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Proximate Analysis And Growth Performance Of Local Upland Rice (*Oriza Sativa*. L) Treated With Various Doses Of Fish Waste-Secondary Vegetation Bokashi On Marginal Lands Of Small Islands

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Abstract

Rice (*Oryza sativa L.*) is an essential food crop and a primary staple for most Indonesian people. One of the potential rice types that can be developed in small island regions is local upland rice, which is known for its strong adaptability to marginal soils and drought conditions. This study aimed to determine the effect of various doses of fish-waste and secondary-vegetation bokashi on the growth of two local upland rice cultivars, Paewuna (Muna Island) and Wakawondu (Buton Island). The research was conducted in Lupia Village, Kabangka Subdistrict, Muna Regency, from July to October 2025. A factorial randomized block design (RBD) was used, consisting of four bokashi doses: without bokashi (P0), 10 ton ha^{-1}, 20 ton ha^{-1}, and 30 ton ha^{-1}, combined with two cultivars: Wakawondu and Paewuna. Growth parameters observed included plant height, number of tillers, number of leaves, leaf length, and leaf width at 4, 6, and 8 weeks after planting (WAP). The results of the study showed that the application of bokashi had a highly significant effect on plant height and leaf length of local upland rice at 4 and 6 weeks after planting (WAP), and on leaf width at 8 WAP, but had no significant effect on plant height at 8 WAP, tiller number at 4 WAP, and the number of leaves at 4, 6, and 8 WAP. The application of 20 tons ha^{-1} bokashi produced the best plant growth. Furthermore, the effect of cultivar differences showed that the cultivars had a highly significant effect on plant height and leaf length at 4, 6, and 8 WAP, tiller number at 4 WAP, and the number of leaves at 4 and 6 WAP, and a significant effect on tiller number at 6 WAP. The Paewuna cultivar demonstrated superior growth performance compared to the Wakawondu cultivar. Proximate analysis indicated that both Wakawondu and Paewuna cultivars contain high nutritional value, with carbohydrate content ranging from 24-29%, protein 6-8%, fat 1-2%, and crude fiber 8-9%, and are categorized as good for consumption as a community food source.

Keywords: Food, Growth, Local, Rice, Vegetation, Waste

1. Introduction

Food security is a major global issue, particularly in small island regions. Southeast Sulawesi is one of the Indonesian provinces characterized by an extensive archipelagic landscape. According to BPS (2024) the total area of Southeast Sulawesi reaches 36,159.71 km², consisting of 590 islands. Small islands frequently face challenges in meeting food needs due to marginal land conditions, traditional farming systems, and limited application of agricultural technologies.

Rice (*Oryza sativa L.*) is a crop of major importance as the primary food source in Indonesia. According to Rokhmah et al (2022) nearly 95% of Indonesia's population consumes rice as a staple food, making rice not only an agricultural commodity but also a symbol of welfare and food security. National rice production in 2024 reached

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53.14 million tons, while rice production in Southeast Sulawesi amounted to 555.84 thousand tons (BPS, 2024) Of this amount, 76.81% was produced in mainland areas, whereas 23.19% originated from island regions (BPS, 2024).

The type of rice widely cultivated in island ecosystems is local upland rice, which has been traditionally maintained for generations and serves as an important food source for local communities. However, its development is constrained by low soil fertility and limited water availability. Drylands in Southeast Sulawesi are dominated by ultisol soils characterized by high acidity, high iron and aluminium content, low rainfall, and uneven rainfall distribution, which limit planting seasons (Hadania et al., 2019).

Local upland rice possesses strong adaptability to poor soils and drought, and is relatively resistant to pests and diseases (Sarwanto et al., 2018; Afa & Anas, 2021), and cultivated by farmers using an organic system and grown on marginal land without fertilizer input, resulting in low productivity of local upland rice, which only reaches 1–2 tons ha^{-1} (Afa & Anas, 2021) . According to Sitaniapessy (2020), agricultural land resources on small islands are very limited. Small islands are consistently faced with soil erosion problems and the loss of soil fertility. Furthermore, Karolinoerita & Yusuf (2020), in Natalia et al (2023) stated that coastal soils in small islands generally possess unfavorable physical and chemical characteristics for optimal agricultural productivity, such as high salinity, low organic matter content, and limited availability of essential nutrients.

Marginal land is an ecosystem characterized by low nutrient content and suboptimal utilization due to low soil organic matter (Wang et al., 2019). Soil fertility in marginal lands is generally low, marked by acidic soil reaction, low nutrient reserves, low cation exchange capacity (CEC), low base saturation, and high aluminium saturation (Mutammimah et al., 2020).

Dryland soils typically contain low organic matter, resulting in low cation exchange capacity. In humid tropical climates, organic matter decomposition occurs rapidly, accompanied by high nutrient leaching, leading to a continual decline in soil organic matter content (Lidya & Rahmi, 2019; Hinarti et al., 2025).

The application of agricultural technologies utilizing local resources and biodiversity is expected to provide an efficient and sustainable solution. Local resources such as secondary vegetation particularly *Chromolaena odorata* (krinyu), often considered a weed and abundant fish waste have the potential to be processed into organic bokashi fertilizer to improve soil productivity and upland rice production in small island ecosystems. Research by Marpaung (2023) demonstrated that liquid organic fertilizer derived from fish waste significantly affected the number of branches, pods per plant, and filled pods per plant. Application of 105 mL $plant^{-1}$ resulted in the highest number of pods (12.94 pods) and filled pods (8.92 pods). Study Desmanto et al (2024) reported a significant interaction between the concentration and dosage of organic fertilizer derived from fish waste on the growth and yield of mustard plants. In addition, Study Wulandari et al (2022) showed that the application of a combination of bokashi fertilizer from secondary vegetation at a dose of 5 tons/ha was efficient and significantly increased nutrient contribution in dry land, thereby supporting the growth of maize under dry-land conditions.

