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Growth and Yield of Bujang Marantau Rice Variety (*Oryza sativa* L.) on Peat Land Due to Application of Fly Ash

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Abstract

Rice production in Indonesia has declined in recent years, primarily due to the conversion of agricultural land into residential areas. Utilizing peatlands as agricultural land presents a viable alternative to address this issue. This study aimed to evaluate the growth and yield of the Bujang Marantau variety of rice in response to various doses of fly ash ameliorant applied to peatlands. The research employed a Randomized Block Design, which included four treatments with different fly ash doses: 0 tons/ha, 5 tons/ha, 10 tons/ha, and 15 tons/ha. Each treatment was replicated three times. Data were analyzed using the F-test at a significance level of 5%, followed by the DNMRT test at the same level if significant effects were observed. The results indicated that the application of fly ash significantly influenced the leaf area index; however, it did not have a notable impact on several growth and yield parameters, including plant height, root length, root volume, total number of tillers, number of productive tillers, Percentage of filled grains per panicle, weight of 1,000 grains, and yield per hectare. Fly ash should be applied at a dosage of 5-10 tons per hectare for peatland cultivation of the Bujang Marantau rice variety, as it is generally effective in enhancing plant growth and yield.

Keywords: Ameliorant, Bujang Marantau, Fly Ash, Peat Land, Rice

1. Introduction

Rice (*Oryza sativa* L.) is one of the primary food crops in Indonesia, as nearly all Indonesians consume rice as a significant source of carbohydrates. Over 95% of the population relies on rice as their staple food, with an average consumption level of 111.58 kg per capita per year (Kementerian Pertanian, 2020). The demand for rice in Indonesia continues to rise due to the growing population. However, in recent years, there has been a decline in national rice production. Specifically, there was a 7.76% decrease in production in 2019 compared to 2018, dropping from 59.20 million tons of harvested paddy (GKG) to 54.60 million tons of harvested paddy (GKG) (Badan Pusat Statistik, 2020).

One of the causes of the decline in rice production in Indonesia is the rice production process, which is still centered on cultivation in rice fields. Meanwhile, many agricultural lands (productive rice fields) have recently been converted into non-agricultural land (settlements). This threatens national rice production (Nurchamidah & Djauhari, 2017; Purwantini, 2014). The conversion of agricultural land, especially rice fields, ranges from 60,000 to 80,000 hectares per year. (Saefudin, 2022). If we only rely on productive rice fields for rice cultivation, national rice production will continue to decline and cannot meet the population's needs. This will undoubtedly impact the amount of rice imports each year.

One alternative that can be done to increase rice production is to utilize land that is still adequate in therea (Hergoualc’h et al., 2018; Osaki & Tsuji, 2015). Indonesia has the second-largest peatland in the world, with an area of 22.5 million hectares (Zamaya et al., 2021). West Sumatra Province has peatlands with an area of approximately 140,000 hectares and is spread across several districts and cities, one of which is in Padang Pariaman Regency (Pemerintah Provinsi Sumatra Barat, 2015). However, the development of agriculture on the peatlands has several obstacles, including the thickness and maturity level of peat, high soil acidity, the presence of pyrite layers, deficiencies of both macro and micronutrients, and poor drainage (Fitra et al., 2019; Permatasari et al., 2021). In addition, the low nutrient

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content in peatlands can inhibit plant growth, causing their productivity to decrease. Therefore, efforts are needed to add organic materials, P and K fertilizers, and ameliorants (Budianto et al., 2022).

Ameliorants are soil conditioners that can improve the physical and chemical properties of the soil. One of the ameliorants is fly ash, the ash left over from burning coal. Using fly ash as an ameliorant can increase the availability of P nutrients in plants. (Santoso et al., 2015). The results of a study by Purnamasari et al. (2024) using a comparison of several types of ameliorants, one of which is fly ash added to peat soil in polybag planting containers, showed that the use of 7.5% fly ash can increase the yield of IR-64 variety rice.

The application of ameliorants and the selection of adaptive varieties are essential strategies in increasing rice productivity on marginal land (Rusanti et al., 2024). West Sumatra has quite a lot of local rice germplasms, one of which is the Bujang Marantau variety. This variety comes from Tanah Datar Regency and has been recognized as superior since 2015. If local varieties are not managed properly, they will be challenging to find and even endangered (Ekawati et al., 2025; Wahyudi & Indrawanis, 2025). The use of fly ash on peatlands planted with the Bujang Marantau variety rice has never been done.

This study aimed to see how the growth and yield responses of the Bujang Marantau variety of rice on peat land were affected by the provision of several doses of fly ash.

