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ASSESSMENT OF THE TOLERANCE OF VARIOUS INDIGENOUS RICE VARIETIES ON WEST SUMATRA PEATLANDS

Zulkarnaini[1], Irfan Suliansyah[2], Gusmini[3], Syafrimen Yasin[3]

[1] Agricultural Science Doctoral Program, Faculty of Agriculture, Andalas University, West Sumatera, Padang, 25175, Indonesia
[2] Department of Agrotechnology, Faculty of Agriculture, Andalas University, West Sumatera, Padang, 25175, Indonesia
[3] Department of Soil Science, Faculty of Agriculture, Universitas Andalas, Limau Manis, Padang, 25163, Indonesia

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Abstract

Rice cultivation on peatlands presents significant challenges due to extreme soil conditions, such as high acidity, high water content, and variable nutrient availability. These conditions can adversely affect plant growth and productivity, making the selection of suitable rice varieties critical for successful cultivation. This study evaluates local rice varieties for cultivation in the peatlands of Padang Pariaman Regency, West Sumatra, by analyzing soil characteristics and genotype performance. Soil samples from Sunua Nan Sabaris, Pungguang Kasik, and Parak Pisang were assessed for water content, pH, ash content, organic carbon, and nutrient levels. Twenty rice genotypes were tested for traits including plant height, tiller number, grain yield, 1000-grain weight, and panicle length. Significant variability was observed among genotypes, with Anak Daro Kuriak and Cantik Manis showing high tiller production, while Bujang Merantau achieved notably higher grain yields. A strong correlation between tiller number and yield per plot was identified, suggesting that increased tiller production could enhance overall yield. Additionally, Batang Piaman and Cisokan demonstrated good tolerance to peatland conditions. These findings provide insights for breeding and agricultural strategies aimed at improving rice productivity in peatland environments.

Keywords: peatland cultivation, rice varieties, soil chemistry, agronomic performance, genotype resilience, West Sumatra

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important crop globally, serving as the primary food source for a significant portion of the world's population (Yadav *et al.*, 2024), particularly in Asia and Indonesia. It contributes 20% of the world's dietary energy supply, surpassing wheat and maize, which provide 19% and 5%, respectively (Bin, R. and Zhang, 2023). However, rice cultivation in Indonesia has experienced a decline in recent years, with a 2.05% reduction in production and a 2.45% decrease in rice field area in 2023 (BPS, 2024). In Indonesia, however, rice cultivation has experienced stagnation in recent years (Connor *et al.*, 2024). This stagnation is primarily attributed to the adverse effects of climate change, soil degradation, and pest outbreaks (Fahad *et al.*, 2019). Moreover, the rapid growth of the global population, with Indonesia, ranked as the fourth most populous country at 273 million people in 2022, poses significant challenges in meeting food demands Durand-Morat and Mulimbi, 2024). Essential strategies are required to maintain food security and address factors affecting food production, particularly rice. Fluctuations in the availability of agricultural land, especially for rice cultivation, further complicate efforts to sustain food production in Indonesia (Durand-Morat and Mulimbi, 2024). The decrease in rice field area in 2021, followed by an increase in 2022, highlights the uncertainties that must be resolved to ensure future food security (Li *et al.*, 2024).

Traditionally, rice cultivation in Indonesia has focused on mineral soils. However, expanding agricultural activities to marginal lands, such as peatlands, is increasingly necessary due to rising food demand and the limited availability of fertile land. Peatlands, characterized by their high organic matter content and unique hydrological conditions, present both opportunities and challenges for rice cultivation. West Sumatra, with its diverse topography and climate, is home to various local rice varieties that have developed unique traits through generations of adaptation to specific environmental conditions. This study aims to assess the resilience and productivity of 20 local rice varieties when cultivated in peatlands in Padang Pariaman Regency, West Sumatra. While peatlands offer substantial yet underutilized resources for agricultural expansion, they are also fragile ecosystems sensitive to changes in water levels and nutrient availability. The degradation of peatlands poses serious environmental challenges, including increased greenhouse gas emissions and a loss of biodiversity (Adesiji *et al.*, 2015). To address these issues, it is essential to identify rice varieties capable of thriving in peatland conditions while maintaining ecological balance. This approach not only supports sustainable agricultural practices but also helps mitigate the adverse impacts of peatland degradation on the environment.

