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The Production Rates of Pakchong Elephant Grass Based on Different Urea Fertilizer Dosage Levels

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ABSTRACT

Pakchong Elephant Grass (PEG) is a super fodder with significant nutritional content and high production levels. The purpose of this research is to evaluate of the growth and yield of PEG that has undergone nitrogen fertilizer strategies with different dosages and gradual application. A completely randomized design was employed in the investigation, with 4 levels of urea dosage (100; 200; 300; and 400 N kg/ha) applied gradually (50% urea dosage at 2 WAP and 50% urea dosage at 6 WAP for each treatment) and each10 replicates. The ANOVA were used to analysis the data, followed by Duncan's Test for significantly different at ($p<0.05$). The research findings demonstrated that the addition of nitrogen fertilizer at dosages of 200–400 N kg/ha was better ($p<0.05$) compared to 100 N kg/ha at 8 weeks after planting for the quantity of leaves, leaf length, the height of plant, production of both fresh and dry biomass of PEG. There were no significant effect in nitrogen fertilizer levels for 8 weeks after planting on the leaf width, leaf chlorophyll content, stem sugar content, tiller quantity, and the leaf-to-stem ratio of PEG. The research's conclusion indicates that adding nitrogen fertilizer dosage up to 400 N kg/ha with gradual application, namely 50% urea dosage at 2 WAP and 50% urea dosage at 6 WAP for each treatment is generally safe and feasible for the growth and production of PEG. A nitrogen fertilizer dosage of 200 N kg/ha is optimal to meet PEG's growth and production needs.

Keywords: G*rowth, Nitrogen, Production, Pakchong elephant grass*

Introduction

Pakchong Elephant Grass (PEG; *Pennisetum purpureum* cv. Thailand is a type of hybrid elephant grass that has great potential as livestock forage due to its high productivity, nutrient content, and palatability. PEG has a wide growth adaptation range to different fertility levels and altitudes. Suherman and Herdiawan (2021) reported that PEG produces biomass yields up to 500 ton/ha/year, contains 16% – 18% crude protein at 45 d of age, grows well at altitudes of 0 – 1500 meters above sea level, and is tolerant to dry conditions. Additionally, the PEG is highly favored by ruminant livestock due to its softer stem texture and the morphology of its hairless stems and leaves (BPPD, 2023; Suherman and Herdiawan, 2021). However, the cultivation distribution of PEG as livestock forage is not yet as widespread as other varieties of elephant grass. PEG is a variety of elephant grass from Thailand that is still being developed in Indonesia (Distan, 2022). PEG's high productivity has to be encouraged by adequate nutrient availability to achieve optimal production. Liman *et al*. (2022) reported that optimal growth and production of elephant grass can be obtained through balanced and ideal fertilization.

Urea fertilizer is an inorganic nitrogen fertilizer containing 45% –46% nitrogen. Nitrogen is a crucial component for sustaining a plant's vegetative growth, related to photosynthesis, protein synthesis, and cell division. Fathi and Zeidali (2021) stated that nitrogen is a dominant component chlorophyll, amino acids, nucleic acids, and proteins, taking part in the phenological evolution of plants during vegetative and generative phases. The characteristic of nitrogen fertilizer is that it dissolves slowly in the soil and is susceptible to loss due to leaching and volatilization. Inappropriate nitrogen fertilizer dosing can cause nitrogen deficiency in plants due to the loss of nitrogen in the soil plant system (Fathi, 2022). Several studies report that nitrogen fertilizer dosage levels for elephant grass show good effectiveness at doses of 100 – 250 N kg/ha (Daryatmo *et al*., 2019; Bueno *et al*., 2020; Chaedir *et al*., 2021; Alves *et al*., 2022). Other reports indicate that excessive urea use negatively impacts plant growth and production as well as environmental health (Fathi, 2022). Gradual application of total nitrogen fertilizer have shown good effectiveness for plants (Syafruddin, 2015). The appropriate application of nitrogen fertilizer doses combined with a gradual nitrogen fertilization strategies will enhance nitrogen use efficiency while reducing the risk of nitrogen loss.

The optimization of different nitrogen fertilizer dosages with gradual application has not been reported to date. This research aims to evaluate the nitrogen fertilizer dosage for PEG with gradual application that supports optimal growth and production. The purpose of this research is to evaluate the growth and yield of PEG that has undergone nitrogen fertilizer strategies with different dosages and gradual application.

