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Adaptation of Rice Varieties (*Oryza sativa* L.) in Paddy Fields Rain Feeding through The Use of Ameliorant in Lahat Regency

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Abstract

Rice is a food crop commodity that serves as the staple food for the Indonesian population. This study examines the adaptation of various rice varieties with the addition of ameliorants on growth and yield in rainfed paddy fields. The research was conducted in Lahat District, Lahat Regency, from January to May 2024, utilizing a split-plot design with 12 treatment combinations, each replicated three times. The main plot treatments consisted of ameliorants, while the subplot treatments involved different rice varieties. The observed parameters included plant height (cm), number of tillers, number of productive tillers, panicle length (cm), flowering age (days after sowing), harvest age (days after sowing), total grains per panicle (grams), percentage of empty grains (%), 1000-grain weight (grams), and productivity (ton/ha). The results indicated that applying ameliorants, such as lime and solid organic fertilizer, yielded the most favorable outcomes for rice plant growth. Tabular analysis revealed that the Situ Bagendit variety exhibited the highest productivity compared to other varieties. Furthermore, the combination of ameliorants, specifically lime and organic fertilizer, along with the Situ Bagendit variety, achieved the highest paddy productivity at 5.13 tons per hectare.

Keywords: Ameliorants, Rainfed Paddy Field, Rice Adaptation, Varieties, Yield

1. Introduction

Rice is a food crop commodity that serves as a staple for the Indonesian population. In 2024, data from the Central Statistics Agency (BPS) indicates that Indonesia's population has continued to grow over the past four years. In 2021, the population was 272.682 million, which increased by 1.13% to 275.773 million in 2022. This figure rose again by 1.06% to 278.696 million in 2023 and increased by 1.04% to 281.603 million in 2024.

BPS (2024) noted that rice production in Indonesia has fluctuated over the past four years. In 2021, production reached 54.42 million tons of dry milled grain (GKG), then increased by 0.59% to 54.75 million tons of GKG in 2022. However, production decreased by 2.05% to 53.68 million tons of GKG in 2023, and fell again by 1.9% in 2024 to 52.66 million tons of GKG. If the decline in rice production continues, Indonesia is at risk of experiencing a deficit in food production growth compared to population growth.

The fulfillment of food needs has thus far been supported by the agricultural sector, particularly through rice commodities, making the existence of rice fields highly sought after. In Indonesia, rice fields are classified into three types: irrigated rice fields, rain-fed rice fields, and swampy rice fields (including lebak and tidal) (Ritung et al., 2011). Rain-fed rice fields are the second-largest contributor to rice production, following irrigated rice fields (Pandu, 2023). Approximately 3.4 million hectares of rain-fed rice fields have the potential to enhance national rice production (Ministry of Agriculture, 2018).

Rainfed rice fields are defined as those that depend on rainwater for irrigation rather than a permanent irrigation system (Pandu, 2023). One of the primary challenges in cultivating rice on rainfed land is the elevated soil acidity level, which can diminish the availability of essential nutrients and hinder plant growth.

Previous studies have shown that high soil acidity has a negative impact on rice productivity because it inhibits the absorption of macronutrients such as phosphorus, calcium, and magnesium. Application of lime as an ameliorant can neutralize acidic soil pH and increase rice growth. Using organic fertilizers can improve soil structure and increase cation exchange capacity in acidic soils.

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Lahat District is one of the Districts in Lahat Regency, most of which are rain-fed rice fields. These rice fields use irrigated rice varieties. In addition to the availability of varieties, consumer interest in consuming irrigated rice varieties is still relatively high. So farmers do not dare to try using more adaptive varieties. Selecting the right variety is essential so rice can grow well in dry conditions, such as rain-fed rice fields.