This study introduces novelty by evaluating various doses of fish-waste bokashi combined with secondary vegetation on the growth performance of local upland rice cultivated in marginal soils of small islands—an area that remains underexplored. The use of fish waste as bokashi offers an environmentally friendly and sustainable organic fertilization alternative, reducing dependence on chemical fertilizers. This study utilizes two local upland rice cultivars, namely Wakawondu and Paewuna, to examine the effects of various doses of fish-waste-based bokashi combined with secondary vegetation on the growth of these two local upland rice cultivars under marginal land conditions. Additionally, this study contributes to the conservation of indigenous upland rice germplasm in small island ecosystems.

2. Material and Methods

2.1. Time and Location

This research was conducted in Lupia Village, Kabangka Subdistrict, Muna Regency, located at the coordinates 4°57′22.18″S and 122°27′57.10″E at an elevation of 43 meters above sea level". The study was carried out from July to October 2025.

2.2. Tools and Materials

The tools used in this study included machetes, hoes, waring nets, scales, measuring tapes, watering cans, buckets, ropes, scissors, plastic bags, treatment labels, and writing instruments. The materials used consisted of local upland rice seeds of the Wakawondu and Paewuna cultivars obtained from farmers in Buton and Muna Islands; fish waste; *Chromolaena odorata* (krinyu); chicken manure; rice husk; sugar; water; EM4; Decis 25EC pesticide; NPK fertilizer (Mutiara); and Furadan 3G

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2.3. Research Method

This study was arranged using a randomized block design (RBD) with a factorial treatment structure and three replications. The first factor was the local upland rice cultivars, consisting of two levels: Wakawondu (V1) and Paewuna (V2). The second factor was the dose of fish-waste + *Chromolaena odorata* bokashi (B), consisting of four levels: P0 = without bokashi, P1 = bokashi at 10 tons ha^{-1}, P2 = bokashi at 20 tons ha^{-1}, P3 = bokashi at 30 tons ha^{-1}. These two factors resulted in 8 treatment combinations, each repeated three times, producing a total of 24 experimental units.

2.4. Research Implementation

Preparation of Bokashi. Bokashi was produced by fermenting *Chromolaena odorata* (krinyu), fish waste, chicken manure, and rice husk at a ratio of 2:1:1:1. After a 21 days fermentation period, the bokashi was considered mature, indicated by its black color, dry texture, and odorless condition. Samples of the bokashi were then analyzed at the UHO Laboratory. **Land Preparation.** The land was first cleared of grasses and other vegetation. Soil tillage was conducted using a hoe to a depth of ±20 cm, followed by loosening the soil. A total of 24 plots were prepared, each measuring 1 m × 2 m. The spacing between plots within a block was 30 cm, and the spacing between blocks was 50 cm. **Planting.** Planting was done by making planting holes 2 cm deep using a dibble. Five seeds were placed in each hole with a spacing of 25 cm × 25 cm, after which the holes were covered with soil. **Fertilization.** The bokashi (fish waste + *Chromolaena odorata*) was applied according to the treatment doses, once, one week before planting, by evenly broadcasting it across each plot and mixing it with the soil. In addition, NPK fertilizer (Mutiara) was applied once at 4 WAP at a dose of 300 kg ha^{-1}. **Maintenance.** Maintenance of the upland rice included: Weeding, which was carried out to remove weeds around the plants to prevent competition, Pest and disease control, performed using Decis 25EC pesticide. **Observations.** Observations consisted of: Laboratory Analysis Proximate analysis of local upland rice grains, including: carbohydrate content,protein content,fat content, crude fiber content. Plant Growth Observations. Growth observations began at 4 week after planting (WAP) and included: Plant height, measured from the soil surface to the tip of the highest panicle, leaf length, measured from the leaf collar to the leaf tip on the uppermost leaf,Leaf width, measured at the widest part of the leaf, number of tillers, counted per plant clump, Number of leaves, counted on each plant clump. Data analisis. Growth data were analyzed using analysis of variance (ANOVA) at the 5% significance level. If a significant effect was found, the Duncan Multiple Range Test (DMRT) at the 5% level was used to compare treatment means (Steel & Torrie, 1991). For more details, see Figure 1.

