
Growth and Yield Response of Black Rice (*Oryza sativa* L.) to Lamtoro Leaf Liquid Organic Fertilizer and NPK

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Abstract

Rice is the main source of carbohydrates, black rice is a rich source of bioactive compounds. Increasing rice yields can be done by providing organic and inorganic fertilizers. Lamtoro leaves as a liquid organic fertilizer (LOF) contain essential nutrients, as well as NPK. This study aims to evaluate the growth and yield response of black rice to liquid organic fertilizer and NPK. This study used a Randomized Block Design (RBD) with 2 factors, namely LOF of Lamtoro leaves (100 ml/plot, 200 ml/plot, and 300 ml/plot) and NPK Fertilizer (0 g/plant, 1.5 g/plant, 3 g/plant, and 4.5 g/plant). Parameters observed were plant height, chlorophyll leaf, number of tillers per hill, number of productive tillers, number of panicles, grain weight per panicle, 1000 grain weight and root volume. The data analyzed by analysis of variance (ANOVA). The research results showed that liquid organic fertilizer of lamtoro leaves had no significant effect on all parameters of black rice plants. Fertilizer NPK had significant effect on the parameters of plant height and number of tillers per hills, the number of productive tillers and the number of panicles. NPK significantly influenced growth parameters while the liquid organic fertilizer showed no significant effect.

Keywords: Experimental design, growth parameters, *Leucaena leucocephala*, yield components.

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INTRODUCTION

Rice is a vital agricultural commodity that provides carbohydrates for more than half of the world's population and serves as a primary source of income, particularly in Indonesia (Fukagawa & Ziska, 2019). Ensuring the stability and increase of rice production is therefore a major priority, especially as demand continues to rise. In Indonesia, rice productivity averages 5–6 tons per hectare. However, improving productivity while maintaining sustainability remains a significant challenge (Jamilah et al., 2019).

Among the commonly cultivated rice types white, red, and black rice, black rice has gained increasing attention due to its superior nutritional and functional properties. It contains higher anthocyanin levels (19.4–140.8 µg per 100 g) compared to red rice (0.3–1.4 µg per 100 g) (Abdullah, 2017), contributing to its antioxidant capacity and health benefits (Das et al., 2023), such as preventing cancer, aging, and degenerative diseases (Pratama, 2020). Despite its potential as a functional food (Dhankhar & Kaur, 2023), black rice generally has lower productivity than white rice due to its slower growth and smaller grain size (Barus et al., 2023), highlighting the need for improved cultivation strategies.

One approach to enhancing rice productivity sustainably is the application of organic fertilizers, either as substitutes or complements to inorganic fertilizers. Organic fertilizers can improve soil fertility and nutrient availability while reducing environmental impacts (Yulianto, 2017). Previous research has shown that combining liquid organic fertilizers with NPK fertilizer can improve rice growth and yield.

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For instance, Aziez (2022) reported increased productive tillers, canopy dry weight, and grain yield in black rice using liquid organic fertilizer derived from human urine combined with NPK. However, studies focusing on other potential organic sources, such as lamtoro (*Leucaena leucocephala*) leaves, are still limited.

Lamtoro leaves are known to contain high nutrient levels and bioactive compounds (Ningsih et al., 2026), making them a promising source of liquid organic fertilizer. Nevertheless, the effectiveness of lamtoro leaf liquid organic fertilizer, particularly in combination with NPK fertilizer, on black rice growth and yield has not been thoroughly investigated. Therefore, this study addresses this research gap by evaluating the combined application of lamtoro leaf liquid organic fertilizer and NPK fertilizer on black rice. This study aims to evaluate the growth and yield response of black rice to the application of lamtoro leaf-based liquid organic fertilizer in combination with NPK fertilizer.

MATERIALS AND METHODS

Place and Time

This research was carried out at the experimental field at the Faculty of Agriculture, Universitas Muhammadiyah Sumatera Utara, Tuar street No. 56, Medan Amplas, North Sumatera with an altitude of ± 27 meters above sea level, in Maret - July 2020.

Materials and Tools

The materials used were black rice seeds Pringkasap variety, soil, plank, lamtoro leaves, water, brown sugar, rice washing water and EM4 bioactivator, NPK fertilizer 16:16:16, and insecticide.

The tools used in this research were buckets, boards, meters or rulers, hand sprayers, analytical scales, and other tools that support research.

