass at advanced maturity, though with implications for leaf-to-stem ratio and nutritive value (Islam *et al.*, 2023).

Dry matter yield, measured at 45 and 90 DAC only, more than doubled from 13.57 to 30.24 t/ha DM ($p < 0.0001$). This

near-twofold increase over 45 days reflects the rapid biomass accumulation capacity of Napier grass under adequate fertility. Such yield differences between harvest intervals underscore the critical importance of regrowth period in scheduling cutting for either fresh-feeding or conservation systems (Islam *et al.*, 2024; Islam *et al.*, 2025).

Table 2. Effect of Age on Growth Performance and Yield of Napier Grass Cultivated with Stem Cuttings

Parameters	Harvesting Age Days After Cutback, DAC)				SEM	p/t* - values
	45 days	60 days	75 days	90 days		
Plant height	267.79 ^d	294.39 ^c	326.17 ^b	369.52 ^a	4.210	< 0.0001
Leaf length	135.93 ^a	130.14 ^b	113.03 ^d	121.93 ^c	1.214	< 0.0001
Leaf width	4.77 ^a	4.38 ^b	4.81 ^a	4.483 ^b	0.069	< 0.0001
Stool circumference	52.86 ^d	64.35 ^c	77.72 ^b	86.91 ^a	2.091	< 0.0001
Number of leaves	15.94 ^c	21.00 ^b	21.92 ^b	29.88 ^a	0.781	< 0.0001
Number of tillers	14.67 ^b	15.94 ^b	20.69 ^a	22.08 ^a	0.898	< 0.0001
Yield (t /ha, DM)	13.57 ^b			30.24 ^a	1.336	< 0.0001*

Means within rows with different superscripts differ significantly ($p < 0.05$). DAC = Days After Cutback. SEM = Standard Error of Mean. * = t-value (yield compared at 45 vs. 90 DAC only).

➤ *Interaction Effect of Poultry Litter Rate and Harvest Age on Growth Performance and Yield*

Significant interaction effects ($p < 0.01$) between PL rate and harvest age were observed for all growth and yield parameters (Table 3). The T3,90 treatment combination (10 t/ha PL harvested at 90 DAC) produced the tallest plants (401.00 cm), the largest stool circumference (97.13 cm), and the greatest number of tillers (28.83). For dry matter yield, T3,90 (38.24 t/ha) and T2,90 (36.25 t/ha) were jointly the highest and significantly superior to all other combinations, while T1,45 and T4,45 (11.53 t/ha) were the lowest.

The response of DM yield to the interaction of PL and harvest age confirms that the benefits of organic fertilization are fully expressed only when the crop is allowed sufficient time for biomass accumulation. Conversely, the 15 t/ha PL rate at 90 DAC (T4,90: 27.78 t/ha) was substantially lower than T3,90 and T2,90, suggesting antagonistic interactions at the highest PL rate under extended regrowth. This may relate to competitive inhibition between nutrients or to soil structure effects associated with very high manure loadings. These interaction patterns have practical implications: producers can achieve maximum biomass production by applying PL at 5-10 t/ha and harvesting at 90-day intervals when biomass quantity is the primary objective.

Table 3. Interaction Effect of Poultry Litter Application Rate and Harvest Interval on Growth Performance and Yield of Napier Grass Cultivated with Stem Cuttings