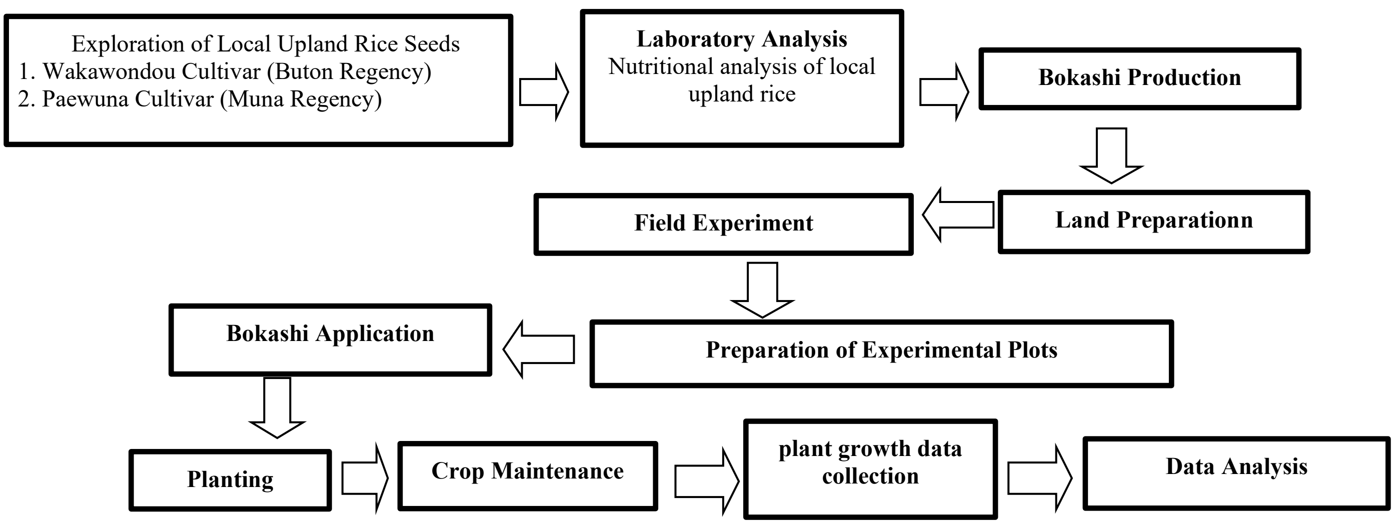

Figure 1. Research flow diagram

3. Results and Discussion

The exploration of local upland rice in Muna Island and Buton Island, Southeast Sulawesi, identified two cultivars, namely the Paewuna cultivar from Muna Island and the Wakawondu cultivar from Buton Island. Both upland rice cultivars are presented in the Figure 2.

3.1. Proximate Analysis

Proximate analysis is a fundamental method used to determine the chemical composition of food materials. In this study, proximate analysis was conducted to determine the main nutritional components of local upland rice from the Wakawondu and Paewuna cultivars, including carbohydrate, protein, fat, and crude fiber content. The results of the nutritional analysis for the Paewuna and Wakawondu upland rice cultivars are presented in the Table 1.

The laboratory analysis of the nutritional content of local upland rice showed that the Paewuna cultivar contained 28.35% carbohydrates, 7.33% protein, 1.18% fat, and 9.01% crude fiber. Meanwhile, the Wakawondu cultivar contained 24.88% carbohydrates, 6.39% protein, 1.30% fat, and 8.56% crude fiber. Carbohydrates were the dominant component, followed by protein and relatively low fat content.

Carbohydrates are the main nutritional component in rice. The results presented in Table 1 indicate that the local upland rice cultivars exhibited their highest values in carbohydrate content. The Paewuna cultivar contained 28.35% carbohydrates, while the Wakawondu cultivar contained 24.88%. According to Fitriyah et al (2020), most carbohydrate components in rice are starch, reaching approximately 85–90%. Rice starch consists of two components, amylose and amylopectin. Rice with higher amylose content produces cooked rice with a dry, non-sticky texture that expands and becomes firm when cooled. Conversely, high amylopectin content results in sticky, non-expanded rice that remains clumped after cooling.

Paewuna variety (Local upland rice from Muna Island) Wakawondu variety (local upland rice from Buton Island)

Figure 2. Two local highland rice varieties on Muna Island and Buton Island, Southeast Sulawesi

Table 1. Laboratory Test Results of Nutritional Content of Local Upland Rice

Cultivars	Parameter	Satuan	unit	Method
Paewuna	carbohydrate	%	28,35	SNI : 0l-2891-1992
	Protein	%	7,33	SNI : 01-2354.4-2006
	Fat	%	1,18	SNI : 01-2891-1992
	crude fiber	%	9,01	SNI : 01-2891-1992
Wakawondu	carbohydrate	%	24,88	SNI : 01-2891-1992
	Protein	%	6,39	SNI : 01-2354.4-2006
	Fat	%	1,30	SNI : 01-2891-1992
	crude fiber	%	8,56	SNI : 01-2891-1992

Note: The proximate analysis was carried out at the Analytical Laboratory of Halu Oleo University, Kendari, using two samples and four analytical parameters

Protein plays an essential role in cell formation, tissue repair, and metabolic processes. Protein, amylose, and lipid contents contribute to the flavor characteristics of rice Fitriyah et al (2020); Rusdin et al (2023). Table 1 shows that the Wakawondu cultivar contains 6.39% protein, while the Paewuna cultivar contains 7.33%. These values indicate that the local upland rice cultivars possess relatively good nutritional potential and fall within the standard protein requirement for rice, which is around 7%. However, Juliano (2016) in Fahroji et al (2025) reported that rice protein content averages around 7%, which is considered low compared to other cereals. Juliano (1993) also stated that rice protein content ranges between 6–8%, placing both cultivars within the medium category. Protein is a primary component in cell formation, repair, and metabolic function. Generally, the levels of protein, amylose, and lipids determine rice flavor. Rice with good eating quality typically contains less than 7% protein and 15.5–16.5% moisture (Fitriyah et al., 2020).

The fat content of the Wakawondu and Paewuna cultivars is categorized as moderate, with values of 1.30% and 1.18%, respectively. These upland rice cultivars can therefore be classified as moderate-energy and low-fat food sources, making them suitable for populations requiring complex energy sources with minimal cholesterol. Low fat content also indicates that the rice is less prone to rancidity, odor development, and deterioration during storage (G. A. Ramadhani et al., 2012); (Rusdin et al., 2023). Fat content in rice may be influenced by cultivar differences, grain maturity levels, cultivation conditions, storage, and extraction methods. Variations in fat content among local rice cultivars generally do not show significant differences due to cultivation practices (Pangerang & Rusyanti, 2018).

Comparison between samples shows that the Paewuna cultivar has a higher crude fiber content (9.01%) compared with Wakawondu (8.56%). According to Almatsier, (2010), high crude fiber content (8–9%) provides physiological benefits for digestion and reduces the risk of degenerative diseases. Rimbawan & Siagian (2004); Pangerang & Rusyanti (2018) reported that dietary fiber influences blood glucose levels. Soluble fiber significantly lowers the glycemic response of food, whereas insoluble fiber increases bulk density in the digestive tract, slowing food passage and reducing enzyme activity, thereby lengthening the digestion process.