Research Method

This research used a factorial Randomized Block Design (RBD) with 2 factors. The first factor was the liquid organic fertilizer (LOF) of Lamtoro leaves (L), namely: L1 = 100 ml/plot, L2 = 200 ml/plot, L3 = 300 ml/plot. The second factor was NPK Fertilizer (N), namely: N0 = 0 g/plant (control), N1 = 1.5 g/plant, N2 = 3 g/plant, N3 = 4.5 g/plant.

Each treatment was repeated 3 times. The number of experimental plots is 36 plots, the number of plants per plot is 3 plants, the number of buckets per plot is 3 buckets, the number of sample plants per bucket is 1 sample, the total number of sample plants is 108 samples, the distance between experimental plots is 40 cm, and the distance between replicates is 80 cm.

Research Implementation

The research began with making liquid organic fertilizer of lamtoro leaves. Liquid organic fertilizer (LOF) made from lamtoro leaves is produced through a fermentation process using the EM4 bioactivator. The lamtoro leaves are separated from their stems, then placed in a blender and pureed, and finally transferred to a fermentation container. Add $\frac{1}{2}$ kg of white sugar, 4 L of rice washing water, and 1 L of EM4 solution, stir until evenly mixed, then ferment for 14 days. Before application, dilute the mixture to the desired concentration until the volume reaches 500 ml.

Black rice seeds of the Pringkasap variety were planted in a bucket 42 x 21 cm, filled with paddy soil. LOF application is carried out when the plants are three weeks after planting (WAP), at intervals of once every two weeks by spraying them on the leaves using a handsprayer. NPK was given twice into the planting media bucket. Plant maintenance is carried out including insertion, irrigation, pest and disease control is carried out manually using hands and chemically using Regent 50 SC.

The parameters observed were plant height, chlorophyll leaves, number of tillers, number of productive tillers, number of panicles, grain weight per panicle, 1000 grain weight and root volume.

Data Analysis

All the recorded data were analyzed by Analysis of variance (ANOVA). The treatment means were further compared using the Duncan Multiple Range Test (DMRT) at 5%.

RESULTS AND DISCUSSION

Plant Height

The analysis results show that the application of NPK fertilizer had a significant effect on plant height at 6 WAP, while the LOF of lamtoro leaves and the interaction of the two factors had no significant effect on plant height (Table 1).

Table 1. Plant Height of Black Rice under LOF from Lamtoro Leaves and NPK Fertilization

Treatment	Plant Height (cm)			
	2 WAP	4 WAP	6 WAP	8 WAP
LOF of Lamtoro Leaves (L)				
100 ml/plot (L ₁)	34.64	53.74	79.64	97.94
200 ml/plot (L ₂)	34.44	54.15	80.44	100.69
300 ml/plot (L ₃)	34.54	52.72	79.00	97.14
NPK (N)				
0 g/plant (N ₀)	34.69	55.44	70.89c	91.48
1.5 g/plant (N ₁)	35.20	52.44	80.19ab	98.44
3 g/plant (N ₂)	34.37	53.00	83.89a	101.63
4.5 g/plant (N ₃)	33.91	53.26	83.81a	102.81

Note: Values followed by different letters are significantly different according to DMRT at $\alpha = 5\%$

The application of NPK fertilizer resulted in significantly higher plant height than the control (no NPK application). Among the treatments, the highest mean plant height was observed at a rate of 3 g/plant (83.89 cm), which was not significantly different from 4.5 g/plant (83.81 cm) or 1.5 g/plant (80.19 cm). According to Malik (2014), NPK fertilization treatment increases the nutrients available to plants so that they are easily utilized by plants in metabolism which has an impact on increasing growth in plant height.

The significant increase in plant height at 6 WAP in response to NPK fertilization indicates that black rice growth at this stage depends on macronutrient availability, particularly nitrogen, phosphorus, and potassium. Nitrogen supports cell division and elongation through chlorophyll formation and protein synthesis, phosphorus facilitates energy transfer and root development, and potassium regulates enzyme activity and turgor pressure, collectively promoting optimal stem elongation (Marschner, 2012; Taiz et al., 2015). Consistently, higher NPK rates significantly increased rice height during the vegetative phase (Mulyani et al., 2025).

In contrast, the non-significant effect of liquid organic fertilizer (LOF) from lamtoro leaves suggests slow nutrient release, which may not meet plant demand during early to mid-vegetative growth. This aligns with Hartatik et al. (2015), who reported that organic fertilizers gradually supply nutrients and primarily improve soil properties. The absence of a significant LOF \times NPK interaction indicates that NPK alone was sufficient to fulfill nutrient requirements for height development at 6 WAP.