Materials and Methods

Description of the research implemental

This research was carried out between March and May of 2024 at the Laboratory of Agrostology Field, Nutrition and Feed Technology Department, Animal Science Faculty of IPB University. The materials used included PEG cuttings, $CaMg(CO_3)_2$ (dolomite lime), organic fertilizer (cow's manure), basal fertilizers (SP_{36} and KCl), and treatment fertilizer (urea).

Design of the treatment and experimental

A completely randomized design was used in the study, with 4 levels of urea dosage applied gradually (50% urea dosage at 2 WAP and 50% urea dosage at 6 WAP for each treatment) and each 10 replicates. The treatments were P1 (basal fertilizer + urea fertilizer 100 N kg/ha); P2 (basal fertilizer + urea fertilizer 200 N kg/ha); P3 (basal fertilizer + urea fertilizer 300 N kg/ha); and P4 (basal fertilizer + urea fertilizer 400 N kg/ha). The basal fertilizer consists of cow's manure at 5% of the planting media weight, SP_{36} fertilizer dose 150 kg/ha, and KCl fertilizer dose 150 kg/ha.

Planting, maintenance, and harvesting

The growing medium was air dried soil sieved to a size of 2 mm. The weight of the growing medium was 5 kg per polybag. The soil was incubated with 2 ton/ha of $CaMg(CO_3)_2$ for one week. Then, basal fertilizers were added, including cow's manure, SP36 fertilizer, and KCl fertilizer. The planting material consists of PEG cuttings with two nodes and three internodes. The planting spacing measures is 0.5 m × 0.5 m. Watering was done daily to maintain field capacity moisture levels. Any weeds that grow were manually removed by pulling. Urea fertilizer was applied twice during the maintenance period, at 2 wk after planting (WAP) and 6 WAP. Harvesting of the PEG was done at 8 WAP and leaves and stems were separated to obtain their fresh biomass ratio. The leaves and stems were then dried using a dome dryer for 96 h.

Data collection and measurement

Growth parameters include the quantity of leaves, leaf length, leaf width, height of plant, stem diameter, and quantity of tillers, which were measured weekly. Production parameters include fresh biomass measured at harvest (8 WAP) and dry biomass were measured after drying in an oven for 72 h. The soil acidity (pH) as a planting medium was measured before and after incubation with dolomite lime using a digital pH meter, with a 1:2 soil-to-water ratio that was homogenized and allowed to sit for 30 min, wich was explained by Suwetja (2007). Leaf chlorophyll content was measured using the method which was explained by Waluyo (2016) and stem sugar content was measured using the method which was explained by Cunha *et al.* (2022) at 8 WAP.

Statistical data analysis

An analysis of variance (ANOVA) were used to analysis of the data, followed by Duncan's test for significantly different using SPSS 25 software.

Results and Discussion

Soil acidity levels (pH) as planting medium

Soil acidity (pH) is an indicator of soil fertility that plays an important role in supporting plant growth and production. Neutral soil pH increases cation exchange capacity (CEC) and nutrient availability for plants. The soil acidity of the growing medium is presented in Table 1. According to Hardjowigeno (2015), soil pH determines the availability of nutrients for plants, influences the development and activity of soil microorganisms, and indicates the presence of toxic elements. The ideal soil pH for plant growth ranges from 5.5 to 6.5 (Gondal *et al.,* 2021).

The results showed that the pH status of the media used was very acidic which is characterized by the low pH namely 4.07. The addition of $CaMg(CO_3)_2$ at a dose of 2 tons/ha with incubation for one week effectively increased the soil pH from 4.07 to 5.93 (Table 1). This result indicate that dolomite lime is effective in increasing the pH status of the media. Prihantoro *et al.* (2023) reported that the application of $CaMg(CO_3)_2$ at doses of 1 – 3 ton/ha is safe to use and effectively increases soil pH for forage crop cultivation. Holland *et al.* (2018) reported that liming effectively increases soil fertility, enhances the availability and uptake of nitrogen and phosphorus, and reduces the uptake of toxic heavy metals for plants, which synergistically increases plant productivity.