Fiber content in rice is influenced by cultivar characteristics, water solubility, and milling processes. Fiber content is higher in the bran layer than in the endosperm; therefore, polishing reduces the fiber content in rice (Fernando, 2013; Fahroji et al., 2025).

According to Murdifin et al (2015); Nashrurrokhman et al (2019), variations in taste, color, physicochemical properties, and nutrient composition of rice depend on the climatic and geographical conditions where the cultivar is grown. Each rice cultivar has distinct physicochemical characteristics and proximate compositions (moisture, total energy, protein, carbohydrate, and fat (Thomas et al., 2013; Nashrurrokhman et al., 2019). The primary metabolites and phytochemical content of plants are regulated by genetic factors and environmental conditions (Samyuni & Supriyadi, 2015; Caretto et al., 2015; Nashrurrokhman, et.al., 2019).

3.2. Plant Growth

The summary of the analysis of variance (ANOVA) results for the growth of local upland rice of the Paewuna and Wakawondu cultivars under various bokashi doses at 4, 6, and 8 weeks after planting (WAP) is presented in the following table:

Table 2. Summary of variance analysis results on the effect of different bokashi doses on local upland rice cultivars Paewuna and Wakawondu

No	Observed Variables		Hasil Uji F			
			Treatment	Dose bokashi	Kultivar Rice	Interaction
1	**Plant Height (Cm)**					
	a	At 4 WAP	**	**	**	tn
	b	At 6 WAP	**	**	**	tn
	c	At 8 WAP	**	*	**	tn
2	**Number of tillers (stems)**					
	a	At 4 WAP	*	*	**	*
	b	At 6 WAP	tn	tn	*	tn
	c	At 8 WAP	tn	tn	tn	tn
3	**Number of Leaves (Leaves)**					
	a	At 4 WAP	**	*	**	tn
	b	At 6 WAP	**	*	**	tn
	c	At 8 WAP	*	*	tn	tn
4	**Leaf Lenght (cm)**					
	a	At 4 WAP	**	**	**	tn
	b	At 6 WAP	**	**	**	tn
	c	At 8 WAP	*	tn	**	tn
5	**Leaf Width (Cm)**					
	a	At 4 WAP	tn	tn	tn	tn
	b	At 6 WAP	tn	tn	tn	tn
	c	At 8 WAP	*	**	tn	tn

Note: ** = Highly significant effect. * = Significant effect. tn = Non-significant effect. The F-test was conducted at a 5% significance level. This study used a factorial Randomized Block Design (RBD) consisting of two factors. The first factor consisted of two treatment levels, and the second factor consisted of four treatment levels with three replications. Thus this study comprised 24 experimental units. Each experimental unit consisted of 32 plants per plot, with 5 of them used as samples.

3.3. Plant Height

The analysis of variance results for plant height of local upland rice showed that the application of various bokashi doses had a highly significant effect on plant height at 4 WAP and 6 WAP, and a significant effect at 8 WAP. Meanwhile, the local upland rice cultivars exhibited a highly significant effect on plant height at 4 WAP, 6 WAP, and 8 WAP. The results of the DMRT 0.05 test for the effects of different bokashi doses and the two upland rice cultivars on plant height at 4, 6, and 8 WAP are presented in Tables 2 and 3.

Table 3 shows that the average rice plant height at 4 Weeks After Planting (WAP) was highest in the bokashi treatment at a dose of 30 tons ha^{-1}, reaching 39.10 cm. This value was significantly different from the 10 tons ha^{-1} treatment and the control (without bokashi), but not significantly different from the 20 tons ha^{-1} treatment. At 6 WAP, the highest average plant height was observed in the bokashi treatment at a dose of 20 tons ha^{-1}, reaching 76.50 cm, which was significantly different from the 10 tons ha^{-1} treatment and the control, but not significantly different from the 30 tons ha^{-1} treatment. At 8 WAP, the highest average plant height was in the bokashi treatment at a dose of 30 tons ha^{-1}, reaching 97.36 cm. This value was significantly different from the control but not from the 20 tons ha^{-1} and 10 tons ha^{-1} treatments.

Table 3. Average Rice Plant Height (cm) at 4 WAP, 6 WAP and 8 WAP under Various Bokashi Doses

Dose bokashi	Plant Height	DMRT 0.05	Plant Height	DMRT 0.05	Plant Height	DMRT 0.05
	At 4 WAP		At 6 WAP		At 8 WAP	
Without bokashi	31,45±3,31b	2 = 6,91	65,91±2,24b		88,56±3,36b	
Bokashi 10 tons ha⁻¹	32,89±1,22b	3 = 7,25	66,42±2,47b	2 = 8 ,42	91,31±3,44a	2 = 10,00
Bokashi 20 tons ha⁻¹	38,97±2,65a	4 = 7,44	76,50±3,14ab	3 = 8,87	97,36±2,80a	3 = 10,51
Bokashi 30 tons ha⁻¹	39,10±3,01a		70,70±2,64a	4 = 9,10	97,13±3,54a	4 = 10,78

Note: Numbers followed by different letters indicate significant differences based on the DMRT test at a 95% confidence level. this study with three replications, comprised 24 experimental units. Each experimental unit consisted of 32 plants per plot, with 5 of them used as samples.