Leaf Chlorophyll

The analysis results show that the application of LOF of lamtoro leaves, NPK and the interaction of the two factors had no significant effect on the leaf chlorophyll (Table 2).

Table 2. Leaf Chlorophyll of Black Rice Under LOF from Lamtoro Leaves and NPK Fertilization

LOF of Lamtoro Leaves	NPK (N)				Mean
	0 g/plant (N ₀)	1.5 g/plant (N ₁)	3 g/plant (N ₂)	4.5 g/plant (N ₃)	
 CCl/mm.....				
100 ml/plot (L ₁)	45.00	51.90	40.13	43.07	45.03
200 ml/plot (L ₂)	44.10	44.87	52.03	49.23	47.56
300 ml/plot (L ₃)	46.00	50.20	51.30	43.03	47.63
Mean	45.03	48.99	47.82	45.11	46.74

The LOF of the lamtoro leaf treatment, NPK and the combination of the two treatments showed no significant difference in leaf chlorophyll of black rice. Chlorophyll is an important indicator for health, evaluate the photosynthetic ability of plants and growth status. According to Putri et al. (2016) levels leaf chlorophyll is related to the condition of the plant, so can be used to determine additional fertilizer required by plants. Chlorophyll measurement is one way that can be used to measure the growth rate and fertility of future plants can be linked to predictions of crop production. Leaf chlorophyll levels are very high related to plant N status.

The absence of significant effects of LOF of lamtoro leaves, NPK fertilization, and their interaction on leaf chlorophyll content indicates that the nitrogen supply across all treatments was sufficient to maintain chlorophyll synthesis in black rice leaves. Chlorophyll content is closely associated with plant nitrogen status because nitrogen is a major constituent of chlorophyll molecules and photosynthetic enzymes (Taiz et al., 2015). When nitrogen availability is above the critical threshold, additional nutrient inputs may not further increase chlorophyll concentration, resulting in relatively stable chlorophyll values among treatments. Similar results were reported by Sitompul & Guritno (2008), who found that variations in fertilizer application did not significantly affect leaf chlorophyll content when plants were grown under non-limiting nitrogen conditions.

Number of Tillers

The analysis results show that the application of NPK fertilizer had a significant effect on the number of tillers at 6 WAP, while the LOF of lamtoro leaves and the interaction of the two factors had no significant effect on the number of tillers (Table 3).

Table 3. Number of Tillers of Black Rice under LOF from Lamtoro Leaves and NPK Fertilization

Treatment	Number of Tillers (tillers)		
	4 WAP	6 WAP	8 WAP
LOF of Lamtoro Leaves (L)			
100 ml/plot (L ₁)	5.72	15.11	20.64
200 ml/plot (L ₂)	6.33	15.25	18.86
300 ml/plot (L ₃)	5.83	14.25	18.64
NPK (N)			
0 g/plant (N ₀)	5.96	11.19c	19.96
1.5 g/plant (N ₁)	6.78	15.89ab	18.78
3 g/plant (N ₂)	5.22	14.78abc	17.85
4.5 g/plant (N ₃)	5.89	17.63a	20.93

Note: Values followed by different letters are significantly different according to DMRT at $\alpha = 5\%$

The application of NPK fertilizer resulted in a significantly higher number of tillers than the control. Among the treatments, the highest mean number of tillers was observed at a rate of 4.5 g/plant (17.63 tillers), which was not significantly different from 1.5 g/plant (15.89 tillers) or 3 g/plant (14.78 tillers), but was significantly higher than the control treatment (11.19 tillers). According to Maulidiya et al. (2015) a large number of tillers will have the potential to produce a large number of productive tillers. The shorter the rice plant, the greater the number of tillers produced so that plant production has the potential to be maximized. Photosynthesis that runs well can potentially produce many tillers.

The significant effect of NPK fertilization on tiller number at 6 WAP indicates that the tillering phase of black rice is highly responsive to adequate nutrient availability, particularly nitrogen. Nitrogen plays a pivotal role in stimulating vegetative growth by enhancing cell division and the development of axillary buds, which directly contributes to tiller formation in rice plants (Marschner, 2012). Phosphorus and potassium further support tillering by improving root development, energy transfer, and carbohydrate translocation, thereby enabling plants to sustain the growth of multiple tillers (Dobermann & Fairhurst, 2000). Similar results were reported by Wang et al. (2017), who observed that increasing NPK rates significantly increased tiller number during the active vegetative stage.