Rice is a vital commodity for Indonesia's food security, as it serves as the staple food for more than 95% of the population (Ansar *et al.*, 2020). The decrease in national rice production is linked to the shrinking area of productive rice fields. The conversion of agricultural land to non-agricultural use poses a threat to national rice production and has also been observed in many countries around the world (Acintya *et al.*, 2024). According to the Ministry of Agriculture Republic of Indonesia followed by an increase in 2022, underscores the uncertainties that must be addressed to ensure future food availability (Li *et al.*, 2024), then the conversion of national rice fields varies between 60,000 and 80,000 hectares per year. To maintain the agricultural land area, extending cultivation to available peatlands is necessary (Hergoualc'h *et al.*, 2018; Osaki and Tsuji, 2016).

Indonesia has the second-largest peatland area in the world, with a total of 22.5 million hectares (Sari *et al.*, 2021). West Sumatra has potential peatland areas of approximately 140,000 hectares, distributed in Pesisir Selatan, Padang Pariaman, and Pasaman Barat Regencies (Bapedalda West Sumatra, 2015). Large-scale agricultural development on peatlands has been undertaken in Kalimantan since 1996 to achieve national food self-sufficiency (Kusin *et al.*, 2020). However, the development of peatlands into paddy fields faces several challenges, including peat thickness and maturity, high soil acidity, the presence of pyrite layers, deficiencies in macro- and micronutrients, and inadequate drainage (Wang *et al.*, 2023). Indonesian peat, derived from decomposing woody plants, produces organic acids that can be toxic to plants, disrupting metabolism and productivity. Due to these constraints, rice cultivation on peatlands has not developed well, and related research is limited (Fawzi and Qurani, 2021).

Peatland's low nutrient content hinders plant growth, marked by low macro- and micronutrient availability, low pH, low base saturation, and high levels of phytotoxic organic acids like phenolic acids (Ratai *et al.*, 2024). Technologies for managing peatlands to address soil acidity and nutrient deficiencies are still limited, so utilizing peatlands for rice farming must be done carefully to ensure optimal productivity (Osaki and Tsuji, 2016). Developing peat-tolerant rice varieties is a cost-effective strategy as it avoids the high costs of modifying the growing environment. West Sumatra is rich in local rice varieties across various regencies and cities (Zul *et al.*, 2024) identified 20 local rice varieties from West Sumatra. To use these varieties on peatlands, their resistance must be evaluated, as not all local varieties may thrive in these conditions. This study aims to determine the tolerance levels of West Sumatra's local rice varieties to peatland cultivation systems.

RESEARCH METHODS

Study Site

This research was conducted from May to October 2023 at several peatland locations in Padang Pariaman Regency, West Sumatra. The selected sampling and research locations include Sunua Nan Sabaris Peatland, Pungguang Kasik Peatland, and Parak Pisang Peatland, Sintuak Toboh. The analysis of nutrient characteristics, moisture content, and ash content was carried out in the soil laboratory of the Faculty of Agriculture, Andalas University, West Sumatra, Padang, 25175, Indonesia.

MATERIALS

Research Method

This research is divided into two stages. The first stage involves exploratory research using a direct survey method at several sampling locations in Padang Pariaman Regency, West Sumatra. Soil samples were collected using purposive random sampling, selecting soil samples from several peatland locations in Padang Pariaman Regency, West Sumatra. Sampling was conducted at three points, which were then composited into one sample for use. The sampling points were divided into three locations: Peat

Location 1 (LP-1) (Sunua Nan Sabaris), Peat Location 2 (LP-2) (Pungguang Kasik), and Peat Location 3 (LP-3) (Parak Pisang, Sintuak Toboh) (Fig. 1).

The results of previous research were used as a reference in selecting the research locations, resulting in the chosen research location being in Nan Sabaris District, Padang Pariaman Regency. This research is based on a randomized block design (RBD), testing 20 varieties of local rice from West Sumatra (Tab. I) from previous research (Gusmini and Yasin, 2024), with three replications.