Plant height is a variable that reflects vegetative growth activity, where increases in height are related to cell division in the plant. The Duncan test results (Table 3) indicate that the 30 tons ha⁻¹ bokashi treatment at 4 WAP promoted better plant height growth, whereas at 6 WAP and 8 WAP, the 20 tons ha⁻¹ dose resulted in better growth. This is likely because, at 4 WAP, bokashi had not fully decomposed, so a higher dose was still needed, whereas at 6 WAP and 8 WAP, the bokashi had decomposed fully and could be more easily absorbed by the plant, requiring a lower dose than at the early growth stage. According to Perteka et al (2020); Garfansa et al (2023), bokashi is initially more difficult for plants to digest due to its complex binding. However, in the long term, plants can readily absorb the nutrients.

Furthermore, it is suggested that at 6 WAP and 8 WAP, the 20 tons ha⁻¹ bokashi treatment was able to maintain nutrient availability, whereas the 30 tons ha⁻¹ treatment did not result in additional growth, possibly because the soil had reached organic matter saturation, making nutrient uptake less efficient. According to Santoso (1998); Fitriany & Abidin (2020), bokashi benefits soil fertility by improving soil properties (physical, chemical, and biological), and it accelerates and facilitates nitrogen absorption by plants. Hapsari & Welasi (2013); Lepongbulan et al (2017), state that, in general, fish waste contains many nutrients, including nitrogen (N), phosphorus (P), and potassium (K), which are components of organic fertilizers. In addition, Adlin et al (2024) stated that krinyuh bokashi not only provides nutrients such as N, P, and K to plants but also contains organic matter that plays a role in improving soil properties. Nitrogen (N) is especially required in large amounts during all growth stages, particularly during the vegetative phase such as stem and leaf development. Nitrogen in organic manure can stimulate plants in the formation of amino acids into proteins (Aldin, 2021; Hinarti et al., 2025). The proteins formed are used to produce growth hormones, namely auxins, gibberellins, and cytokinins. Gibberellins increase metabolic activity and photosynthesis rates (Nurjanah et al., 2020; Hinarti et al., 2025). The resulting carbohydrates also increase, further improving root, stem, and leaf growth, thereby optimizing plant height.

Table 4. Average plant height of rice (cm) at 4 WAP, 6 WAP, and 8 WAP for various local upland rice cultivars.

Local Upland Rice Cultivars	Plant height	DMRT 0.05	Plant height	DMRT 0.05	Plant height	DMRT 0.05
	At 4 WAP		At 6 WAP		At 8 WAP	
Wakawondu	30,98±1,94b	2 = 6,91	65,61±2,07b	2 = 8 ,42	87,81±2,08b	2 = 10,00
Paewuna	40,22±2,76a		74,65±3,03a		99,39±2,43a	

Note: Numbers followed by different letters indicate significant differences based on the DMRT test at a 95% confidence level. this study with three replications, comprised 24 experimental units. Each experimental unit consisted of 32 plants per plot, with 5 of them used as samples.

The DMRT 0.05% test results showed that the local upland rice cultivar Paewuna produced taller plants compared to the Wakawondu cultivar. Plant height is a characteristic of rice influenced by the plant's internal genetic makeup (Erlianus et al., 2021). According to Mulyaningsih & Indrayani, (2014); Wijayanto et al (2024), variations in plant height result in different appearances because they are influenced by the plant's genetic factors, where each genotype has its own advantages. Therefore, genetic differences lead to variations in expressed traits. Differences in plant height among rice varieties are also affected by environmental factors such as nutrient availability. This aligns with the view of Marpaung & Ratmini, (2014); Mafaza et al (2018), stating that plant height is determined by the plant's genetic traits and its adaptation to the environment. Variation in plant height is influenced by the genotype used, as each genotype has different genetic properties and nutrient uptake abilities, resulting in diverse heights.

3.4. Number of tillers

The analysis of variance results showed that there was a significant interaction effect between bokashi dose treatments and local upland rice cultivars, Paewuan and Wakawondu, on the number of tillers at 4 WAP. Meanwhile, the treatment of different local upland rice cultivars had a highly significant effect on the number of tillers at 6 WAP. The DMRT 0.05% test results for the interaction between bokashi dose and the local upland rice cultivars Paewuan and Wakawondu at 4 WAP are presented in the following table.

Table 5. Average number of tillers (stems) of rice plants at 4 WAP, in the interaction between various Bokashi doses and local upland rice cultivars

Local Upland Rice Cultivars	Dose Bokashi				DMRT 0,05
	Without Bokashi	Bokasi 10 tons ha^{-1}.	Bokashi 20 tons ha^{-1}.	Bokashi 30 tons ha^{-1}.	
Wakawondu	4,22±0,11c	6,44±0,29b	6,11±0,78b	6,11±0,11b	2 = 1,53
	r	q	q	q	3 = 1,67
Paewuna	6,34±0,66b	6,15±0,59b	8,67±0,66a	6,33±0,39b	4 = 1,78
	q	q	p	q	

Note: Numbers followed by different letters indicate significant differences based on the DMRT test at a 95% confidence level. this study with three replications, comprised 24 experimental units. Each experimental unit consisted of 32 plants per plot, with 5 of them used as samples.

The results of the DMRT 0.05% test (Table 5) showed that the Wakawondu cultivar had the highest average number of tillers in the treatment with 10 tons ha^{-1} of bokashi, which amounted to 6.44 tillers, but it was not significantly different from the treatments with 20 tons ha^{-1} and 30 tons ha^{-1}. The lowest average number of tillers was observed in the treatment without bokashi, which was 4.22 tillers. For the Paewuna cultivar, the highest average number of tillers was observed in the treatment with 20 tons ha^{-1} of bokashi, which was significantly different from the treatments without bokashi, 10 tons ha^{-1}, and 30 tons ha^{-1}. Overall, the interaction between bokashi dose and local upland rice cultivars showed that the highest average number of tillers occurred in the Paewuna cultivar at 20 tons ha^{-1}, amounting to 8.67 tillers, while the lowest average number of tillers was in the Wakawondu cultivar without bokashi, at 4.22 tillers.

