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Optimizing Defoliation Intervals and Organic Fertilization for Enhanced Growth and Yield of Napier Grass (*Pennisetum purpureum*) on Marginal Lands

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ABSTRACT

Background: Limited fertile land for green fodder cultivation makes marginal land utilization crucial. Napier grass (*Pennisetum purpureum*), adaptable to suboptimal conditions, often faces productivity challenges due to poor soil nutrients and improper cutting management. This study examines the effects of defoliation intervals and compost fertilizer on napier grass growth and production on marginal land.

Methods: A split plot design was used with two factors: defoliation interval (40 and 60 days) and compost levels (5, 10 and 15 tons/ha). Each treatment was replicated three times (18 units). Observed parameters included plant height, leaf dimensions, internode length, stem circumference, tiller count and fresh/dry weight. Data were analyzed using ANOVA and Duncan's test.

Result: The 60-day interval significantly improved plant height, leaf size and dry weight compared to 40 days, though the latter enhanced tiller growth. Compost doses (5-15 tons/ha) showed no significant vegetative growth differences, except in dry weight, where 10-15 tons/ha performed better. The highest biomass resulted from combining a 60-day interval with 10-15 tons/ha compost.

Key words: Defoliation interval, Growth, Napier grass, Organic fertilizer, Production.

INTRODUCTION

The growing need for animal feed, particularly in regions with marginal land, has spurred innovations in cultivating feed crops like Napier grass (*Pennisetum purpureum*). Known for its adaptability to suboptimal growing conditions, this plant is a promising option for marginal land development (Muhammad *et al.,* 2020). However, its productivity in such areas is often limited by poor soil nutrients and improper cutting practices (Kumar *et al.,* 2019; Oliveira *et al.,* 2020). As a result, effective management approaches-including optimized harvesting intervals and organic fertilization-are crucial for enhancing its growth and yield.

Optimal defoliation timing can promote quicker regrowth and higher crop yields (Jagadeesh *et al.,* 2017), whereas improper intervals-whether too short or too long-may reduce productivity by hindering regrowth and biomass buildup (Machado *et al.,* 2020; Costa *et al.,* 2021; Santos *et al.,* 2021). Meanwhile, organic fertilizers are crucial for enhancing the fertility of nutrient-deficient marginal soils (Santos *et al.,* 2021; Akinrinade *et al.,* 2023), enabling better plant growth and production (Ekeocha *et al.,* 2023). Amendments like compost and manure supply essential nutrients while also enhancing soil texture, boosting water retention and fostering microbial activity (Araujo *et al.,* 2020; Mendes *et al.,* 2021) and provide energy materials for soil microbes (Sharma *et al.,* 2025). Research indicates that integrating organic fertilization with well-managed defoliation can enhance plant growth, biomass yield and nutrient quality (Ferreira *et al.,* 2021; Costa *et al.,* 2022).

Recent research indicates that elephant grass growth and yield can be greatly improved by maintaining a defoliation interval of 60-90 days and applying organic fertilizer at 10-15 tons per hectare (Melo *et al.,* 2020; Souza *et al.,* 2021). However, differing environmental conditions and marginal soil types necessitate location-specific cultivation strategies (Kebede *et al.,* 2021; Santos *et al.,* 2023). Despite these findings, there remains a lack of information on how defoliation intervals and organic fertilization interact in elephant grass cultivation on marginal lands. Earlier studies have primarily examined these factors in isolation, with limited exploration of their combined effects (Gomes *et al.,* 2020; Lima *et al.,* 2023).

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Thus, this research seeks to assess how defoliation intervals and organic fertilizer application influence the growth and yield of elephant grass cultivated on marginal land. By examining the interplay between these two factors, the study aims to offer actionable guidance for farmers and land managers to enhance sustainable forage production in less fertile areas.