Table 1. The Soil acidity level (pH) as planting medium

Soil acidity levels (pH)	
Treatments	Average
Before incubation of CaMg $(CO_3)_2$	4.07±0.02
After incubation of CaMg $(CO_3)_2$	5.93±0.06

Leaf growth characteristics of PEG

Leaves are the site of photosynthesis, which supplies energy or food for the plant. Good leaf growth is directly related to plant growth and production. Analysis of variance for leaf growth characteristics such as quantity, length, and their width is presented in Table 2. In general, different nitrogen fertilizer dosages with gradual application significantly ($p<0.05$) affected the quantity of leaves and leaf length of PEG at 8 WAP.

Table 2. The Quantity, length, and width of PEG leaves based on different nitrogen fertilizer dosages

Treatment	Plant Ages (WAP)						
	2	3	4	5	6	7	8
Leaves Quantity							
P1	6.40±1.51	19.20±4.20	37.40±7.16	41.80±9.33	43.60±10.31	46.20±9.20	49.80±10.40^{b}
P2	9.00±2.34	27.20±9.36	53.00±13.34	61.20±15.61	59.60±13.53	60.40±10.71	66.00±10.53^{ab}
P3	8.20±3.11	24.20±9.90	50.80±12.43	58.60±14.27	58.80±12.37	64.00±13.32	68.40±11.08^{a}
P4	8.40±1.34	21.40±6.65	44.20±12.85	51.00±19.20	48.80±11.86	54.80±15.36	66.20±16.08^{ab}
Leaf Length (cm):							
P1	13.53±4.43	19.64±4.77	57.44±6.23^{B}	63.46±5.55^{B}	67.76±4.40^{B}	73.50±4.19	83.20±5.77^{B}
P2	14.70±2.27	21.53±3.29	64.90±4.42^{AB}	71.98±3.93^{A}	72.00±3.48^{AB}	77.80±3.97	87.76±3.43^{AB}
P3	15.15±5.47	23.60±5.65	67.38±6.72^{AB}	75.02±3.47^{A}	77.10±3.15^{A}	82.46±4.74	89.40±5.68^{AB}
P4	13.57±4.58	22.00±2.65	70.06±5.73^{A}	76.10±4.03^{A}	77.70±5.12^{A}	82.10±5.50	93.20±3.27^{A}
Leaf Width (cm):							
P1	1.44±0.27	1.44±0.32	2.42±0.27	2.34±0.45^{b}	2.28±0.48^{B}	2.52±0.48	3.16±0.23
P2	1.53±0.14	1.42±0.13	2.74±0.30	2.80±0.18^{ab}	2.82±0.24^{AB}	3.04±0.29	3.38±0.21
P3	1.58±0.27	1.28±0.27	2.50±0.17	2.70±0.29^{ab}	2.64±0.36^{AB}	2.76±0.32	3.22±0.65
P4	1.58±0.14	1.37±0.12	2.64±0.26	2.86±0.41^{a}	3.08±0.23^{A}	2.94±0.41	3.48±0.32

Note: P1 (basal fertilizer + urea 100 kg/ha), P2 (basal fertilizer + urea 200 kg/ha), P3 (basal fertilizer + urea 300 kg/ha), and P4 (basal fertilizer + urea 400 kg/ha); WAP=Week After Planting; values followed by lowercase letters in the same column indicate significant differences ($p<0.05$); values followed by uppercase letters in the same column indicate very significant differences ($p<0.01$).

Nitrogen fertilizer strategies at a dosage of 300 N kg/ha with gradual application (50% urea dosage at 2 WAP and 50% urea dosage at 6 WAP for each treatment) significantly ($p<0.05$) increased the quantity of leaves of PEG compared to a dosage of 100 N kg/ha and did not different ($p>0.05$) with dosages of 200 and 400 N kg/ha at 8 WAP. This result indicates that the use of a 300 N kg/ha dosage is better for increasing the quantity of PEG leaves compared to a dosage of 100 N kg/ha. The increase in nitrogen levels directly promotes an increase in the quantity of leaves through enhanced protein synthesis, photosynthesis, cell division, and growth hormone synthesis. Arvin (2019) stated that nitrogen is taking part in vegetative growth and plant branching, thereby directly increasing the quantity of leaves produced by the plant.