2. Material and Methods

The research was conducted from May to November 2024 in peat rice fields in Sunur Village, Nan Sabaris District, Padang Pariaman Regency, West Sumatra Province, with coordinates 0 ° 40'21.5 "S 100 ° 11'03.7" E, which has an elevation of 8 m above sea level. The materials used in the study included Bujang Marantau variety rice seeds, coal fly ash ameliorants, Urea fertilizer, SP 36 fertilizer, KCl fertilizer, and pesticides (Insecticides and Fungicides). At the same time, the tools used were land processing tools, digital scales, a Portable Leaf Area Meter, a Seed Moisture Meter, meters, stationery, and several other supporting tools.

The study used a Randomized Block Design (RBD) consisting of 4 fly ash dose treatments, including 0 tons/ha, 5 tons/ha, 10 tons/ha, and 15 tons/ha. Each treatment was repeated 3 times, where each experimental unit contained 6 sample plants for observation. The observation data were analyzed statistically using the F test at a level of 5%, and the DNMRT test was continued at a level of 5% if it showed a significant effect. Data was analyzed using STAR (Statistical Tool for Agriculture research) 2.0.1 software.

Soil analysis was conducted at the end (after harvest) to determine the effect of each dose treatment of fly ash ameliorant on the chemical content of the soil. Analysis was conducted to see the soil pH using the pH meter glass electrode method, soil water content using the oven method, C-Organic using the dry ashing method, N-Total using the Kjeldhal method, P-Total and K-Total using the 25% HCl method, Fe, Cu, and Zn using the HNO_3 and $HClO_4$ methods.

The research activities began with seed preparation, seed sowing, land preparation, treatment application, planting, maintenance, and harvesting (Figure 1). The planting method used was the System of Rice Intensification (SRI) method with a planting distance of 25 cm x 25 cm. Each experimental unit was 2 m x 1.5 m in size with a distance between plots of 0.5 m.

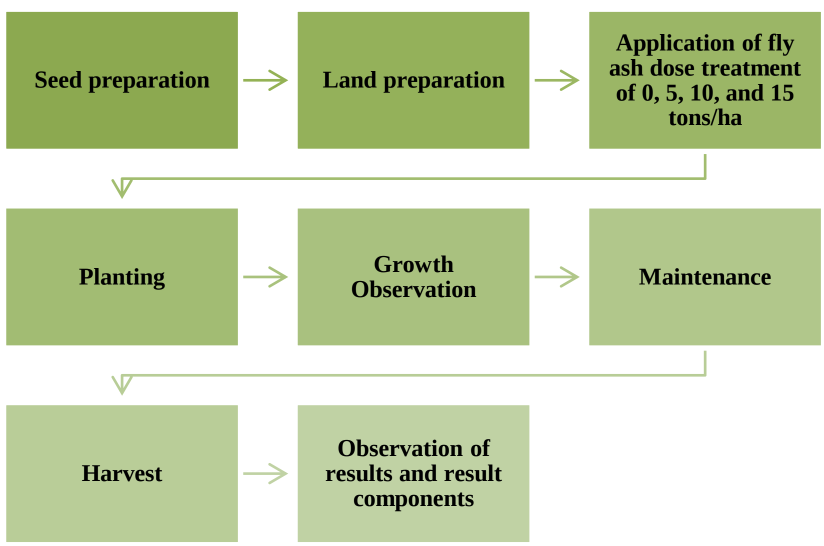

Figure 1. Research flow diagram

Observations were made on the results of soil analysis, as well as plant growth and yield parameters including plant height, leaf area index, root length, root volume, total number of tillers, number of productive tillers, Percentage of whole grain per panicle, weight of 1000 complete grain grains, and yield per hectare.

3. Results and Discussion

3.1. Soil Analysis Results After Application of Several Doses of Fly Ash

The soil analysis conducted gave different results between treatments (Table 1). The acidity level (pH) of the soil without fly ash was 4.9 and increased along with the increase in the dose of fly ash. This is because fly ash has a basic pH, contains macro and micronutrients, and is fine in size to increase the pH value (Utami, 2018).

Table 1. Results of soil analysis after application of several doses of fly ash on peat land.

No	Fly ash dosage (ton/ha)	Parameter*								
		pH	Water content (%)	Organic C (%)	N Total (%)	P Total (%)	K Total (%)	Fe (ppm)	Cu (ppm)	Zn (ppm)
1	0	4.90	38.50	14.50	3.25	0.04	0.003	12.3	0.93	0.85
2	5	5.61	43.04	29.36	0.54	0.06	0.310	0.39	0.45	0.64
3	10	5.63	45.24	30.68	0.56	0.06	0.320	0.40	0.46	0.64
4	15	6.65	45.90	32.42	0.57	0.06	0.330	0.41	0.46	0.65

Note: *Soil analysis was conducted at the Environmental Engineering Laboratory, Andalas University. Soil test samples for each parameter were tested at the end (after the rice plants were harvested), where each treatment consisted of 3 test samples.