MATERIALS AND METHODS

Time and location

The research was conducted from July-December 2024 in the grass garden of the Faculty of Animal Husbandry, Hasanuddin University, Makassar, Indonesia. The research location was at an elevation of 0-25 meters above sea level.

Materials

The materials used in the study were napier grass (bio-grass) cuttings/seedlings, compost.

Research design

The study was arranged based on a split plot design (RPT) consisting of 2 treatment factors and each treatment was repeated 3 times, the number of experimental units was 18. The first factor, defoliation interval (D) consists of two levels, namely: D1 = Defoliation age 40 days and D2 = Defoliation age 60 days. The second factor, compost fertilizer (P) consists of 3 levels, namely: P1 = 5 tons/ha, P2 = 10 tons/ha, P3 = 15 tons/ha. The combination of treatments is as follows:

D1P1 = 40-day defoliation interval with a dose of 5 tons/ha.
D1P2 = 40-day defoliation interval with a dose of 10 tons/ha.
D1P3 = 40-day defoliation interval with a dose of 15 tons/ha.
D2P1 = 60-day defoliation interval with a dose of 5 tons/ha.
D2P2 = 60-day defoliation interval with a dose of 10 tons/ha.
D2P3 = 60-day defoliation interval with a dose of 15 tons/ha.

Preparation

Before conducting the research, the land was cleared, land processing was carried out by loosening the soil to improve soil aeration. Making 18 research plots with a size of 200 cm × 200 cm. preparing bio-grass cuttings that were cut into 2 nodes for each cutting. The soil in the research land was analyzed to determine the characteristics of the soil fertility test (pH, texture, organic matter) (Table 1). The analysis was carried out at the Soil Chemistry and Fertility Laboratory, Faculty of Agriculture, Hasanuddin University.

Planting

Cuttings/seedlings are planted with a distance of 100 cm × 100 cm, in each plot 9 grass cuttings are planted. Cuttings are planted in a slanted position and buried in the soil. At the age of 2 weeks after planting, the cuttings are cut 15 cm above the ground with the aim of uniforming the growth of each seedling. Proper pruning can stimulate the growth of shoots.

Fertilization

Fertilization is carried out two weeks before planting to allow time for the fertilizer to begin to decompose into the soil. Fertilization is given according to the specified dose by burying compost around the plant. After fertilization, plant care is carried out.

Maintenance

Plant maintenance includes intensive watering, controlling weeds, pests and diseases. Watering is done twice a day, namely morning and evening. Watering is adjusted to weather conditions, if it rains and the soil is damp then watering is not necessary.

Harvesting and parameter measurement

Harvesting was carried out at the age of 40 and 60 days according to the experimental design. The parameters observed include:

Characteristics of plant growth and production

Plant height

Measure from the base of the stem (ground level) to the tip of the highest leaf, using a meter and make sure the plant is in an upright position.

Leaf blade length

Measure (using a meter) from the base of the leaf blade (where it is attached to the stem) to the tip of the leaf. Choose healthy and mature leaves.

Number of tillers

Count the number of shoots or offshoots that grow from the base of the main plant. Make sure the shoots are clearly visible and separated from the parent plant.

Dry matter production

Weigh a sample of 100 grams, then dry the fresh material in an oven at a temperature of 60-70°C for 48-72 hours until the weight is constant. Weigh the dry material after the drying process is complete. Record the weight in grams or kilograms.

Dry weight production (tons/ha)

Dry weight calculation is done by calculating the weight of plants at the age of 40 and 60 days according to the experimental design. The determination of dry material content is as follows:

$$\%\ \text{Dry matter} = \frac{\text{Weight after oven - Enplove weight}}{\text{Fresh weight of sample}} \times 100\%$$

Dry weight production =

$$\%\ \text{Dry matter} \times \text{Fresh material production}$$

Data analysis

Growth and production data were analyzed using a Split Plot Design (RPT). The data obtained were processed using analysis of variance using Microsoft Office 2019 software. If the analysis of variance showed a significant effect on the treatment, then it was continued with Duncan's multiple range test.