The number of tillers is a commonly used indicator of plant growth; the higher the total number of tillers, the greater the likelihood of more productive tillers and higher yield levels (Wijayanto et al., 2024). The DMRT 0.05% test (Table 5) indicated that the highest number of tillers was produced by the Paewuna cultivar at a dose of 20 tons ha^{-1} of bokashi. This is suspected to be due to genetic differences between the Paewuna and Wakawondu cultivars and their differential responses to various bokashi doses and soil fertility improvement. These results indicate that the Paewuna cultivar responds better in utilizing nutrients from bokashi compared to the Wakawondu cultivar.

Rice phenotypes are influenced by both genetic and environmental factors (Wu et al., 2024; Chen et al., 2024; Ahmad et al., 2024). According to Lingga (1993), each plant variety has a different capacity to absorb nutrients. Varieties capable of absorbing more nutrients will enhance the synthesis of organic compounds such as fats and proteins. According to Darliah et al (2001), a plant's nutrient absorption ability is influenced by the variety planted. According to Kamarani et al (2022), genetic factors in each upland rice variety affect the morphological characteristics of rice plants during growth. This is consistent with the findings of Sasaki et al (2010) which showed that rice growth, particularly tiller number, is influenced by genotypic differences.

Table 6. Average Number of Tillers (stems) of Upland Rice Plants at 6 Weeks After Planting (WAP) in Various Local Upland Rice Cultivars

Local Upland Rice Cultivars	Number of Tillers	DMRT 0.05
	At 6 WAP	
Wakawondu	12,28±1,57a	2 = 4,46
Paewuna	15,08±0,50a	

Note: Numbers followed by different letters indicate significant differences based on the DMRT test at a 95% confidence level. this study with three replications, comprised 24 experimental units. Each experimental unit consisted of 32 plants per plot, with 5 of them used as samples.

The differences in tiller number indicate the ability of a variety to grow according to its genetic potential in various environments (Asis, *et al.,* 2021). The results of the DMRT 0.05% test (Table 6) showed that the highest average number of tillers at 6 WAT was produced by the Paewuna cultivar, with 15.08 tillers, which was higher than the Wakawondu cultivar. This suggests that the number of tillers is influenced by varietal differences. According to Sasmita, *et al.,* (2020) in Sanjaya, M.F., *et al*., (2023), the local upland rice cultivar Paewuna has a higher number of productive tillers compared to the tested local Sultra upland rice cultivar. Plants generally produce responses in line with the growth and generative development of the plant (Wang et al., 2019). Plant growth and development are influenced by genetic factors, and varietal differences are one of the factors causing diversity in plant appearance due to different genetic factors (Lakitan, 2007; Chrismadha et al., 2007; Muhtadin & Latifah, 2018).

3.5. Number of Leaves

The analysis of variance on the number of leaves of local upland rice showed that treatment with various doses of bokashi had a significant effect on the number of leaves at 4 WAP, 6 WAP, and 8 WAP. Meanwhile, the treatment with different local upland rice cultivars had a highly significant effect on the number of leaves at 4 and 6 WAP but had no significant effect at 8 WAP. The results of the DMRT 0.05% test on the number of leaves of local upland rice under various bokashi doses at 4, 6, and 8 WAP, and on different local upland rice cultivars at 6 WAP, are presented in the following table:

Table 7. Average Number of Rice Leaves (leaves) at 4 WAP, 6 WAP, and 8 WAP under Various Bokashi Dosages

Dosis bokashi	Number of Leaves 4 WAP	DMRT 0.05	Number of Leaves 6 WAP	DMRT 0.05	Number of Leaves 8 WAP	DMRT 0.05
Without bokashi	16,89±1,87b	2 = 6,10	37,90±9,40a		68,72 ±5,99 b	
Bokashi 10 tons ha⁻¹	19,29±0,80ab	3 = 7,33	50,45±3,00a	2 = 14,90	84,22±5,83b	2 = 12,99
Bokashi 20 tons ha⁻¹	22,45±1,91a	4 = 8,15	49,22±3,78a	3 = 18,20	88,11±3,90a	3 = 13,82
Bokashi 30 tons ha⁻¹	20,34±1,22ab		50,59±4,39a	4 = 20,20	86,33±6,95b	4 = 14,46

Note: Numbers followed by different letters indicate significant differences based on the DMRT test at a 95% confidence level. this study with three replications, comprised 24 experimental units. Each experimental unit consisted of 32 plants per plot, with 5 of them used as samples.

The number of leaves is also a frequently used measure as a growth indicator, because leaves function as the main organ in the photosynthesis process in plants. Leaves can store carbohydrates that will be distributed to the panicles and other tissues/organs (Parman, 2007; Wijayanto et al., 2024).

The DMRT 0.05 test results (Table 7) showed that the highest average number of leaves in local upland rice at 4 WAP was found in the treatment with bokashi at a dose of 20 tons ha⁻¹, with 20.34 leaves, which was significantly different from the treatment without bokashi but not significantly different from bokashi at 10 tons ha⁻¹ and 30 tons ha⁻¹. In local upland rice at 6 WAP, the highest average number of leaves was observed in the treatment with bokashi at 30 tons ha⁻¹, with 50.59 leaves, and was not significantly different from the treatments without bokashi, bokashi at 10 tons ha⁻¹, and bokashi at 30 tons ha⁻¹. Meanwhile, at 8 WAP, the highest average number of leaves was found in the treatment with bokashi at 20 tons ha⁻¹, with 88.11 leaves, which was significantly different from treatments without bokashi, bokashi at 10 tons ha⁻¹, and bokashi at 30 tons ha⁻¹.