Increasing the quantity of rice harvest can be done by optimizing the physical properties of the soil. The physical properties of the soil can be improved through ameliorant application, which is a material used to improve soil fertility of all physical, chemical, and biological properties to support optimal plant development and growth. Ameliorants include organic substances, inorganic substances, or a combination thereof. For example, organic ameliorants are straw and manure, while inorganic ameliorants can be zeolite, volcanic ash, and dolomite (lime) (Berutu, 2022).

Several previous studies have shown that using ameliorants such as lime and organic matter can improve the physical and chemical properties of the soil and increase rice yields, especially on acidic soils. For example, research by Suyanto et al. (2023) showed that applying organic matter increased rice's growth and yield and improved the quality of acid sulfate soils. However, most of these studies were conducted in irrigated rice fields and did not consider the interaction between ameliorants and rice varieties. Rainfed rice fields and examine the adaptation of various rice varieties with the addition of ameliorants in rainfed rice fields.

2. Material and Methods

The research was conducted from January 2024 to May 2024 in Rainfed Rice Fields, Pasar Lama Village, Lahat District, Lahat Regency at coordinates 3°46'44.4” S and 103°32'51.2” E.

The study involved planting four rice varieties and three types of ameliorants. The experimental design used in this study was a Split Plot Design with a Factorial Randomized Block Design (RAKF) of 3 replications. The ameliorant treatment was the main plot, and the rice variety treatment was the subplot.

Data analysis was performed statistically using Analysis of Variance (ANOVA) to determine the treatment effect, followed by further Duncan's Multiple Range Test (DMRT) at the 5% level to compare treatments. The data processing and analysis were done using the IBM SPSS Statistics 21 application and Microsoft Excel as a data visualization tool. The following is a flow diagram of the research implementation carried out:

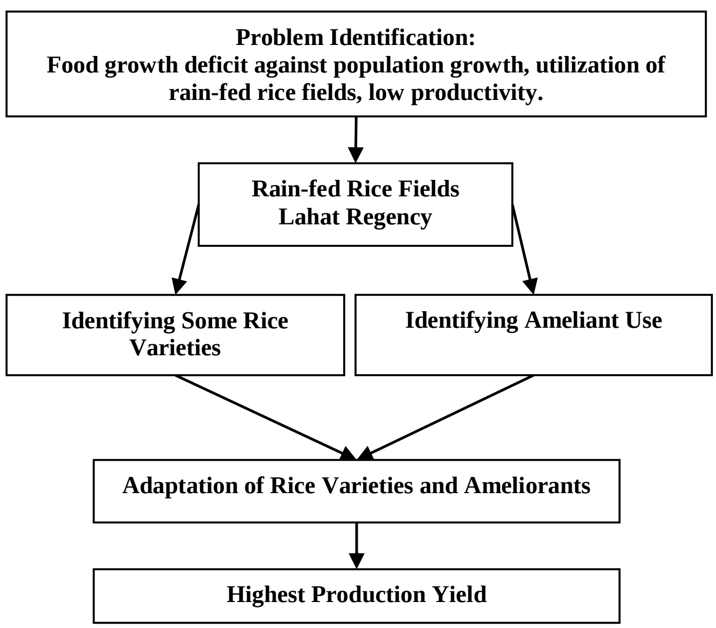

Figure 1. Research flow diagram

3. Results and Discussion

3.1. General Conditions of Research

Topographically, the research area is included in the category of wetlands dominated by rain-fed rice plants. Land conditions are generally flat to slightly sloping, with an altitude of around ±129 meters above sea level. The type of soil that dominates the research location is red-yellow podzolic with a fine and sandy texture.

The research area has a tropical climate with an average temperature between 26°C and 28°C. This research occurred from January to May 2024, with an average rainfall of 251 to 835.5 mm.

The soil analysis results using the Dry Soil Test Kit (PUTK) showed that the soil pH was 5–6. In addition, the C-organic content at the location was relatively low. The recommended organic matter requirement for rice plants is

2 tons per hectare.