Similar results showed the effectiveness of increased nitrogen fertilizer dosage with gradual application (50% urea dosage at 2 WAP and 50% urea dosage at 6 WAP for each treatment) on the leaf length of PEG. In general, the addition of nitrogen fertilizer dosage significantly ($p<0.01$) increased the leaf length of PEG from 4 WAP. The treatment with a nitrogen fertilizer dosage of 400 N kg/ha consistently showed better results in increasing leaf length compared to a dosage of 100 N kg/ha until 8 WAP. These results indicate that a nitrogen fertilizer dosage of 400 N kg/ha is better than a dosage of 100 N kg/ha in increasing the leaf length of PEG. Adequate nitrogen nutrients increase leaf length as an indicator of leaf area production through the synergy of photosynthesis, protein synthesis, and growth hormone synthesis processes. Leghari *et al.,* (2016) reported that appropriate nitrogen content enhances leaf area production.

Furthermore, the strategy of different nitrogen fertilizer dosages with gradual application (50% urea dosage at 2 WAP and 50% urea dosage at 6 WAP for each treatment) showed the same results ($p>0.05$) on the leaf width of PEG. These results indicate that the addition of nitrogen fertilizer dosages of 100 – 400 N kg/ha with repeated fertilization is not related to an increase in leaf width but is more related to an increase in the quantity of leaves and leaf length. Mangiring *et al.,* (2017) reported that increasing the use of nitrogen fertilizer doses significantly supports leaf growth of elephant grass.

The chlorophyll content of PEG leaves

Chlorophyll is the green pigment in leaves that captures light as an energy source for plants. The analysis of variance for leaf chlorophyll content is presented in Figure 1. The findings indicate that increasing the level of nitrogen fertilizer dosage produced similar results ($p>0.05$) for the chlorophyll content of PEG leaves. The chlorophyll values from nitrogen fertilizer strategies in PEG ranged from 34.36 to 35.28 SPAD, which is categorized as normal. This indicates that nitrogen fertilizer dosages of 100–400 N kg/ha with gradual application (50% urea dosage at 2 WAP and 50% urea dosage at 6 WAP for each treatment) do not affect the chlorophyll status of PEG leaves. Several studies report that the chlorophyll content in elephant grass is 53.50 (Kang *et al.,* 2012); 36.6 and 38.4 (Ettebeb *et al*., 2020). Lasamadi *et al.* (2017) reported that the use of nitrogen in elephant grass has an optimal limit for increasing chlorophyll content as part of plant metabolism through photosynthesis. Some factors that influence the chlorophyll include cultivar, harvest time, ripening stage, and parts of the plant (Yilmaz and Gokmen, 2016)

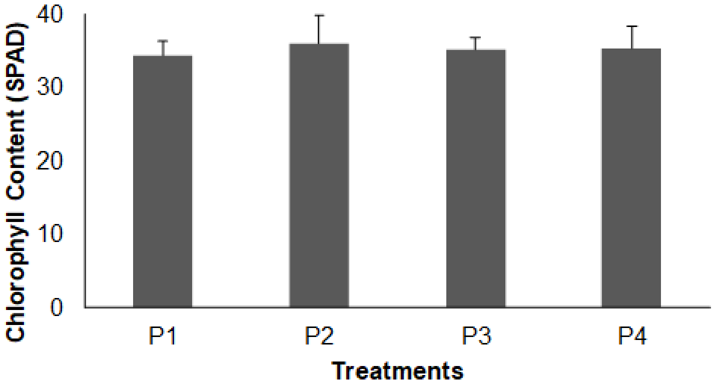

Figure 1. The chlorophyll content of PEG leaves based on different nitrogen fertilizer dosages

Plant height of PEG

Plant height is a part of the vegetative growth indicators that contribute to crop production. An increase in plant height is directly related to an increase in crop yield. The results showed that an increase in nitrogen dosage significantly increased ($p<0.05$) plant height from the beginning to the end of the PEG growing period (3 – 8 WAP) (Table 3). The treatment with a nitrogen fertilizer dosage of 400 N kg/ha significantly ($p<0.05$) produced taller PEG plants compared to the dosage of 100 N kg/ha, and there was no significant difference ($p>0.05$) compared to the dosages of 200 and 300 N kg/ha. This indicates that the strategy nitrogen fertilizer dosage of 400 N kg/ha resulted in taller plants compared to the dosage of 100 N kg/ha. Nitrogen functions in vegetative growth such as leaves and stems through cell division, cell enlargement, and protein synthesis. Leaves are the site of the photosynthesis process that produces energy for plants to grow. The accumulation of leaf addition and energy impacts the increase in plant height growth. A similar report was made by Ebrahim *et al.* (2020) that elephant grass fertilized with increasing doses of nitrogen produced taller plants compared to the control treatment.