This is further supported by Ashlihah et al (2020), who stated that the availability of nutrients in the soil, especially nitrogen (N), can affect leaf area and the number of leaves in plants. (Sipayung et al., 2017; Garfansa et al., 2023) stated that bokashi contains micronutrients such as Ca, Mg, B, and S, as well as macronutrients such as N, P, and K. This indicates that the application of organic fish fertilizer can improve soil properties, thus benefiting plant growth. This aligns with the opinion of Mutryarny et al (2014), who stated that organic fertilizers can increase the proliferation of soil microorganisms that actively decompose and release nutrients during the humification process, which in turn aggregates soil particles, improving water retention and making the growth medium more favorable for plant development.

Table 8. Average Number of Rice Leaves (blades) at 4 WAP and 6 WAP in Various Local Upland Rice Cultivars.

Local Upland Rice Cultivars	Number of Leaves 4 WAP	DMRT 0.05	Number of Leaves 6 WAP	DMRT 0.05
Wakawondu	17,36±0,86b	2 = 4,13	42,00±4,50a	2 = 10,30
Paewuna	22,11±1,15a		52,28±1,73a	

Note: Numbers followed by different letters indicate significant differences based on the DMRT test at a 95% confidence level. this study with three replications, comprised 24 experimental units. Each experimental unit consisted of 32 plants per plot, with 5 of them used as samples

The DMRT 0.05% test results (Table 8) show that the average number of leaves of local upland rice on the Paewuna and Wakawondu cultivars indicates that at 4 and 6 WAP, the highest number of leaves was found in the Paewuna cultivar, with 22.11 and 52.28 leaves, respectively, compared to the Wakawondu cultivar, which had 17.36 and 42.00 leaves. It is suspected that the difference in leaf number between the Paewuna and Wakawondu cultivars is due to genetic factors of the two local upland rice cultivars. This aligns with what was stated by Rahayu & Harjoso (2011); Wijayanto et al (2024), that the difference in leaf number in each plant is greatly influenced by the genotype of each plant, as each genotype has different genetic traits. According to Parman (2007); Wijayanto et al (2024), the greater the number of leaves, the more assimilates are expected to be produced, which also reflects a higher number of tillers, thereby potentially increasing rice crop yield.

3.6. Leaf Lenght

The analysis of variance on leaf length of local upland rice showed that the application of different doses of bokashi had a highly significant effect on leaf length at 4 WAP and 6 WAP. Meanwhile, the treatment of various local upland rice cultivars had a highly significant effect on leaf length at 4 WAP, 6 WAP, and 8 WAP.

The results of the DMRT 0.05% test for leaf length observations of local upland rice under different bokashi doses at 4 WAP and 6 WAP, and for various local upland rice cultivars at 4 WAP, 6 WAP, and 8 WAP, are presented in the following table.

Table 9. Average Leaf Length of Rice Plants (cm) at 4 WAP and 6 WAP under Various Bokashi Fertilizer Doses

Dose Bokashi	Leaf Length 4 WAP	DMRT 0.05	Leaf Length 6 Wap	DMRT 0.05
Without bokashi	23,36±3,59b	2 = 3,11 3 = 3,79 4 = 4,39	46,70±1,29b	
Bokashi 10 tons ha⁻¹	22,52±0,09b		47,02±1,67ab	2 = 3,74
Bokashi 20 tons ha⁻¹	27,80±3,10a		53,59±1,97a	3 = 4,56
Bokashi 30 tons ha⁻¹	27,21±4,27a		50,05±2,15ab	4 = 5,07

Note: Numbers followed by different letters indicate significant differences based on the DMRT test at a 95% confidence level. this study with three replications, comprised 24 experimental units. Each experimental unit consisted of 32 plants per plot, with 5 of them used as samples

The results of the DMRT 0.05 test (Table 9) showed that the average leaf length of local upland rice at 4 WAP was highest in the treatment with bokashi at a dose of 20 tons ha^{-1}, measuring 27.80 cm. This was significantly different from the treatment without bokashi and bokashi at a dose of 10 tons ha^{-1}, but not significantly different from bokashi at a dose of 30 tons ha^{-1}. at 6 WAP, the average leaf length of local upland rice was highest in the treatment with bokashi at a dose of 20 tons ha^{-1}, measuring 53.59 cm, significantly different from the treatment without bokashi and also significantly different from bokashi at doses of 10 tons ha^{-1} and 30 tons ha^{-1}.

This condition indicates that the 20 tons ha^{-1} dose provides sufficient nutrients for growth, resulting in increased leaf length. According to (Sitompul & Guritno, 2016; Hinarti, 2025), plants undergo active vegetative growth when nutrients in the soil are available and can be utilized by the plants. Plants require nutrients for metabolism, especially during vegetative growth. Moreover, sufficient nutrients during growth will enhance the rate of photosynthesis. This is supported by (Gardner & Mitchell, 1991; Hinarti, 2025), who stated that adequate nutrition allows both young and old leaves to meet their nutrient requirements, whereas limited nutrients are often allocated to young leaves, reducing the photosynthesis rate in older leaves. With sufficient nutrients, plant organs develop optimally, and the amount of photosynthate produced increases, ultimately enhancing crop yield.

Table 10. Average Leaf Length (cm) of Upland Rice Plants at 4 WAP, 6 WAP, and 8 WAP Across Various Local Upland Rice Types.