3.2. Results of diversity analysis

As demonstrated in Table 1, the diversity analysis results indicate that the ameliorant treatment significantly affected the number of tillers and panicle length. The variety treatment exhibited a substantial impact on several agronomic traits, including plant height (cm), the number of productive tillers, panicle length (cm), flowering age (days after planting), harvest age (Dap), and total grain per panicle (grams). Additionally, it significantly influenced the percentage of empty grain (%). The interaction treatment substantially influenced the weight of 1000 grains (grams).

Table 1. Results of the analysis of the diversity of the influence of ameliorant treatment, varieties, and interaction with observed variables.

Observed variables	Treatment			KK %
	Ameliorant	Varieties	Interaction	
Plant Height (cm)	tn	**	tn	5.14%
Number of Offspring	*	tn	tn	10.26%
Number of Productive Offspring	tn	**	tn	9.61%
Panicle Length (cm)	*	**	tn	1.39%
Flowering Age (dap)	tn	**	tn	1.75%
Harvest Age (DAP)	tn	**	tn	0.89%
Total Grain per Panicle (grams)	tn	**	tn	20.50%
Empty Grain Percentage (%)	tn	*	tn	26.90%
Weight 1000 Grains (grams)	tn	tn	**	2.59%
Productivity (tons)	tn	tn	tn	12.96%

Description: * = significantly influential; ** = very significant effect; tn = no significant effect; KK= coefficient of diversity

3.3. Plant Height

The results of the variance analysis show that variety treatment has a very significant effect on plant height. Table 2 shows that the average plant height of the Inpari 32 treatment is 65.08 cm, significantly shorter than the Ciherang, Inpari 39, and Situ Bagendit treatments. Varieties have a very significant effect on plant height. Inpari 32 has the lowest plant height (65.08 cm) compared to other varieties. This difference indicates genetic diversity between varieties. According to Sasmitha and Nugraha (2020), rice plants with dwarf genes (semi-dwarf), such as Inpari 32, have advantages in resistance to lodging. Dingkuhn et al. (2015) also emphasized that modern rice varieties are designed to have shorter but stronger stems, which contributes to increasing the harvest index.

Table 2. Effect of Variety on Plant Height

Treatment	Plant Height (cm)
Ciherang	71.17 ± 2.64 b
Inpari 32	65.08 ± 2.51 a
Inpari 39	71.87 ± 2.62 b
Bagendit Lake	69.22 ± 2.65 b

Numbers followed by the same letter are not significantly different at the 5% DMRT test level.

3.4. Number of offspring

The results of the variance analysis showed that the ameliorant treatment had a significant effect on the number of tillers. Table 3. shows that the average number of tillers in treatment A1 was 23.42, significantly different from treatment A3 of 27.75. However, it was not significantly different from treatment A2. Ameliorants had a significant effect on the number of tillers. The combination of lime and organic fertilizer (A3) produced the highest number of tillers (27.75). Halim et al. (2018) reported that the application of ameliorants improved acidic soil conditions and increased nutrient availability, thereby encouraging tiller formation. Hamoud et al. (2024) added that the combination of lime and organic matter synergized in expanding the availability of N, P, and K, which are essential for tiller formation.

Table 3. Effect of Ameliorants on the Number of Offspring

Treatment	Number of offspring
Lime	23.42 ± 1.77 a
Organic fertilizer	25.67 ± 0.28 ab
Lime + Organic Fertilizer	27.75 ± 1.64 b

Numbers followed by the same letter are not significantly different at the 5% DMRT test level.

3.5. Number of Productive Offspring

Table 4 shows the average number of productive offspring in the Ciherang treatment 20.11, significantly less than the Situ Bagendit treatment of 24.33. However, it was not substantially different from the Inpari 32 and Inpari 39 treatments. The results of the variance analysis showed that the variety treatment had a very significant effect on the number of productive tillers. The variety had a very considerable impact on the number of productive tillers. Situ Bagendit produced the highest number of tillers (24.33). Rohaeni and Ishaq (2015) stated that Situ Bagendit adapts well to agro-ecosystem conditions, including rainfed land.