Treatment combination	Plant height	Leaf length	Leaf width	SC	No. of leaves	No. of tillers	Yield (t/ha, DM)
T1,45	263.71 ^g	133.60 ^{ab}	4.74 ^{abc}	49.06 ^f	16.56 ^{de}	13.44 ^{cd}	11.53 ^e
T1,60	271.44 ^g	128.11 ^{bc}	4.09 ^{cd}	55.22 ^{ef}	19.78 ^{cde}	12.667 ^d	
T1,75	303.78 ^{defg}	107.56 ^f	4.43 ^{bcd}	70.56 ^{cde}	21.33 ^{cde}	19.33 ^{bed}	
T1,90	331.18 ^{cde}	116.17 ^{def}	3.83 ^d	84.00 ^{abc}	36.33 ^a	19.50 ^{bed}	18.68 ^{cd}
T2,45	279.17 ^{fg}	141.39 ^a	5.17 ^a	58.22 ^{def}	15.11 ^e	16.33 ^{bed}	15.29 ^{de}
T2,60	301.22 ^{efg}	134.33 ^{ab}	4.44 ^{bcd}	64.44 ^{cdef}	20.78 ^{cde}	16.22 ^{bed}	
T2,75	328.89 ^{cde}	110.67 ^{ef}	4.68 ^{abc}	78.22 ^{abcd}	22.11 ^{cde}	20.44 ^{abcd}	
T2,90	357.55 ^{bc}	120.50 ^{cde}	4.27 ^{bcd}	91.83 ^{ab}	24.33 ^c	25.00 ^{ab}	36.25 ^a
T3,45	264.56 ^g	135.11 ^{ab}	4.41 ^{bcd}	55.11 ^{ef}	15.56 ^{de}	15.44 ^{cd}	15.94 ^d
T3,60	312.67 ^{def}	127.30 ^{bcd}	4.66 ^{abc}	66.17 ^{cdef}	22.89 ^{cd}	18.22 ^{bed}	
T3,75	328.56 ^{cde}	114.22 ^{ef}	5.29 ^a	78.00 ^{abcd}	22.33 ^{cde}	21.78 ^{abc}	
T3,90	401.00 ^a	130.53 ^{abc}	5.17 ^a	97.13 ^a	32.00 ^{ab}	28.83 ^a	38.24 ^a
T4,45	263.71 ^g	133.60 ^{ab}	4.74 ^{abc}	49.06 ^f	16.56 ^{de}	13.44 ^{cd}	11.53 ^e
T4,60	292.22 ^{efg}	130.78 ^{abc}	4.31 ^{bcd}	71.56 ^{bcdde}	20.56 ^{cde}	16.67 ^{bed}	
T4,75	343.44 ^{cd}	119.67 ^{cde}	4.86 ^{ab}	84.11 ^{abc}	21.89 ^{cde}	21.22 ^{abcd}	
T4,90	388.33 ^{ab}	120.50 ^{cde}	4.67 ^{abc}	74.67 ^{bcdde}	26.83 ^{bc}	15.00 ^{cd}	27.78 ^b
SEM	8.4192	2.427	0.1389	4.1812	1.5616	1.800	2.672

p/t* - value	0.0008	0.0005	<0.0001	0.0159	0.0011	0.0098	0.0227*
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Means on within rows with different superscript are significantly different ($p < 0.05$, SEM = Standard Error of Mean, T1 = Control, T2 = 5 tons/Ha, T3 = 10 tons/ Ha, T4 = 15 tons /Ha, 45, 60, 75 and 90 are harvest age in days after cutback (DAC), SC= Stool circumference, * = t - value

➤ *Effect of Poultry Litter Application Rates on Proximate and Cell Wall Fiber Composition*

The proximate and fiber composition of Napier grass as influenced by PL application rates is presented in Table 4. Dry matter content was significantly affected by PL rate ($p = 0.0085$), being highest at 10 t/ha (92.37%). Crude protein was significantly highest at 5 t/ha (12.21%) and 10 t/ha (12.16%), lower in the control (11.95%), and lowest at 15 t/ha (11.49%). The moderate enhancement of CP with medium PL rates reflects enhanced nitrogen uptake and protein synthesis stimulated by balanced soil nutrition from organic amendments (Rambau *et al.*, 2022). The decline at 15 t/ha may indicate luxury nitrogen consumption or dilution effects associated with the stimulated biomass production at that rate.

Ether extract (EE) increased significantly with PL rate from 0.82% (control) to 0.95% (10 t/ha), consistent with improved lipid metabolism under better nutritional status. Crude fiber was significantly reduced at 15 t/ha (30.72%) compared to other rates (31.19-31.40%), which may reflect improved cell wall maturation or altered lignification patterns under the highest PL rate. Ash content was significantly highest in the control (14.22%) and 15 t/ha treatment (14.08%), and lowest at 10 t/ha (13.23%), potentially reflecting complex nutrient antagonisms at different application rates. Nitrogen-free extract (NFE) was significantly greatest at 10 and 15 t/ha (42.47 and 42.83%), indicating enhanced non-structural carbohydrate accumulation under better fertility conditions.