Water content increased after several doses of fly ash were applied compared to without fly ash on peatlands. Adding fly ash has been shown to increase the soil's ability to retain water, so the water content in the soil remains optimal for plant growth. Sufficient water content in the soil is a key factor supporting growth (Khoirunisa et al., 2021). The C-Organic content also increased with increasing doses of fly ash. High C-Organic levels in the soil can increase the activity of soil microorganisms that play a role in the decomposition of organic matter and biochemical reactions in the soil (Hardjowigeno, 2012).

The N-Total content was higher in the treatment without fly ash and was classified as high, but in the treatment of 5 tons/ha, 10 tons/ha, and 15 tons/ha fly ash, it was only 0.54% to 0.57% which was categorized as very low (Balai Penelitian Tanah, 2005). The loss of N in the soil after the crop is harvested because the nutrients in this case are available N that have been absorbed by the plants and carried away by the harvest, while in the treatment without fly ash, much of the N is not yet available so that the plants are unable to utilize the element and are still left in the soil.

The P-Total level was 0.04% in the treatment without fly ash and increased to 0.06% at fly ash doses of 5 tons/ha, 10 tons/ha, and 15 tons/ha. Likewise, the K-Total level was 0.003% in the treatment without fly ash and increased successively to 0.310%, 0.320%, and 0.330% at fly ash doses of 5 tons/ha, 10 tons/ha, and 15 tons/ha. Meanwhile, the Fe, Cu, and Zn content decreased along with the increase in the fly ash dose. Based on (Balai Penelitian Tanah, 2005), the content of these micronutrients is included in the very low category, except for the Fe content in the treatment without fly ash. The Cu micronutrient contained in fly ash is indeed classified as low (Purnamasari et al., 2024); its levels will decrease after being utilized by plants.

3.2. Plant Height and Leaf Area Index

Based on the results of the variance analysis, it was found that the application of fly ash to peatland did not significantly affect plant height. Still, it substantially affected the leaf area index (Table 2).

Table 2. Plant height and leaf area index of Bujang Marantau variety rice due to administering several doses of fly ash.

Fly Ash Dosage (ton/ha)	Plant Height (cm)	Leaf Area Index
0	60.77 ± 8.38	0.26 ± 0.07 c
5	64.27 ± 5.21	0.31 ± 0.07 bc
10	72.87 ± 2.87	0.42 ± 0.05 a
15	66.00 ± 5.57	0.35 ± 0.07 ab
KK	7.18%	10.89%

Description: The numbers in the same column followed by different lowercase letters are significantly different according to the DNMRT test at the 5% level. However, the numbers not followed by lowercase letters are not significantly different according to the F test at the 5% level.

The height of the Bujang Marantau variety rice plant at a dose of 10 tons/ha of fly ash produced the highest plant height of 72.87 cm compared to other treatments, but the difference was not significant based on the F test. Sufficient soil water content conditions can support plant height growth. According to (Yulianto et al., 2017), in salinity-stressed conditions, plants lack water, which can interfere with plant height growth. In the research conditions, based on the soil water content analysis results, sufficient water content was found in all treatments so that height growth remains optimal.

The treatment of fly ash dosage significantly affected the Leaf Area Index of Bujang Marantau Variety rice, where a dosage of 10 tons/ha produced a higher leaf area index value but was not significantly different from a dosage of 15 tons/ha. The study's results (Purnamasari et al., 2024) showed that fly ash applied to peat soil planted with the IR-64 variety rice significantly affected plant height. Adding fly ash can help improve soil aggregates and increase soil chemical properties, including the content of N, P, K, and CEC values that play a role in plant growth (Ferdian et al., 2023).

3.3. Root Length and Root Volume

Based on the analysis of variance, it was found that the application of fly ash to peat land did not significantly affect root length and volume (Table 3).

Table 3. Root length and root volume of Bujang Marantau variety rice due to administering several doses of fly ash.

Fly Ash Dosage (ton/ha)	Root length (cm)	Root volume (mL)
0	18.33 ± 2.89	50.00 ± 43.6
5	18.33 ± 6.11	123.33 ± 81.4
10	21.67 ± 3.79	108.33 ± 55.3
15	19.67 ± 0.58	93.33 ± 11.5
KK	15.83%	18.45%

Description: The numbers in the same column are not significantly different according to the F test at the 5% significance level.