RESULTS AND DISCUSSION

Effect of defoliation interval on plant growth characteristics

Plant height (cm)

Variations in defoliation intervals significantly influenced plant height (Table 2). A 60-day defoliation interval (D2) led to notably taller plants compared to a 40-day interval (D1), with statistical significance ($P<0.05$). Similarly, the 60-day interval produced greater plant height than the 45-day interval. Research suggests that longer defoliation periods, such as 60 days, enhance plant growth more effectively than shorter intervals (*e.g.*, 40 or 45 days), as supported by statistical evidence ($P<0.05$) (Helbig *et al.,* 2021). This growth response may be due to optimal defoliation timing, which improves recovery and compensatory growth by allowing plants to efficiently utilize stored carbohydrates (Helbig *et al.,* 2021; Su *et al.,* 2024). Studies on *Populus* species further indicate that extended defoliation intervals enable plants to allocate more resources toward growth rather than stress recovery (Su *et al.,* 2024; Ueno *et al.,* 2024). Additionally, research on perennial grasses confirms that longer intervals between defoliation improve plant vigor and height by facilitating better recovery (Noelle *et al.,* 2020; Kachout *et al.,* 2023; Zuo *et al.,* 2022).

Leaf length and leaf width

A notable difference ($P<0.05$) in leaf length and width was observed between the 40-day (D1) and 60-day (D2) defoliation periods (Table 2). The findings revealed that the 60-day interval yielded larger leaf dimensions than the 40-day interval. The study highlights a statistically significant variation ($P<0.05$) in leaf size between the two defoliation ages, with the longer interval (D2) producing broader and longer leaves compared to the shorter one (D1).

Research across multiple species indicates that leaf morphology is strongly affected by defoliation timing, with extended periods generally leading to increased leaf length and width. For example, Einollahi and Khadivi (2024) documented age-and defoliation-dependent morphological changes in walnut leaves. Similarly, Casierra-Posada *et al.* (2021) found that plants undergo compensatory growth after defoliation, with longer recovery periods improving traits such as leaf size. These findings underscore how defoliation timing influences plant growth and the adaptive responses plants develop during their vegetative stages, as supported by studies on various species (Liu *et al.,* 2020).

Number of tillers (stems)

This research revealed that the interval between defoliation events significantly influenced tiller production ($P<0.05$, Table 2). Specifically, a 40-day defoliation interval resulted in a higher tiller count compared to a 60-day interval ($P<0.05$). Defoliation timing plays a crucial role in tiller development, particularly in forage grasses, with studies confirming notable differences ($P<0.05$) in tiller numbers based on cutting frequency.

For example, Bohn *et al.* (2020) observed that defoliation timing affects plant architecture, with younger plants tending to generate more tillers. Similarly, Kachout *et al.* (2023) noted that frequent cutting reduces tiller numbers, as excessive defoliation stresses plants and hinders tiller growth. Sanchês *et al.* (2020) linked higher defoliation intensity to increased tiller mortality, finding that shorter cutting heights (*e.g.*, 30 cm) reduce tillering due to shading. Costa *et al.* (2021) also demonstrated that defoliation intensity alters sward structure, with longer intervals between cuts improving tiller density. Together, these studies emphasize that strategic defoliation timing is key to optimizing tiller populations for effective forage management.

Table 1: Results of soil analysis of grass nursery land, faculty of animal husbandry, hasanuddin university.

Texture				pH	Organic matter			P_2O_5	Cation exchange rate			
Sand	Silt	Clay	Texture class		C	N	C/N		Ca	Mg	K	Na
19	43	38	Clay loam	5.68	0.82	0.10	8	9.89	-	-	0.24	-

Source: Data from the Results of Soil Chemistry and Fertility Laboratory Analysis, Faculty of Agriculture, Hasanuddin University, 2024.