Local Upland Rice Cultivars	Leaf Length 4 WAP	DMRT 0.05	Leaf Length 6 WAP	DMRT 0.05	Leaf Length 8 WAP	DMRT 0.05
Wakawondu	22,47±1,02b	2 = 2,18	46,38±1,06b	2 = 2,65	57,99±b	2 = 3,84
Paewuna	28,98±2,05a		52,30±1,28a		64,74±a	

Note: Numbers followed by different letters indicate significant differences based on the DMRT test at a 95% confidence level. this study with three replications, comprised 24 experimental units. Each experimental unit consisted of 32 plants per plot, with 5 of them used as samples.

The results of the DMRT 0.05% test (Table 10) show that the average leaf length of local upland rice cultivars Paewuna and Wakawondu indicates that at 4 WAP, 6 WAP, and 8 WAP, the longest leaf length was observed in the Paewuna cultivar, measuring 28.98 cm, 52.30 cm, and 64.74 cm, respectively, compared to the Wakawondu cultivar, which measured 22.47 cm, 46.38 cm, and 57.99 cm. This condition is suspected to be due to genetic variation between the Paewuna and Wakawondu cultivars, which affects the vegetative growth rate of local upland rice.

The Paewuna cultivar, which has longer leave, is likely to have a higher photosynthetic capacity. This aligns with the statement by Ren et al (2023) that there are significant differences in leaf growth among different rice varieties and under varying light quality treatments. According to (Wahyuti et al., 2013; Ramadhani & Santosa, 2025), leaf length and width in upland rice affect the plant canopy structure, which is directly related to the plant's ability to capture solar radiation. Leaf length and width are factors related to canopy structure, and the resulting canopy shape plays an important role in intercepting sunlight (Wahyuti et al., 2013).

This is consistent with the findings of Suhartini et al (2021), which state that upland rice varieties that adapt well to dryland conditions tend to have longer and thicker leaves to support efficient transpiration.

3.7. Leaf Width

The analysis of variance on the leaf width of local upland rice plants showed that the application of various doses of bokashi had a highly significant effect on leaf width at 8 WAP, but had no significant effect on leaf width at 4 WAP and 6 WAP. Meanwhile, the application of different local upland rice cultivars had no significant effect on the leaf width of rice plants at 4 WAP, 6 WAP, and 8 WAP. The results of the DMRT 0.05% test for leaf length observations of local upland rice under different bokashi doses at 8 WAP are presented in the following table.

Table 11. Average Leaf Width (cm) of Rice Plants at 8 Weeks After Planting (WAP) under Various Bokashi Dosages

Dose bokashi	Leaf Width 8 WAP	DMRT 0.05
Without bokashi	1,31±0,03b	2 = 2,95
Bokashi 10 tons ha⁻¹	1,34±0,03b	3 = 3,10

Bokashi 20 tons ha⁻¹	1,42±0,03a	4 = 3,18
Bokashi 30 tons ha⁻¹	1,44±0,03a	

Note: Numbers followed by different letters indicate significant differences based on the DMRT test at a 95% confidence level. this study with three replications, comprised 24 experimental units. Each experimental unit consisted of 32 plants per plot, with 5 of them used as samples.

The results of the DMRT 0.05 test (Table 11) showed that the highest average leaf width of local upland rice at 8 WAP was observed in the treatment with bokashi at a dose of 30 tons ha^{-1}, measuring 1.44 cm. This was significantly different from the treatments without bokashi and bokashi at a dose of 10 tons ha^{-1}, but not significantly different from the bokashi 20 tons ha^{-1} treatment. Meanwhile, the lowest average leaf width was observed in the treatment without bokashi, measuring 1.31 cm, which was significantly different from the bokashi 20 tons ha^{-1} and 30 tons ha^{-1} treatments, but not significantly different from the bokashi 10 tons ha^{-1} treatment.

This indicates that the application of various doses of bokashi fertilizer affects leaf width and provides sufficient nutrient availability for leaf formation in the plants. The nutrients absorbed are used by the plant for cell division and the formation of new cells to develop plant organs such as leaves, stems, and roots, thereby facilitating the photosynthesis process. Furthermore, it is suspected that the N, P, and K content in bokashi can meet the nutrient requirements of local upland rice, thereby supporting good plant growth. According to Gardner & Pearce (1991); Hinarti et al (2025), the growth phase of plants requires adequate N, P, and K, especially for plant height increment. Nitrogen plays a crucial role in stem elongation, which occurs due to the processes of cell division, elongation, and enlargement in the meristem of stems and leaves, causing the plant to grow taller. This is in line with Garfansa et al (2022), who stated that the main role of nitrogen in bokashi is to stimulate overall plant growth, particularly in stems, branches, and leaves.

4. Conclusion

Based on the results and discussion of the research conducted, the following conclusions can be drawn:

1. The application of bokashi had a highly significant effect on plant height and leaf length of local upland rice at 4 and 6 weeks after planting (WAP), and a significant effect on leaf width at 8 WAP. However, it had no significant effect on plant height at 8 WAP, number of tillers at 4 WAP, and number of leaves at 4, 6, and 8 WAP. The application rate of 20 tons ha^{-1} resulted in the best plant growth.The growth response of local upland rice cultivars Wakawondu and Paewuna is best achieved with a Bokashi application at a dose of 20 t ha^{-1}.
2. The differences among cultivars had a highly significant effect on plant height and leaf length at 4, 6, and 8 WAP, the number of tillers at 4 WAP, and the number of leaves at 4 and 6 WAP, and had a significant effect on the number of tillers at 6 WAP. The Paewuna cultivar showed better growth performance than the Wakawondu upland rice cultivar
3. The upland rice cultivars Wakawondu and Paewuna have high nutritional content, with carbohydrate levels ranging from 24–29%, protein 6–8%, fat 1–2%, and crude fiber 8–9%, and are classified as good for consumption as a community food source.

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