Applying fly ash with a dose of 10 tons/ha showed the highest root length value compared to other treatments. Fly ash, as an ameliorant derived from coal combustion residue, contains minerals such as calcium (Ca), magnesium (Mg), potassium (K), and phosphorus (P), which play an essential role in supporting root growth (Wardhani et al., 2012). However, this study did not affect the roots of Bujang Marantau variety rice plants. This means that the minerals contained in peat soil can meet the nutrient needs of plants, because in its cultivation, the provision of N, P, and K fertilizers is given according to the recommended dose, namely Urea 200 kg/ha, SP-36 100 kg/ha, and HCl 100 kg/ha.

Fly ash application with a dose of 5 tons/ha showed the largest root volume compared to other treatments. Although not significantly different, the provision of fly ash had a larger root volume when compared to that without fly ash. Plants with high root volumes can absorb more water so they can survive in water shortage conditions. Increased root volume is an essential morphological response in plant adaptation to water shortages (Budiasih, 2009).

3.4. Total Number of Offspring and Number of Productive Offspring

Based on the results of the variance analysis, it was found that the application of fly ash to peatland did not significantly affect the total number of shoots and the number of productive shoots (Table 4).

Table 4. Due to the administration of several doses of fly ash, the total number of tillers and productive tillers of Bujang Marantau variety rice.

Fly Ash Dosage (ton/ha)	Total number of offspring	Number of productive offspring
0	19.00 ± 7.79	12.20 ± 3.49
5	19.20 ± 9.85	14.33 ± 3.79
10	22.20 ± 8.03	17.13 ± 4.14
15	21.27 ± 2.91	14.73 ± 3.84
KK	18.73%	11.22%

Description: The numbers in the same column are not significantly different according to the F test at the 5% significance level.

The total number of offspring and productive offspring on the application of fly ash with a dose of 10 tons/ha showed the largest number compared to other treatments. However, it showed a different effect that was not significant based on statistical tests. The number of total tillers and the number of productive tillers in rice plants is caused by genetic factors, where the number of tillers less than 12 stems per hill is classified as few, and 13 to 20 stems per hill is classified as moderate. More than 20 stems per hill is classified as many (Yulina et al., 2021). Based on this classification, the total number of tillers of the Bujang Marantau variety of rice planted on the peatlands has a moderate to large number of tillers. However, the study by Purnamasari et al. (2024) showed that the provision of fly ash can increase the number of tillers in the IR-64 variety rice planted on peat soil.

3.5. Percentage of Whole Grain per Panicle, Weight of 1000 Grains of Whole Grain, and Yield per Hectare

Based on the results of the analysis of variance, it was found that the application of fly ash on peat land did not have a significant effect on the Percentage of fully grained grains per Panicle, Weight of 1000 1000-grained grains, and Yield per Hectare (Table 5).

The proportion of whole grains per panicle increased when treated with fly ash at a rate of 10 tons/ha compared to other treatments, but this difference was not statistically significant. According to Haris (2020), the Percentage of quality grain refers to the Percentage of whole grain between 85% and 95%. Consistent with this finding, the weight of 1000 grains of whole grain and the yield per hectare with a 10 tons/ha fly ash application also showed higher results than other treatments. However, the difference was not statistically significant. The high weight of 1000 individual grains suggests a more complete grain filling. The variation in rice plant yield and yield components is attributable to the uniqueness.

Table 5. Due to administering several doses of fly ash, the Percentage of whole grain per panicle, the weight of 1000 complete grains, and yield per hectare of Bujang Marantau variety rice.

Fly Ash Dosage (ton/ha)	Percentage of Grainy Grains per Panicle (%)	Weight of 1000 Grains of Rice (g)	Yield Per Hectare (ton/ha)
0	68.33 ± 11.55	28.39 ± 6.52	5.28 ± 0.91
5	68.00 ± 17.52	23.56 ± 0.34	6.02 ± 1.28
10	83.00 ± 6.24	30.95 ± 2.87	6.46 ± 0.92
15	79.33 ± 11.72	23.95 ± 5.86	4.08 ± 1.27
KK	8.42%	19.27%	20.58%

Description: The numbers in the same column are not significantly different according to the F test at the 5% significance level.

4. Conclusion

Using fly ash as a soil improver notably impacts the leaf area index. Still, it does not significantly affect growth and yield factors such as plant height, root length, root volume, total number of tillers, productive tillers, Percentage of whole grain per panicle, weight of 1000 grains, and yield per hectare. Applying 5-10 tons/ha of fly ash is typically successful in boosting the growth and yield of Bujang Marantau variety rice plants.

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