3.6. Panicle Length

The analysis of variance showed that the ameliorant treatment had a significant effect on panicle length, while the variety treatment had a very substantial impact on panicle length. Table 5 shows that the average panicle length of the A1 treatment was significantly shorter than that of the A1 and A3 treatments. Table 6 The average panicle length of the Inpari 32 treatment was significantly shorter than the Ciherang, Inpari 39, and Situ Bagendit treatments. The average panicle length of the Inpari 39 treatment was 23.96, significantly different from the Ciherang and Situ Bagendit treatments. However, the average panicle length of the longest Ciherang treatment was not significantly different from that of Situ Bagendit. Ameliorants and varieties had a significant effect on panicle length. Organic fertilizer treatment (A2) and a combination of lime-organic fertilizer (A3) produced longer panicles. The Ciherang and Situ Bagendit varieties had the longest panicles. Lubis and Silvina (2017) reported that ameliorants increased P availability, which plays an essential role in panicle formation.

Table 4. Effect of Variety on the Number of Productive Offspring

Treatment	Number of Productive Offspring
Ciherang	20.11 ± 1.76 a
Inpari 32	22.11 ± 1.56 ab
Inpari 39	21.89 ± 1.73 a
Bagendit Lake	24.33 ± 1.68 b

Numbers followed by the same letter are not significantly different at the 5% DMRT test level.

Table 5. Effect of Ameliorants on Panicle Length

Treatment	Panicle Length (cm)
Lime	24.30 ± 0.28 a
Organic fertilizer	24.78 ± 0.30 b
Lime + Organic Fertilizer	24.78 ± 0.30 b

Numbers followed by the same letter are not significantly different at the 5% DMRT test level.

Table 6. Influence of Variety on Panicle Length

Treatment	Panicle Length (cm)
Ciherang	25.92 ± 1.40 c
Inpari 32	22.90 ± 1.42 a
Inpari 39	23.96 ± 1.39 b
Bagendit Lake	25.70 ± 1.38 c

Numbers followed by the same letter are not significantly different at the 5% DMRT test level.

3.7. Flowering Age

The results of the variance analysis show that variety treatment has a very significant effect on flowering age. Table 7 shows the average flowering age of the Situ Bagendit treatment. 74.78 DAP was significantly faster than the Ciherang and Inpari 32 treatments. However, it was not significantly different from the Inpari 39 treatment. The Ciherang treatment of 79.22 DAP is significantly different and slower than the Inpari 32, Inpari 39, and Situ Bagendit treatments. Varieties have a very significant effect on flowering age. Situ Bagendit has the fastest flowering age (74.78 DAP) and Ciherang the longest (79.22 DAP). Aqil et al. (2013) stated that early maturing varieties have advantages in adapting to climate change.

3.8. Harvest Age

The results of the variance analysis show that variety treatment has a very significant effect on harvest age. Table 8 Average Situ Bagendit treatment harvest age for 102 DAP is faster than Ciherang, Inpari 32, and Inpari 39. The variety has a very significant effect on the harvest age. Situ Bagendit has the fastest harvest age (102 DAP). The advantages of early-maturing varieties are that they save water and increase planting intensity. Adji (2023) added that a short harvest age increases the planting index and reduces the risk of damage due to natural disasters.

Table 7. Influence of Variety on Flowering Age

Treatment	Flowering Age (dap)
Ciherang	79.22 ± 1.81c
Inpari 32	76.22 ± 1.88 b
Inpari 39	75.89 ± 1.93 ab
Bagendit Lake	74.78 ± 1.92 a

Numbers followed by the same letter are not significantly different at the 5% DMRT test level.

Table 8. Effect of Variety on Harvest Age

Treatment	Harvest Age (DAP)
Ciherang	118.00 ± 7.02 d
Inpari 32	113.78 ± 6.71c
Inpari 39	107.44 ± 7.06 b
Bagendit Lake	102.00 ± 7.03 a

Numbers followed by the same letter are not significantly different at the 5% DMRT test level.