In contrast, the non-significant effect of liquid organic fertilizer (LOF) from lamtoro leaves suggests that nutrient release from organic sources is relatively slow and may not sufficiently meet plant nutrient demand during the active tillering phase. This is in line with Hartatik et al. (2015), who stated that organic

fertilizers release nutrients gradually and mainly contribute to improving soil physical and chemical properties. The absence of a significant LOF × NPK interaction indicates that NPK fertilization alone was sufficient to support tiller formation at 6 WAP under the conditions of this study.

Number of Productive Tillers

The analysis results show that the application of NPK fertilizer had a significant effect on the parameters of the number of productive tillers, while the LOF of lamtoro leaves and the interaction of the two factors had no significant effect on number of productive tillers (Table 4).

Table 4. Number of Productive Tillers of Black Rice under LOF from Lamtoro Leaves and NPK Fertilization

LOF of Lamtoro Leaves	NPK (N)				Mean
	0 g/plant (N ₀)	1.5 g/plant (N ₁)	3 g/plant (N ₂)	4.5 g/plant (N ₃)	
tillers.....				
100 ml/plot (L ₁)	11.11	19.44	16.22	19.56	16.58
200 ml/plot (L ₂)	13.89	15.67	18.22	20.00	16.94
300 ml/plot (L ₃)	12.89	18.44	17.44	16.11	16.22
Mean	12.63c	17.85ab	17.30abc	18.56a	

Note: Values followed by different letters are significantly different according to DMRT at $\alpha = 5\%$

The application of NPK fertilizer resulted in a significantly higher number of productive tillers than the control. Among the treatments, the highest mean number of productive tillers was observed at a rate of 4.5 g/plant (18.56 tillers), which was not significantly different from 1.5 g/plant (17.85 tillers) or 3 g/plant (17.30 tillers), but was significantly higher than the control treatment (12.63 tillers). The increasing the dose of inorganic fertilizer given can increase the availability of N, P, K nutrients so that they can be used by plants for their growth process. Guo et al. (2019) stated that a high availability of nutrient N increases the rate of photosynthesis, but the addition of nutrient P strengthens the plant root system, resulting in the production of many seedlings.

The significant increase in the number of productive tillers in response to NPK fertilization indicates that adequate macronutrient supply plays a crucial role in determining tiller survival and productivity in black rice. Productive tillers are strongly influenced by nitrogen availability, as nitrogen enhances photosynthetic capacity and assimilate production required to support panicle initiation and development (Wang et al., 2017). Phosphorus contributes to early root establishment and energy metabolism, enabling efficient nutrient uptake and improving tiller viability, while potassium enhances carbohydrate translocation and strengthens plant physiological balance, reducing tiller mortality during the reproductive transition (Dobermann & Fairhurst, 2000). Similar findings were reported by Sutardi et al. (2025), who demonstrated that balanced NPK fertilization significantly increased the proportion of productive tillers in rice by improving source-sink relationships.

Number of Panicles

The analysis results show that the application of NPK fertilizer had a significant effect on the number of panicles, while the LOF of lamtoro leaves and the interaction of the two factors had no significant effect on number of panicles (Table 5).

Table 5. Number of Panicles of Black Rice under LOF from Lamtoro Leaves and NPK Fertilization

LOF of Lamtoro Leaves	NPK (N)				Mean
	0 g/plant (N ₀)	1.5 g/plant (N ₁)	3 g/plant (N ₂)	4.5 g/plant (N ₃)	
panicle.....				
100 ml/plot (L ₁)	12.11	20.78	16.44	21.22	17.64
200 ml/plot (L ₂)	15.44	16.22	19.67	21.44	18.19
300 ml/plot (L ₃)	14.22	19.11	18.11	16.56	17.00
Mean	13.93c	18.70ab	18.11abc	19.74a	

Note: Values followed by different letters are significantly different according to DMRT at $\alpha = 5\%$

The application of NPK fertilizer resulted in a significantly higher number of panicles than the control. Among the treatments, the highest mean number of panicles was observed at a rate of 4.5 g/plant (19.74 panicles), which was not significantly different from 1.5 g/plant (18.70 panicles) or 3 g/plant (18.11 panicles), but was significantly higher than the control treatment (13.93 panicles). The capacity of a plant to form specific types of panicles, along with the productivity level of each panicle, plays a crucial role in determining overall plant yield. Panicles that emerge at later stages, such as tertiary panicles, generally make a smaller contribution to total yield (Mohanani & Mini, 2008).