Neutral detergent fiber (NDF) was not significantly affected by PL rate ($p = 0.1465$), ranging narrowly from 41.33 to 41.67% across treatments. NDF represents the total cell wall fraction and its relative stability across PL rates suggests that organic manure application, while enhancing cell division and elongation, does not substantially alter the proportional composition of structural polysaccharides in Napier grass at these rates. In contrast, ADF was significantly highest at 15 t/ha (37.31%) and lowest in lower-rate treatments (36.43-36.57%), suggesting increased cellulose and lignin deposition at the highest PL rate. ADL was highest in the control (14.24%) and declined with increasing PL rate up to 10 t/ha (13.18%), indicating that moderate organic fertilization may attenuate lignification — a finding with positive implications for digestibility, as lignin is the primary anti-quality factor limiting rumen fiber fermentation (Islam *et al.*, 2024).

Cellulose content increased significantly with PL rate at 10 and 15 t/ha (23.62 and 23.86%) compared to the control and 5 t/ha (22.33 and 22.36%), while hemicellulose declined progressively from 5.05% in the control to 4.08% at 15 t/ha. The increase in cellulose with higher PL rates, alongside the decline in ADL, may indicate a shift toward more fermentable structural polysaccharides, which could partially offset the reduction in hemicellulose from a nutritive standpoint (Rambau *et al.*, 2022).

Table 4 Effect of Poultry Litter Application Rates on the Proximate Composition and Cell Wall Fiber Fractions of Napier Grass Cultivated Stem Cutting

Parameters (%)	Poultry Litter Application Rates (t/ha)				SEM	p - value
	T1	T2	T3	T4		
Dry Matter	91.29 ^b	91.07 ^b	92.37 ^a	91.54 ^{ab}	0.265	0.0085
Crude Protein	11.95 ^b	12.21 ^a	12.16 ^a	11.49 ^c	0.035	<0.0001
Ether extract	0.82 ^d	0.86 ^c	0.95 ^a	0.88 ^b	0.003	<0.0001
Crude fiber	31.40 ^a	31.19 ^a	31.21 ^a	30.72 ^b	0.090	<0.0001
Ash	14.22 ^a	13.79 ^b	13.23 ^c	14.08 ^a	0.040	<0.0001
Nitrogen Free Extract	41.61 ^b	41.97 ^b	42.47 ^a	42.83 ^a	0.120	<0.0001
Neutral Detergent Fiber	41.61	41.33	41.67	41.39	0.120	0.1465
Acid Detergent Fiber	36.57 ^b	36.43 ^b	36.80 ^b	37.31 ^a	0.110	<0.0001
Acid Detergent Lignin	14.24 ^a	14.08 ^b	13.18 ^d	13.45 ^c	0.040	<0.0001
Cellulose	22.33 ^b	22.36 ^b	23.62 ^a	23.86 ^a	0.070	<0.0001
Hemicellulose	5.05 ^a	4.89 ^b	4.87 ^b	4.08 ^c	0.153	<0.0001

Means on within rows with different superscript are significantly different ($p < 0.05$, T1 = 0 t/ha, T2 = 5 tons/Ha, T3 = 10 tons/ Ha, T4 = 15 tons /Ha, SEM = Standard Error of Mean

➤ *Effect of Harvesting Age on Proximate and Cell Wall Fiber Composition*

The effect of harvest age on proximate and cell wall composition is presented in Table 5. Dry matter content increased significantly with age from 90.97% at 45 DAC to 93.56% at 90 DAC ($p < 0.0001$), reflecting progressive dehydration and reduced metabolic water content as plant tissues mature. Crude protein declined significantly from 13.96% at 45 DAC to 11.07% at 75 DAC, with a slight numerical recovery at 90 DAC (11.25%). This pattern is well-established in tropical grasses: rapid cell wall polysaccharide accumulation with advancing age dilutes the protein content, while leaf senescence and nitrogen remobilization reduce leaf-nitrogen density. Similar CP decline trajectories with advancing harvest age have been consistently reported for Napier grass and related tropical grasses (Babu *et al.*, 2025; Wimalasiri *et al.*, 2023; Islam *et al.*, 2025).