Table 3. The plant height of PEG based on different nitrogen fertilizer dosages

Treatment	Plant Ages (WAP)						
	2	3	4	5	6	7	8
	Plant Height (cm)						
P1	39.82±4.53	61.80±6.50^{b}	76.80±9.95^{b}	89.92±11.09^{b}	107.70±13.54^{b}	138.40±14.77^{b}	170.50±13.39^{b}
P2	49.40±7.62	73.96±6.90^{a}	88.28±4.76^{a}	106.74±8.63^{a}	123.64±8.60^{a}	156.10±8.51^{a}	185.00±7.03^{ab}
P3	41.70±8.31	71.10±8.59^{ab}	88.30±7.26^{a}	110.56±7.39^{a}	127.96±12.91^{a}	160.88±9.50^{a}	187.60±9.65^{ab}
P4	42.68±11.13	73.40±9.22^{a}	96.14±8.71^{a}	112.18±8.73^{a}	131.10±7.62^{a}	165.46±11.85^{a}	200.80±18.75^{a}

Note: P1 (basal fertilizer + urea 100 kg/ha), P2 (basal fertilizer + urea 200 kg/ha), P3 (basal fertilizer + urea 300 kg/ha), and P4 (basal fertilizer + urea 400 kg/ha); WAP=Week After Planting; values followed by lowercase letters in the same column indicate significant differences ($p<0.05$).

Stem diameter of PEG

Stem diameter is a commonly measured indicator of vegetative growth. Good stem thickness plays an important role in the growth of leaves and flowers and contributes to biomass production. The results showed that nitrogen fertilizer strategies with dosages of 100–300 N kg/ha with gradual application produced similar stem diameters but significantly increased ($p<0.05$) compared to dosage of 400 N kg/ha at 8 WAP (Table 4). This indicates that gradual application of nirogen fertilizer (50% urea dosage at 2 WAP and 50% urea dosage at 6 WAP for each treatment) at dosages of 100 – 300 N kg/ha meets the developmental needs of PEG stem diameter. The addition of nitrogen dosage at the level of 400 N kg/ha suggests an overdose and shows a tendency to disturb the development of PEG stem diameter. Similar results were reported by Ebrahim *et al.* (2020) indicating that increased nitrogen fertilizer dosages reduced the stem diameter of elephant grass at a cutting height of 7.5 cm. Excessive nitrogen fertilizer alters the structure and carbohydrate content in the stem's internodes, disrupting lignin and cellulose synthesis and leading to a reduced stem diameter (Chen *et al.,* 2018).

Table 4. The stem diameter of PEG based on different nitrogen fertilizer dosages

Treatment	Plant Ages (WAP)						
	2	3	4	5	6	7	8
	Stem Diameter (mm)						
P1	8.09±1.81[b]	9.58±3.34	10.15±2.05	9.78±4.53[b]	13.97±1.94	13.98±1.51[b]	16.59±1.73[ab]
P2	10.91±0.77[a]	9.59±2.21	11.41±2.06	12.39±1.79[ab]	15.71±1.31	15.65±2.18[ab]	17.50±1.06[ab]
P3	11.42±3.00[a]	10.68±2.02	12.03±1.62	15.31±3.17[a]	14.76±1.55	16.64±1.12[a]	18.01±1.84[a]
P4	9.43±1.24[ab]	9.06±1.88	11.75±2.32	11.08±1.43[b]	13.98±1.59	15.43±1.11[ab]	15.69±1.56[b]

Note: P1 (basal fertilizer + urea 100 kg/ha), P2 (basal fertilizer + urea 200 kg/ha), P3 (basal fertilizer + urea 300 kg/ha), and P4 (basal fertilizer + urea 400 kg/ha); WAP=Week After Planting; values followed by lowercase letters in the same column indicate significant differences ($p<0.05$).