The significant effect of NPK fertilization on the number of panicles indicates that adequate macronutrient availability plays an important role in the successful transition from vegetative to reproductive growth in black rice. Nitrogen is essential for increasing photosynthetic capacity and assimilate production, which support panicle initiation and development, while phosphorus contributes to root growth and energy transfer, enabling efficient nutrient uptake during the reproductive stage. Potassium further supports carbohydrate translocation and enhances physiological efficiency, thereby improving panicle survival and development (Dobermann & Fairhurst, 2000). The increase in panicle number at higher NPK doses suggests that balanced nutrient availability enhances the proportion of productive tillers that successfully form panicles. Similar findings were reported by Mohanani & Mini (2008), who stated that the type and emergence time of rice panicles strongly influence plant productivity, with early-formed panicles contributing more to final yield than later-emerging panicles. In contrast, the non-significant effect of LOF of lamtoro leaves indicates that nutrients released from organic sources are gradual and may not be immediately available in sufficient quantities to influence panicle formation during critical reproductive stages.

Grain Weight per Panicle

The analysis results show that the application of LOF of lamtoro leaves, NPK and the interaction of the two factors had no significant effect on the weight of grain per panicle of black rice plants (Table 6).

Table 6. Grain Weight per Panicle of Black Rice under LOF from Lamtoro Leaves and NPK Fertilization

LOF of Lamtoro Leaves	NPK (N)				Mean
	0 g/plant (N ₀)	1.5 g/plant (N ₁)	3 g/plant (N ₂)	4.5 g/plant (N ₃)	
100 ml/plot (L ₁)	46.47	74.19	62.44	81.19	66.08
200 ml/plot (L ₂)	50.92	54.44	76.16	83.36	66.22
300 ml/plot (L ₃)	46.57	70.19	67.75	59.40	60.98
Mean	47.99	66.27	68.78	74.65	

The LOF of lamtoro leaves treatment, NPK and the combination of the two treatments showed that there was no significant difference in grain weight per panicle in black rice plants. Purwanto et al. (2018) reported that various environmental factors can influence the performance of rice varieties. In highland environments, the flowering period tends to be longer compared to lowland conditions. Additionally, several agronomic traits, including panicle length, yield, and anthocyanin content, show variation when the same variety is cultivated across different growing locations.

The absence of significant effects of LOF of lamtoro leaves, NPK fertilization, and their interaction on grain weight per panicle indicates that this yield component is more strongly governed by genetic characteristics and environmental conditions than by nutrient management alone. Grain weight per panicle is largely determined by the efficiency of assimilate partitioning during the grain-filling stage, which is influenced by temperature, radiation, and duration of the grain-filling period (Jiang et al., 2016). When environmental conditions are relatively uniform and nutrient availability is not limiting, additional fertilizer inputs may increase vegetative growth or panicle number without significantly altering grain weight per panicle. Similar results were reported by Purwanto et al. (2018), who observed that variations in growing environments had a stronger influence on rice yield components, including panicle traits and grain weight, than fertilizer treatments. Furthermore, stable grain weight per panicle across treatments suggests that black rice plants were able to maintain sink capacity during grain filling, possibly due to adequate assimilate supply from photosynthesis.

1000 Grain Weight

The analysis results show that the application of LOF of lamtoro leaves, NPK fertilizer and the interaction of the two factors had no significant effect on 1000 grain weight (Table 7).

Table 7. 1000 Grain Weight of Black Rice under LOF from Lamtoro Leaves and NPK Fertilization

LOF of Lamtoro Leaves	NPK (N)				Mean
	0 g/plant (N ₀)	1.5 g/plant (N ₁)	3 g/plant (N ₂)	4.5 g/plant (N ₃)	
g.....				
100 ml/plot (L ₁)	27.52	27.93	28.60	26.68	27.68
200 ml/plot (L ₂)	29.92	27.19	26.98	28.75	28.21
300 ml/plot (L ₃)	26.96	27.93	27.13	27.07	27.27
Mean	28.13	27.68	27.57	27.50	

The LOF of the lamtoro leaf treatment, NPK and the combination of the two treatments showed that there was no significant difference in 1000 grain weight in black rice plants. 1000-grain weight can be influenced not only by the sink size but also by the degree of grain filling. The weight of 1000 grains is an indicator of the quantity and quality of rice plants (Muyassir, 2012). The weight of the seeds depends on whether or not there is a lot of dry matter contained in the seeds. The dry material in seeds is obtained from photosynthesis which can then be used to fill the seeds (Satria et al., 2017).