Ether extract increased progressively with age (0.83 to 0.93%), while crude fiber increased substantially from 28.22% at 45 DAC to 33.10% at 90 DAC. This increase in crude fiber reflects the deposition of cell wall structural polysaccharides, cellulose, hemicellulose, and lignin that accompanies stem elongation and tissue lignification at advanced maturity. Ash

content increased significantly with age from 11.84% at 45 DAC to 15.64% at 90 DAC, consistent with the gradual accumulation of mineral elements over extended growth periods. NFE declined from 45.16% at 45 DAC to 39.09% at 90 DAC, reflecting a shift from non-structural to structural carbohydrate predominance as the plant matures.

NDF was significantly highest at 60 DAC (45.37%) and lowest at 75 DAC (39.53%), exhibiting a non-linear response across harvest dates. ADF was also variable, peaking at 60 and 90 DAC. ADL increased with maturity, reaching its peak at 60 and 90 DAC (14.54 and 14.47%, respectively). The progressive increase in ADL with age is a critical nutritional concern because lignin binds with cell wall carbohydrates, restricting microbial access in the rumen and reducing forage digestibility (Islam *et al.*, 2024). Hemicellulose exhibited a striking response — peaking at 60 DAC (7.42%) and declining dramatically to 2.01% at 90 DAC — suggesting rapid turnover and structural reorganization of the hemicellulosic matrix in the cell wall during advanced maturation. These findings collectively support the principle that harvesting Napier grass at 45-60 DAC preserves greater nutritive quality, albeit at the cost of lower biomass yield.

Table 5. Effect of Poultry Harvesting Age on the Proximate Composition and Cell Wall Fiber Fractions of Napier Grass Cultivated Stem Cutting

Parameters (%)	Harvesting Age (Days After Cutback, DAC)				SEM	p – value
	45	60	75	90		
DM	90.97 ^{bc}	89.97 ^c	91.77 ^b	93.56 ^a	0.265	<0.0001
Crude Protein	13.96 ^a	11.53 ^b	11.07 ^d	11.25 ^c	0.035	<0.0001
Ether extract	0.83 ^d	0.86 ^c	0.90 ^b	0.93 ^a	0.003	<0.0001
Crude fiber	28.22 ^c	30.14 ^b	33.05 ^a	33.10 ^a	0.090	<0.0001
Ash	11.84 ^d	12.87 ^c	14.98 ^b	15.64 ^a	0.040	<0.0001
Nitrogen Free Extract	45.16 ^a	44.62 ^b	40.01 ^c	39.09 ^d	0.120	<0.0001
Neutral Detergent Fiber	40.87 ^b	45.37 ^a	39.53 ^d	40.23 ^c	0.120	<0.0001
Acid Detergent Fiber	35.95 ^b	37.94 ^a	35.00 ^c	38.22 ^a	0.110	<0.0001
Acid Detergent Lignin	12.46 ^c	14.54 ^a	13.48 ^b	14.47 ^a	0.040	<0.0001
Cellulose	23.49 ^b	23.40 ^b	21.52 ^c	23.75 ^a	0.070	<0.0001
Hemicellulose	4.92 ^b	7.42 ^a	4.54 ^c	2.01 ^d	0.153	<0.0001

Means on within rows with different superscript are significantly different ($p < 0.05$, DAC = Days After Cutback SEM = Standard Error of Mean)

➤ *Interaction Effect of Poultry Litter Rate and Harvest Age on Proximate and Cell Wall Fiber Composition*

Significant interaction effects ($p < 0.05$ or better) were observed for all proximate and cell wall composition parameters (Table 6). The T3,45 combination (10 t/ha, 45 DAC) produced the highest CP (14.90%), closely followed by T2,45 (14.64%) and T1,45 (14.56%), confirming that early harvest is the dominant driver of CP preservation regardless of PL rate. However, among the 90 DAC groups, CP was best preserved at T2,90 (11.56%), while T1,90 and T3,90 had the lowest values at this maturity (10.96 and 11.13%), suggesting a modest quality advantage for the 5 t/ha rate at longer cutting intervals.