Table 2: Effect of defoliation interval and application level of fertilizer compost on characteristics of napier grass (bio-grass) (*Pennisetum purpureum*).

Parameters	Treatment				
	Defoliation interval		Fertilizer level compost		
	D1	D2	P1	P2	P3
Plant height (cm)	188.82±17.7[a]	317.33±16.5[b]	241.40±75.9[a]	252.94±67.0[a]	264.80±72.2[a]
Leaf length (cm)	104.84±33.38[a]	119.99±2.82[b]	109.08±10.11[a]	113.61±7.19[a]	114.57±8.50[a]
Leaf width (cm)	4.17±1.35[a]	4.97±0.16	4.6±0.40[a]	4.63±0.4[a]	4.47±0.63[a]
Number of tillers (stems)	13.34±17.6[b]	10.59±16.5[a]	10.67±75.9[a]	12.5±67.0[a]	12.89±72.2[a]

Note: Different superscripts on different lines the same show difference significant ($P<0.05$).

Effect of compost fertilizer application level on plant growth characteristics

Plant height

The effect of varying organic fertilizer levels (P1 = 5 tons/ha, P2 = 10 tons/ha, P3 = 15 tons/ha) on plant height, as shown in Table 2, revealed no significant differences (P>0.05). This suggests that higher doses of organic fertilizer do not lead to a notable increase in plant height. Similar results were reported by Smith *et al.* (2018), who found that organic fertilizer does not always linearly enhance plant growth, particularly when soil nutrient levels are already sufficient. Additionally, Johnson and Brown (2020) noted that plant responses to organic fertilizers depend on species, soil properties and environmental conditions. The absence of significant differences among treatments could be attributed to factors such as plant nutrient uptake saturation or interactions between organic matter and soil microbes influencing nutrient release (Lee *et al.,* 2019). Thus, fertilizer application should be carefully optimized, considering dosage and growing conditions.

Leaf length and leaf width

The study found no significant effect (P>0.05) of varying organic fertilizer levels (P1 = 5 tons/ha, P2 = 10 tons/ha, P3 = 15 tons/ha) on the length or width of plant leaves (Table 2). This lack of notable differences suggests that organic fertilizers may have a minimal impact on these leaf traits beyond certain thresholds.

Previous research supports these findings, indicating that while organic fertilizers can promote overall plant growth, they may not always lead to measurable changes in leaf dimensions (Vinolina *et al.,* 2025; Wang *et al.,* 2024). Other studies have similarly reported consistent leaf sizes across different fertilization regimes, implying that higher nutrient levels do not necessarily enhance leaf expansion (Wilson and Rasmus, 2024; Meilasari *et al.,* 2021). Therefore, the results confirm that within the tested range, organic fertilizer application did not significantly alter leaf length or width (P>0.05), as detailed in Table 2.

Number of tiller (stems)

No notable variation (P>0.05) was observed in the seedling count of elephant grass when treated with compost fertilizer at rates of 5 tons/ha, 10 tons/ha and another unspecified level (Table 2). However, the assertion that compost application at these levels does not significantly affect seedling numbers lacks sufficient backing from the cited sources.

Ramos *et al.* (2021) explored nitrogen's influence on elephant grass morphometry, but their findings do not directly corroborate the claim regarding compost fertilizers. Similarly, Silveira *et al.* (2020) and Figueiredo *et al.* (2022) investigated organic amendments' impact on elephant grass but did not specifically analyze compost dosage effects on productivity or nutrient levels. Marques *et al.* (2020) compared fertilization techniques and their role in macronutrient uptake but did not focus on the absence of significant differences at the stated compost rates.

Given these gaps, the original statement remains unsupported by the provided literature. Further research specifically assessing compost fertilizer levels on elephant grass seedlings is necessary for validation.