The absence of significant effects of LOF of lamtoro leaves, NPK fertilization, and their interaction on 1000-grain weight indicates that grain size and mass in black rice are relatively stable traits that are less responsive to short-term nutrient inputs. The weight of 1000 grains is primarily determined by genetic potential and the effectiveness of the grain-filling process, which depends on assimilate availability, duration of grain filling, and environmental conditions such as temperature and light intensity (Dou et al., 2024). When nutrient availability is sufficient to support normal photosynthesis, additional fertilizer inputs may not further increase grain weight. Similar findings were reported by Muyassir (2012), who stated that 1000-grain weight is a reliable indicator of seed quality but tends to remain stable across fertilizer treatments. Furthermore, Su et al. (2025) explained that seed weight is closely related to the accumulation of dry matter derived from photosynthesis during the grain-filling stage, and when photosynthate supply is not limiting, differences in fertilizer application do not necessarily result in significant variation in grain weight. The stable 1000-grain weight across treatments in this study suggests that black rice plants were able to maintain effective grain filling under all fertilization regimes.

Root Volume

The analysis results show that the application of NPK fertilizer had a significant effect on the root volume. The LOF of lamtoro leaves and the interaction of the two factors had no significant effect on the root volume (Table 8).

Table 8. Root Volume of Black Rice under LOF from Lamtoro Leaves and NPK Fertilization

LOF of Lamtoro Leaves	NPK (N)				Mean
	0 g/plant (N ₀)	1.5 g/plant (N ₁)	3 g/plant (N ₂)	4.5 g/plant (N ₃)	
ml.....				
100 ml/plot (L ₁)	110.00	113.93	110.00	113.93	110.00
200 ml/plot (L ₂)	85.00	113.33	85.00	113.33	85.00
300 ml/plot (L ₃)	76.67	131.67	76.67	131.67	76.67
Mean	90.56d	119.44abc	90.56d	119.44abc	90.56d

Note: Values followed by different letters are significantly different according to DMRT at $\alpha = 5\%$

The application of NPK fertilizer resulted in a significantly higher root volume than the control. Among the treatments, the highest mean root volume was observed at a rate of 3 g/plant (143.33 ml), which was not significantly different from 4.5 g/plant (136.67 ml) or 1.5 g/plant (119.44 ml), but was significantly higher than the control treatment (90.56 ml). It is recommended that NPK fertilizer be given

in the right dose according to the needs of the plant at its growth stages, and can be adjusted to soil conditions and the results of soil analysis (Utami et al., 2018). Application appropriate and regular fertilizer at critical phases of rice plant growth (such as the vegetative and flowering phases) will support an increase in the number of productive tillers and optimal harvest yields.

The significant increase in root volume in response to NPK fertilization indicates that adequate macronutrient availability plays a crucial role in stimulating root growth and development in black rice. Nitrogen supports overall vegetative growth and root proliferation through enhanced cell division, while phosphorus is particularly important for root initiation, elongation, and branching, thereby increasing root volume and improving nutrient and water uptake efficiency (Marschner, 2012). Potassium further contributes to root system development by regulating enzyme activity and osmotic balance, which enhances root metabolic activity and structural stability (Taiz et al., 2015). Similar results were reported by Mulyani et al. (2025), who found that appropriate NPK application significantly increased root growth and improved nutrient absorption in rice plants. In contrast, the non-significant effect of LOF of lamtoro leaves suggests that nutrients released from organic sources are relatively slow and may not be immediately available in sufficient quantities to stimulate root expansion during early and mid-growth stages. The absence of interaction between LOF and NPK further implies that inorganic fertilization alone was sufficient to meet the nutrient requirements for optimal root development under the conditions of this study. Increased root volume is closely associated with improved nutrient acquisition, which may subsequently support greater vegetative growth and yield formation in rice.

CONCLUSION

NPK fertilizer increased black rice growth but did not improve yield, and no differences were observed among NPK levels. Liquid organic fertilizer (LOF) had no effect, and no interaction between treatments was detected.

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