Rice genotypes represent the genetic composition that influences traits like disease resistance, environmental adaptability, yield, and grain quality. The local rice genotypes in Tab. I are naturally adapted to peatlands-acidic, waterlogged, and nutrient-poor soils. Their diversity provides essential genetic resources for developing climate-resilient rice varieties and reflects the cultural and agricultural heritage of local communities. In this study, 20 indigenous rice genotypes from West Sumatra were selected for their potential tolerance to peatland conditions, supporting sustainable agriculture in the region.

I: *Indigenous rice genotypes of West Sumatra from previous research (Gusmini and Yasin, 2024)*

No	Genotipe	Origin	Genotype Code
1.	Batang Piaman	Padang Pariaman	G01
2.	Sokan Junjuang	Padang Pariaman	G02
3.	Cisokan	Padang Pariaman	G03
4.	Randah Kuning	Padang Pariaman	G05
5.	Rumpun Gadang	Mentawai	G06
6.	Batang Nias	Mentawai	G07
7.	Redek	Mentawai	G08
8.	Simaung	Mentawai	G09
9.	PB-42	Solok Selatan	G10
10.	Kuruik Kusuik Sirah	Solok Selatan	G11
11.	Kuruik Kusuik Putiah	Padang Panjang	G12
12.	Cantik Manis	Padang Panjang	G13
13.	Kuriak Supayang	Padang Panjang	G14
14.	Kuriak Saruaso	Padang Panjang	G15
15.	Bujang Merantau	Tanah Datar	G16
16.	Anak Daro Kuriak	Tanah Datar	G17
17.	100 Hari	Tanah Datar	G18
18.	Serang Bimas	Tanah Datar	G19
19.	Bm Sigah	Pasaman Barat	G20
20.	Malin Putih	Pasaman Barat	G21

Enlightenment: The genotypes listed in the table were selected based on their potential tolerance to the conditions of the peatlands in West Sumatra.

Research Implementation

Exploration of Peatlands in West Sumatra

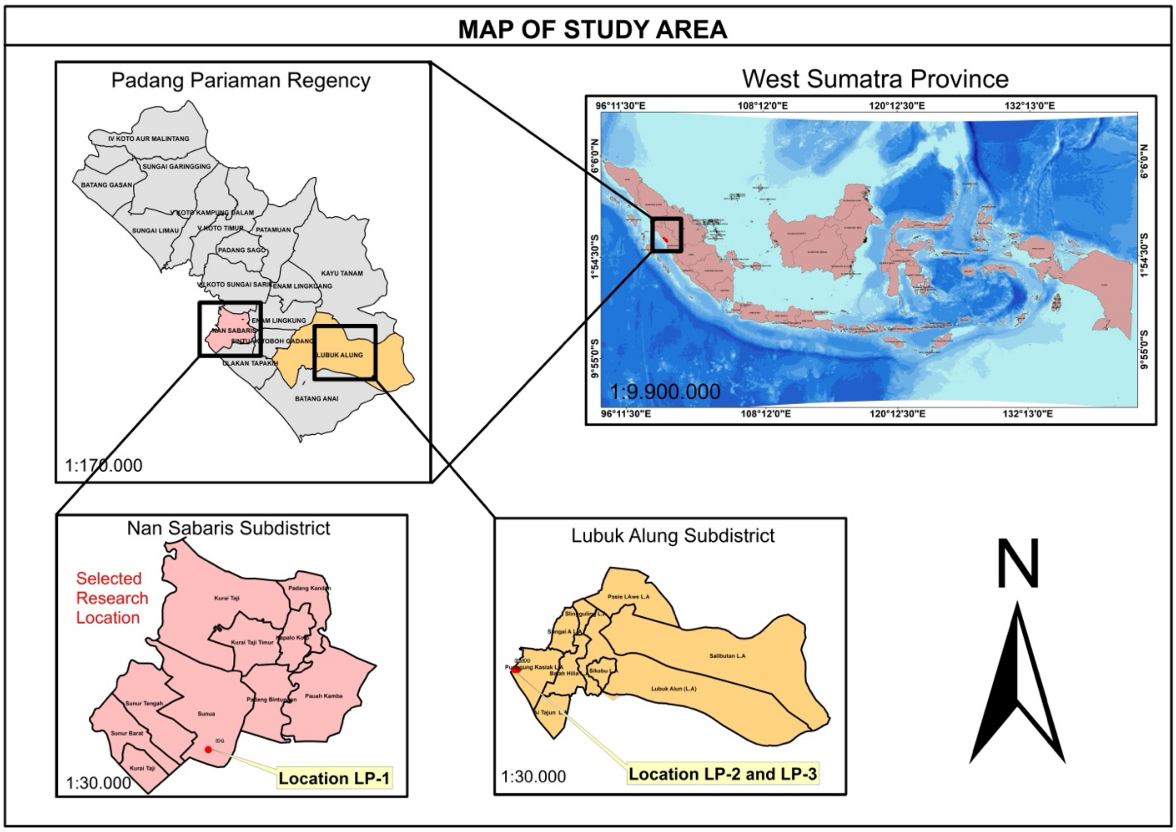
To identify suitable peatlands for rice cultivation, an optimal selection process was conducted, focusing on the peatlands in Padang Pariaman Regency. The study commenced with soil sampling using purposive random sampling from several peatland sites within the regency. The sampling was organized into three areas: Peat Location 1 (LP-1) at Sunua Nan Sabaris, Peat Location 2 (LP-2) at Pungguang Kasik, and Peat Location 3 (LP-3) at Parak Pisang, Sintuak Toboh (Fig. 1). These sites were chosen based on their presumed fertility potential. Soil samples were collected from three points at each location, with each sample weighing 500 grams and combined into a composite sample. Sampling was performed using a peat corer on a 200 m² subplot, at a distance of 50 meters from the drainage channel. For disturbed soil, samples were collected at a depth of 0–20 cm. The composite samples were then analyzed in the laboratory to assess various chemical characteristics of the peat soil (Tab. II).