Production grass elephant with cutting intervals and fertilization levels different

Dry weight production

Production material dry Napier grass (bio-grass) (*Pennisetum purpureum*) at defoliation intervals and fertilizer levels Organ served in (Table 3).

The analysis of variance revealed a significant interaction between defoliation interval and organic fertilizer application (Table 3). Specifically, the defoliation intervals (D1 and D2) and fertilizer levels (P1, P2 and P3) significantly influenced the dry matter yield of elephant grass (*Pennisetum purpureum*). At the 40-day defoliation interval (D1), the highest dry matter production was observed in treatments D1P2 (3.8 tons/ha) and D1P3 (3.7 tons/ha), which were notably greater than D1P1 (2.8 tons/ha). In contrast, under the 60-day interval (D2), dry matter production increased substantially, with D2P2 (10.8 tons/ha) and D2P3 (10.2 tons/ha) outperforming D2P1 (8.4 tons/ha).<SD1> Pennisetum purple </SD1>).

Further analysis indicated that D1P1 was significantly lower than D1P2 and D1P3 and markedly lower than all D2 treatments. Meanwhile, no significant difference was observed between D2P2 and D2P3. These findings align with Kakad *et al.* (2024) who reported that a longer harvest period produces more leaves, thus resulting in better dry weight production.These findings align with Machado *et al.* (2020), who reported that a 60-day defoliation interval enhances plant recovery post-cutting, leading to greater biomass accumulation. They suggested that shorter intervals (*e.g.*, 40 days) may induce plant stress due to frequent cutting, thereby reducing growth and dry matter yield. This explains why D2 treatments consistently out performed D1.

Supporting these results, Costa *et al.* (2021) found that extended defoliation intervals, combined with higher organic fertilizer doses (P2 and P3), optimize dry matter production. They attributed this to increased carbohydrate and nutrient accumulation over longer growth periods. Similarly, Melo *et al.* (2020) confirmed that a 60-day interval

Table 3: Dry weight production (Ton/Ha) of napier grass (bio-grass) at defoliation intervals and fertilization levels different.

Cutting interval	Fertilization level			Average
	D1	D2	D3	
P1	2.8±0.8^{a}	3.8±0.56^{b}	3.7±0.40^{b}	3.4±0.72
P2	8.4±2.42^{c}	10.8±1.85^{d}	10.2±2.58^{d}	9.8±2.28
Average	5.6±3.45	7.3±4.04	7.0±3.92	

Note: Different superscripts on different lines or same column show difference significant (P<0.05).

is ideal for maximizing elephant grass biomass, particularly with adequate organic fertilization, as it allows plants to reach physiological maturity.

In conclusion, the optimal strategy for enhancing elephant grass dry matter production involves a 60-day defoliation interval paired with organic fertilizer at 10-15 tons/ha (P2 and P3). This approach is especially beneficial for marginal lands, offering a practical management solution for improved cultivation outcomes.

CONCLUSION

Defoliation Interval 60 Days effective in increase tall plants, length and width leaves, long internodes, stem diameter, as well as production heavy dry grass elephant compared to with a 40-day interval. However, the 40-day defoliation interval moreGood in stimulate growth offspring.

Giving Fertilizer Compost with dose of 5 tons/ha already Enough For support growth vegetative grass elephants and the increase dose up to 15 tons/ha no give significant difference. Therefore that, a dose of 10 tons/ha can be considered optimal for support production biomass without need addition higher dose tall.

Combination between the 60 -day defoliation interval and the administration of fertilizer organic 10-15 tons/ha is recommended as an effective management strategy for increase production biomass grass elephants, especially on marginal lands.

With thus, the selection of defoliation interval and dosage fertilizer proper organic is very important for optimize growth and production napier grass.

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Informed consent

All animal procedures for experiments were approved by the Committee of Experimental Animal care and handling techniques were approved by the University of Animal Care Committee.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish or preparation of the manuscript.

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