The sugar content of PEG stem

The sugar content in plants is related to the effectiveness of photosynthesis, nutrient uptake, and the production of photosynthates. The results showed that increasing the level of nitrogen fertilizer dosage produced similar results ($p>0.05$) for the sugar content in PEG stems (Figure 2). The sugar content values in PEG stems through nitrogen fertilizer strategies ranged from 4.18% to 4.54% Brix, which is categorized as normal. These results indicate that nitrogen fertilizer dosages of 100–400 N kg/ha applied gradually (50% urea dosage at 2 WAP and 50% urea dosage at 6 WAP for each treatment) do not have a negative impact on the sugar content of the stems, suggesting that photosynthesis and PEG growth processes are not disrupted. The normal of sugar content variation in elephant grass germplasm ranges from 4.03% to 6.99% (Cunha *et al.,* 2022).

Table 5. The quantity of tillers of PEG based on different nitrogen fertilizer dosages

Treatment	Plant Ages (WAP)						
	2	3	4	5	6	7	8
	Tillers Quantity						
P1	0±0	2.40±1.51	3.80±1.30	3.80±1.30	3.80±1.30	3.80±1.30	4.00±1.00
P2	0.60±0.54	4.40±2.07	5.60±2.07	5.40±1.14	6.00±1.87	6.00±1.87	6.20±1.64
P3	0.60±0.89	4.20±1.64	5.20±1.78	5.80±1.78	5.80±1.78	5.80±1.78	5.80±1.78
P4	0.40±0.54	2.40±1.51	4.40±2.30	4.40±2.30	4.80±2.16	5.60±1.51	5.80±1.92

Note: P1 (basal fertilizer + urea 100 kg/ha), P2 (basal fertilizer + urea 200 kg/ha), P3 (basal fertilizer + urea 300 kg/ha), and P4 (basal fertilizer + urea 400 kg/ha); WAP=Week After.

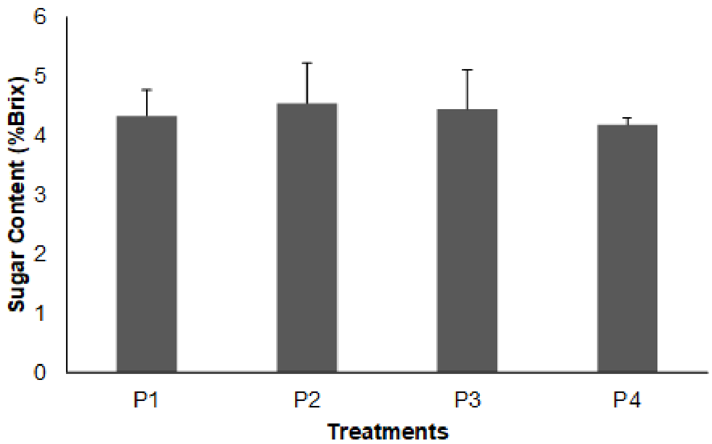

Figure 2. The sugar content of PEG stem based on different nitrogen fertilizer dosages

The impact of nitrogen fertilizer dosage levels on the sugar content of plants in previous studies has been inconsistent, with sorghum being one of the crops frequently studied. Miri and Rana (2014) reported that increasing nitrogen dosages will enhance the sugar content of sorghum; however, research by Almodares *et al.* (2008) indicated that sugar content was not significantly affected by nitrogen fertilizer dosages but was significantly influenced by cultivar type.

Tiller quantity of PEG

The quantity of tillers is a commonly measured indicator of vegetative growth. Plants with a good quantity of tillers contribute to biomass production. The results showed that increasing the level of nitrogen fertilizer dosage with gradual application (50% urea dosage at 2 WAP and 50% urea dosage at 6 WAP for each treatment) did not effect ($p>0.05$) on the quantity of PEG tillers (Table 5). The quantity of tillers produced is normal category. These results indicate that the nitrogen fertilizer dosage is sufficient to support the increase in the quantity of PEG tillers. Nitrogen fertilizer strategies with dosages of 100–400 N kg/ha with gradual application is more related to the increase in the quantity and length of leaves (Table 2) and plant height (Table 3). This is consistent with the statement by Chen *et al.* (2020) that available nitrogen promotes the increase in leaf quantity and vertical plant growth. The effect of nitrogen fertilizer on the number of tillers per plant of elephant grass in previous studies has been inconsistent. Some reports indicate an increase in the number of tillers due to the nitrogen fertilizer rate (Ebrahim *et al.* 2020), while others noted no significant effect (Norsuwan *et al.* 2014).