3.9. Total Grain per Panicle

The results of the variance analysis showed that the variety treatment had a very significant effect on the total grain per panicle. Table 9 shows that the average total grain per panicle of the Ciherang treatment was 160.22, significantly different from the Inpari 32, Inpari 39, and Situ Bagendit treatments. However, the Situ Bagendit treatment differs considerably from the Inpari 39 and Situ Bagendit treatments. The variety had a very significant effect on the total grain per panicle. Ciherang produced the highest amount of grain (160.22). Donggulo et al. (2017) emphasized that the amount of grain per panicle was influenced by the length of the panicle and the density, which were determined by genetic factors.

Table 9. Effect of Variety on Total Grain per Panicle

Treatment	Total Grain per Panicle
Ciherang	160.22 ± 23.52 b
Inpari 32	129.00 ± 23.16 a
Inpari 39	120.44 ± 21.05 a
Bagendit Lake	108.33 ±22.08 a

Numbers followed by the same letter are not significantly different at the 5% DMRT test level.

3.10. Empty Grain Percentage (%)

The results of the variance analysis showed that the variety treatment had a significant effect on the percentage of empty grain. Table 10 shows that the average rate of empty grain in Ciherang was 34.43%, significantly different from the Situ Bagendit treatment. However, it was not substantially different from the Inpari 32 and Inpari 39 treatments. The variety had a significant effect on the percentage of empty grain. Ciherang showed the highest percentage (34.46%). This phenomenon is a source-sink imbalance, where the amount of grain exceeds the plant's ability to provide assimilates. Wahyuningrum et al. (2022) found that varieties with many grains per panicle also tend to have a high percentage of empty grains.

Table 10. Effect of Variety on Empty Grain Percentage (%)

Treatment	Percentage Empty Paddy (%)
Ciherang	34.46 ± 4.67 b
Inpari 32	24.43 ± 5.29 ab
Inpari 39	25.64 ±4.34 ab
Bagendit Lake	22.67 ± 5.25 a

Numbers followed by the same letter are not significantly different at the 5% DMRT test level.

3.11. Weight 1000 grains (grams)

The results of the variance analysis showed that the treatment in the form of interaction between ameliorant and variety had a very significant effect on the weight of 1000 grains. Table 11 shows that the average weight of 1000 grains of Lime + Organic Fertilizer + Ciherang was 25 grams, significantly lighter than the Lime + Ciherang treatment. Chalk+Inpari 32, Chalk+Situ Bagendit, Organic Fertilizer+Ciherang, Organic Fertilizer+Inpari 32, Organic Fertilizer+Situ Bagendit, Chalk+Organic Fertilizer+Inpari 39, Chalk+Organic Fertilizer+Situ Bagendit. However, it is not significantly different from other interaction treatments. The interaction of ameliorants and varieties has a very significant effect on the weight of 1000 grains. The combination of Chalk+Inpari 32 and Chalk+Organic Fertilizer+Situ Bagendit produced the highest weight (27.67 grams). The weight of 1000 grains is the most stable yield component. Safrida et al. (2019) reported that ameliorants can increase the availability of P and K, which play a role in filling grain.

Table 11. Effect of Ameliorant Interaction with Variety against Weight 1000 Grains (grams)

Treatment	Weight 1000 Grains
Chalk + Ciherang	27.33 ± 0.82 bc
Chalk+Inpari 32	27.67 ± 0.91c
Chalk+Inpari 39	26.00 ± 0.78 ab
Chalk + Lake Bagendit	26.33 ± 0.88 b
Organic Fertilizer + Ciherang	26.33 ± 0.84 b
Organic Fertilizer + Inpari 32	27.00 ± 0.82 bc
Organic Fertilizer + Inpari 39	26.00 ± 0.91ab
Organic Fertilizer + Situ Bagendit	26.33 ± 0.81 b
Chalk + Organic Fertilizer + Ciherang	25.00 ± 0.82 a
Chalk + Organic Fertilizer + Inpari 32	25.67 ± 0.85 ab
Chalk + Organic Fertilizer + Inpari 39	26.67 ± 0.86 b
Lime + Organic Fertilizer + Situ Bagendit	27.67 ± 0.92 c

Numbers followed by the same letter are not significantly different at the 5% DMRT test level.