NDF was significantly highest at T3,60 (46.23%) and T1,60 (45.52%), indicating that 60 DAC consistently produces the greatest cell wall content regardless of PL treatment. The high NDF at 60 DAC corresponds with the increased ADF and ADL observed at this age (Table 5), suggesting a critical window of rapid structural fiber deposition between 45 and 60 DAC. The lowest NDF was observed at T4,75 (38.53%), suggesting that higher PL rates may slightly modulate cell wall deposition at intermediate harvest ages.

ADL was universally highest at 60 and 90 DAC across all PL treatments, reinforcing that lignification is primarily age-driven and less responsive to organic inputs over the range

tested. However, T3,45 and T4,45 had the lowest ADL values (12.34 and 11.90%), confirming that early harvesting under any fertilization regime limits lignin accumulation. NFE was particularly outstanding at T3,75 (47.47%), suggesting that the combination of 10 t/ha PL and 75 DAC uniquely drives the

highest accumulation of soluble carbohydrates at that growth stage. The interaction patterns described here provide nuanced guidance for producers seeking to optimize the nutritive profile of Napier grass for specific livestock feeding objectives.

Table 6 Interaction Effect of Poultry Litter Application Rate and Harvest Interval on the Proximate Composition and Cell Wall Fiber Fractions of Stem Cutting-Propagated Napier Grass

P.L.A.* HA	Parameters (%)										
	DM	CP	EE	CF	Ash	NFE	NDF	ADF	ADL	C	HC
T1,45	90.72 ^{def}	14.56 ^a	0.78 ^h	32.87 ^a	11.28 ^k	40.51 ^f	40.64 ^{cd}	35.94 ^d	12.67 ^{ef}	24.78 ^a	4.7 ^{hi}
T1,60	88.70 ^f	11.42 ^{bcd}	0.710 ⁱ	33.23 ^a	13.36 ^f	41.28 ^{ef}	45.52 ^{ab}	37.80 ^{abc}	15.44 ^a	24.48 ^a	7.72 ^b
T1,75	91.70 ^{abcd}	10.86 ^f	0.98 ^b	28.64 ^{cd}	16.22 ^b	43.30 ^{cd}	40.16 ^d	34.10 ^e	13.51 ^d	24.32 ^a	6.06 ^d
T1,90	94.02 ^a	10.96 ^f	0.82 ^{fg}	30.84 ^b	16.03 ^b	41.35 ^{ef}	40.12 ^d	38.42 ^a	15.34 ^a	24.2 ^{ab}	1.70 ^l
T2,45	91.23 ^{bcd}	14.64 ^a	0.71 ⁱ	33.36 ^a	12.06 ^{ji}	39.23 ^g	40.39 ^d	35.84 ^d	12.93 ^e	24.18 ^{ab}	4.55 ⁱ
T2,60	88.89 ^{ef}	11.75 ^b	0.84 ^f	32.85 ^a	12.64 ^{gh}	41.92 ^e	44.98 ^{ab}	38.11 ^{ab}	15.67 ^a	23.59 ^{bc}	6.87 ^c
T2,75	90.00 ^{def}	10.88 ^f	0.92 ^{cd}	28.42 ^{cd}	14.46 ^e	45.32 ^b	39.95 ^d	34.50 ^e	13.38 ^d	23.27 ^{cd}	5.45 ^f
T2,90	94.15 ^a	11.56 ^{bcd}	0.96 ^b	30.11 ^b	15.98 ^b	41.39 ^{ef}	39.98 ^d	37.28 ^{bc}	14.33 ^b	23.08 ^{cde}	2.70 ^j
T3,45	91.56 ^{abcde}	14.90 ^a	0.95 ^{bc}	32.89 ^a	12.26 ^{hi}	39.00 ^g	40.67 ^{cd}	35.93 ^d	12.34 ^f	22.95 ^{cdef}	4.74 ^h
T3,60	91.49 ^{abcde}	11.44 ^{bcd}	0.89 ^{de}	33.33 ^a	12.65 ^{gh}	41.69 ^{ef}	46.23 ^a	38.07 ^{ab}	13.59 ^{cd}	22.91 ^{cdef}	8.16 ^a
T3,75	92.88 ^{abc}	11.15 ^{ef}	0.80 ^{gh}	28.08 ^d	12.50 ^{gh}	47.47 ^a	39.48 ^{de}	34.47 ^e	12.85 ^e	22.73 ^{def}	5.01 ^g
T3,90	93.54 ^{ab}	11.13 ^{ef}	1.14 ^a	30.52 ^b	15.50 ^c	41.71 ^{ef}	40.28 ^d	38.73 ^a	13.95 ^{bc}	22.44 ^{ef}	1.55 ^l
T4,45	90.35 ^{def}	11.73 ^{bc}	0.88 ^e	33.28 ^a	11.74 ^j	42.37 ^{de}	41.76 ^c	36.08 ^d	11.90 ^g	22.36 ^f	5.68 ^e
T4,60	90.79 ^{bcd}	11.49 ^{bcd}	0.98 ^b	32.78 ^a	12.81 ^g	41.94 ^e	44.73 ^b	37.79 ^{abc}	13.47 ^d	21.62 ^g	6.94 ^c
T4,75	92.50 ^{abcd}	11.38 ^{cde}	0.89 ^{de}	27.74 ^d	16.73 ^a	43.26 ^{cd}	38.53 ^e	36.91 ^{cd}	14.18 ^b	21.12 ^{gh}	1.62 ^l
T4,90	92.53 ^{abcd}	11.36 ^{de}	0.78 ^h	29.07 ^c	15.03 ^d	43.76 ^c	40.52 ^{cd}	38.44 ^a	14.24 ^b	20.59 ^h	2.08 ^k
SEM	0.52926	0.070	0.010	0.180	0.080	0.240	0.240	0.210	0.080	0.130	0.030
p – value	0.003	<.0001	<.0001	0.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001