Fresh biomass, dry biomass, and leaf to stem ratio of PEG

Fresh biomass and dry biomass production of plants represents the accumulated results of vegetative growth (leaves and stems), indicating the harvest yield. Nitrogen fertilizer strategies with dosages of 200 – 400 N kg/ha using the gradual application (50% urea dosage at 2 WAP and 50% urea dosage at 6 WAP for each treatment) significantly ($p<0.01$) increased the fresh and dry biomass production of PEG compared to the 100 N kg/ha dosage at 8 WAP (Table 6). The use of 200 N kg/ha nitrogen dosage resulted in fresh and dry biomass production equivalent to the 400 N kg/ha nitrogen dosage. These results indicate that the 200 N kg/ha dosage is sufficient to meet the nitrogen needs of PEG. Nitrogen is an essential nutrient for plant growth as it plays a role in protein synthesis, enzyme activator for cell division, enhances photosynthesis efficiency, and generates more energy to promote vegetative growth, thereby synergistically increasing biomass production. Fathi (2022) reported that nitrogen influences plant physiology and metabolic processes, and at the right levels, it can enhance plant growth and yield. Similar results were reported by Fauzi *et al.* (2020), indicating that increased nitrogen fertilizer dosages had a significant impact on enhancing both fresh and dry biomass production of elephant grass.

Furthermore, increasing nitrogen dosage should be balanced with other essential nutrients, namely phosphorus (P) and potassium (K), for optimal plant growth. Hardjowigeno (2015) reported that balanced inorganic N-P-K fertilizers need to be available, easily absorbed, and at sufficient levels for ideal plant development. Kusuma (2014) reported that a 16:16:16 N:P:K ratio provides a high response in the growth and production of elephant grass.

The leaf-to-stem ratio indicates the quality of forage related to nutrient status. Nitrogen fertilizer strategies with dosages of 100–400 N kg/ha using the gradual application (50% urea dosage at 2 WAP and 50% urea dosage at 6 WAP for each treatment) did not effect ($p>0.05$) on the leaf-to-stem ratio of PEG (Table 6). These results indicate that different nitrogen fertilizer dosages resulted in similar leaf-to-stem ratio characteristics, supporting PEG plant growth through a greater leaf proportion compared to the stem, with a ratio value of 0.74 – 0.85. Similar results were reported by Alves *et al.* (2022), which indicated that increasing nitrogen fertilizer dosages did not significantly affect the leaf-to-stem ratio of elephant grass. Furthermore, stems play an essential role in supporting the increase in plant height and leaves for optimal growth. Xu *et al.* (2023) confirmed that well-developed stems positively impact crop yield production as they serve as supports, connectors, and transporters of essential plant substances.

Table 6. Fresh biomass production, dry biomass production, and leaf-to-stem ratio of PEG based on different nitrogen fertilizer dosages

Treatment	Fresh Biomass (g)	Dry Biomass (g)	Ratio of leaf : stem
P1	350.28 ± 43.49^B	54.05 ± 8.58^B	0.84±0.04
P2	579.00 ± 43.53^A	83.78 ± 14.62^A	0.85±0.09
P3	613.34 ± 60.29^A	87.12 ± 5.99^A	0.84±0.14
P4	638.98 ± 44.07^A	88.41 ± 10.87^A	0.74±0.07

Note: P1 (basal fertilizer + urea 100 kg/ha), P2 (basal fertilizer + urea 200 kg/ha), P3 (basal fertilizer + urea 300 kg/ha), and P4 (basal fertilizer + urea 400 kg/ha); values followed by lowercase letters in the same column indicate significant differences ($p<0.05$); values followed by uppercase letters in the same column indicate very significant differences ($p<0.01$).

Conclusion

The adding nitrogen fertilizer dosage up to 400 N kg/ha with gradual application, namely 50% urea dosage at 2 WAP and 50% urea dosage at 6 WAP for each treatment is generally safe and feasible for the growth and production of PEG. A nitrogen fertilizer dosage of 200 N kg/ha is optimal for PEG's growth and production.

Conflict of interest

The authors attest that there aren't any disclosed conflicts of interest. Each author has reviewed and given their approval to the manuscript's content.

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Author's contribution

The following are the authors' roles in the paper: The conceptualization and design of the study were aided by FRC, IP, and TT. The data was collected by FRC. The data were analyzed and interpreted by FRC and IP. The draft manuscript was prepared by IP and FRC. After carefully examining the results, all authors approved the manuscript's final draft.

Ethics approval

The research conducted does not pertain to the use of humans or animals in any way.

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