Assessing the Resilience of Local Rice Varieties in Peatland West Sumatra

Following the identification of the research site, the most suitable peatland was selected for testing the tolerance of 20 local rice varieties. The land was initially prepared by plowing with a tractor and subsequently divided into 21 plots, each measuring 3 meters by 1.5 meters. Seeds from the 20 rice genotypes, as detailed in Tab. I, were sourced from a collection gathered during an exploration in West Sumatra. Prior to sowing, the seeds were soaked in water at temperatures ranging from 20 °C to 25 °C for a duration of 24 hours. After the soaking period, the seeds were grown in a germination medium and permitted to grow for 14 days post-sowing. During this germination phase, the medium was irrigated daily to ensure it maintained adequate moisture levels. From the seedlings that emerged, three per genotype were selected and transplanted into the prepared plots. The cultivation process involved various maintenance activities, including weeding, pest and disease management, irrigation, and fertilization.

II: *Chemical characteristics of peat soil*

No	Parameter	Unit	Method/Instrument
1	Water content	%	Gravimetri
2	pH	Unit	pH meter
3	Ash content	%	Gravimetri
4	C-Organik	%	*Loss-on Ignition* (LOI)
5	N Total	%	Kjedhal
6	P and K Total	%	HCl 25%
7	Fe, Cu and Zn	ppm	HNO_3 dan $HClO_4$



1: *Map of sample collection and research locations. Enlightenment: Peat Location 1 (LP-1) (Sunua Nan Sabaris), Peat Location 2 (LP-2) (Pungguang Kasik), and Peat Location 3 (LP-3) (Parak Pisang, Sintuak Toboh)*

Weeding was conducted intensively twice a month through manual removal methods. Pest and disease management was executed using both mechanical approaches, such as manual pest removal, and chemical treatments with Dharmabas 500 EC, an insecticide containing 500 g/l of BPMC. Chemical applications were administered weekly, commencing when the rice plants reached 10 weeks after planting (WAP) or upon entering the generative phase. Irrigation was maintained from the onset of plant growth until the grain-filling stage. Harvesting was undertaken when approximately 80% of the plants had reached physiological maturity, as indicated by the yellowing of the plants. The harvest was executed by cutting the plant stalks approximately 20 cm above the soil surface. Selanjutnya pengamatan dilakukan yang terdiri dari agronomic parameters recorded included plant height, number of tillers, weight grain per plot, 1000-grain weight, and panicle length.