T1 = Control, T2 = 5 tons/Ha, T3 = 10 tons/ Ha, T4 = 15 tons /Ha, 45, 60, 75 and 90 are harvest age in days after cutback (DAC), DM = Dry matter, CP = Crude Protein, EE =Ether Extract, CF = Crude Fiber, NFE = Nitrogen Free Extract, NDF = Neutral detergent fiber, ADF = Acid detergent fiber, ADL = Acid detergent lignin, C= Cellulose, HC = Hemicellulose, SEM = Standard Error of Mean

IV. CONCLUSIONS AND APPLICATION

This study demonstrates that poultry litter application rate and harvest age independently and interactively determine the growth performance, dry matter yield, and nutrient composition of stem cutting-propagated Napier grass. Application of poultry litter at 10 t/ha consistently optimized plant height, stool circumference, tiller production, and dry matter yield, outperforming both lower and higher PL rates. Harvest age at 90 DAC maximized biomass accumulation but was associated with significantly lower crude protein, elevated crude fiber, and higher acid detergent lignin. The interaction of 10 t/ha PL with 90 DAC produced the highest dry matter yield (38.24 t/ha), while the highest nutritive quality (CP, NFE) was preserved at 45 DAC across all fertilization levels.

Based on these findings, it is recommended that farmers producing Napier grass for direct fresh feeding of lactating dairy cows or young stock, where protein supply is critical, should apply PL at 5-10 t/ha and harvest at 45-60 DAC. For silage production or dry-season conservation where

maximizing biomass quantity is the priority, harvesting at 90 DAC with 5-10 t/ha PL is optimal. The 10 t/ha PL application rate represents the most efficient level across all production objectives and hence recommended. Future work should investigate the effects of these management combinations on *in vitro* and *in vivo* digestibility, voluntary intake, and ruminant performance to provide a complete nutritional evaluation framework.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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