3.12. Productivity

Based on the 12 treatments tested, the average productivity ranged from 3.92 to 5.13 tons/ha. The lowest average productivity was found in the interaction treatment A 2 V 4 and A 3 V 1, while the highest was found in the A 3 V 4 interaction treatment. The results of the variance analysis showed that the ameliorant treatment, varieties, and the interaction of ameliorant with varieties had no significant effect on productivity. There was no significant effect of treatment on productivity, although there was a variation of 3.92-5.13 tons/ha. Benauli (2021) stated that water availability and nutrients are limiting factors significantly influencing rice productivity on rainfed land. Irawan et al. (2015) added that soil physical conditions, acidity, and Al toxicity often limit productivity on red yellow podzolic soils.

3.13. NPK Analysis of Plant Tissue (%)

Based on the 12 treatments tested, the analysis results of NPK content analysis in plant tissue are shown in Figure 4.1. The highest percentage of nitrogen (N) of 1.42% was found in the A3 V3 interaction treatment, while the lowest of 0.72% was found in the A1 V4 interaction. For phosphorus (P), the highest percentage of 0.215% was found in the A3 V2 treatment, while the lowest percentage of 0.075% was found in the A2 V2 interaction. Meanwhile, potassium (K) showed the highest percentage of 1.77% in the A3 V2 treatment, while the lowest percentage of 0.86% was found in the A2 V3 interaction. The results of the analysis showed variations in nutrient absorption between treatments. The highest percentage of N (1.42%) was in the combination of lime + organic fertilizer + Inpari 39 (A3V3). The highest percentage of P (0.215%) and the highest K (1.77%) were in the combination of lime + organic fertilizer + Inpari 32 (A3V2). According to Wang et al. (2017), the combined use of lime and organic matter resulted in an increase in nutrient availability by enhancing the chemical properties of the soil. Postma et al. is used to reference the work of Postma and colleagues. Postma et al. (2014) emphasized the differences in root architecture and exudation among varieties, leading to variations in nutrient absorption efficiency.

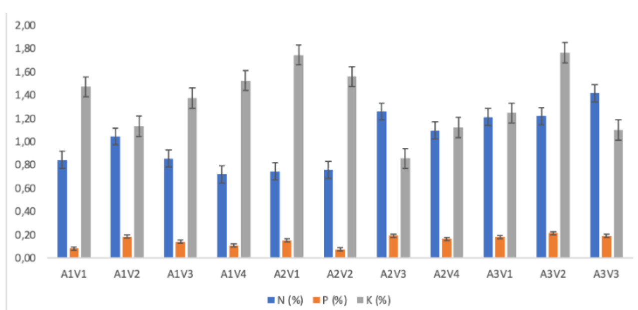

Figure 2. Graph of NPK Content Analysis Results of Plant Tissue (%)

4. Conclusion

The application of lime and solid organic fertilizer as ameliorants yields optimal outcomes for the growth of rice plants. According to the data table, the Situ Bagendit variety demonstrates superior growth and productivity compared to other varieties. When presented in a table, using lime + organic fertilizer as ameliorants with the Situ Bagendit variety results in the highest yield of 5.13 tons per hectare for lowland rice plants.

Suggestions

It is imperative to conduct experiments in rain-fed rice fields during various planting seasons to observe variations in outcomes. To achieve optimal outcomes, it is necessary to augment the application of organic material doses to 8 tons per hectare.

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