Data Analysis

The data analysis to determine the 20 rice varieties that can survive in peatland was conducted using the Analysis of Variance (ANOVA) and Tukey's Honest Significant Difference (HSD) test at a 5% confidence level (Abdi and Williams, 2010). This methodology compared the mean values of each variety, identifying specific differences and ensuring that the observed differences were statistically robust and reliable.

RESULTS

Exploration of Peatlands in West Sumatra

The characterization of the selected locations analyzed obtained variations in nutrient content, pH levels, and organic matter, in each location assessed (Tab. III), these values will affect the growth performance of rice varieties.

The soil analysis was conducted through direct surveys at several sampling locations in Padang Pariaman Regency, West Sumatra. The water content in peat soil exceeds 4x, with pH values ranging from 3.83 to 4.81. The highest pH value was recorded at Pungguang Kasik (LP-2), indicating acidic conditions due to organic acids produced from the decomposition of plant litter. High soil acidity can render essential nutrients unavailable to plants, posing a significant challenge for agricultural practices. The ash content of peat soil varied between 16.27% and 39.13%, indicating eutrophic fertility levels. Eutrophic peat is rich in mineral content, with ash values exceeding 10%. The elevated ash content at certain sites may result from river or floodwater deposition, which brings

III: *Chemical characteristics of peat soil*

Location	Label	Water	pH 1:5	Ash	Dry Ashing				Dry Ashing		
			H_2O		N-total	P-total	K-total	C-Org	Fe	Cu	Zn
		(%)		(%)	(%)				(ppm)		
Sunua Nan Sabaris	LP-1	481	3.83	16.27	0.87	5.58	1.74	48.14	2.88	0.23	0.31
Pungguang Kasik	LP-2	443	4.81	39.13	0.76	6.04	2.11	35.30	3.03	0.26	0.21
Parak Pisang, Sintuak Toboh	LP-3	502	3.68	34.93	3.52	11.79	2.31	37.73	2.71	0.26	0.26

mineral-rich particles that settle in the peatland. The organic carbon content ranged from 35.30% to 48.14%, categorized as very high, demonstrating the significant presence of decomposed organic matter such as leaves, wood twigs, and plant roots in the peat. The macronutrient composition (N, P, K) of peat at various locations showed N-total ranging from 0.76% to 3.52%, P-total from 5.58% to 11.79%, and K-total from 1.74% to 2.31%, with the highest values observed at Parak Pisang, Sintuak Toboh (LP-3). The micronutrient composition (Fe, Cu, Zn) revealed Fe content ranging from 2.71 to 3.03 ppm, Cu from 0.23 to 0.26 ppm, and Zn from 0.21 to 0.31 ppm, with the highest Fe and Cu values at Pungguang Kasik (LP-2) and the highest Zn value at Sunua Nan Sabaris (LP-1). Peat soil typically exhibits low fertility, characterized by low pH and limited availability of macro (N, P, K) and micronutrients (Fe, Cu, Zn). The high organic acid content, resulting from the anaerobic decomposition of organic matter, contributes to acidic conditions and toxicity, impeding plant growth. Ideal pH levels for nutrient availability in peat soil range from 5.0 to 6.0, but increasing peat pH to above 5.0 requires substantial investment. Therefore, alternative technologies must be developed to enhance the fertility of peat soils for sustainable agricultural practices.

Based on the results of the study, the most strategic location for testing the resistance of 20 local rice varieties from West Sumatra is Peat Location 1 (LP-1) (Sunua Nan Sabaris). This location was chosen due to its relatively balanced nutrient content and manageable pH level, which, although acidic, can be ameliorated through appropriate soil management practices. The high water content in peat soil, while beneficial for maintaining moisture levels, also poses challenges in terms of aeration and root development. Proper drainage systems must be implemented to ensure optimal water management, preventing waterlogging and promoting healthy root growth. Additionally, the use of organic amendments such as compost and biochar can help improve soil structure, enhance nutrient retention, and reduce soil acidity. The low pH levels in peat soil necessitate the application of lime or other alkaline materials to raise the pH to more favorable levels for plant growth. This liming process should be carefully managed to avoid over-application, which could lead to nutrient imbalances and other soil health issues. Given the high organic carbon content in peat soils, it is crucial to adopt sustainable agricultural practices that minimize soil disturbance and promote carbon sequestration. The elevated ash content in certain locations indicates the presence of mineral-rich particles, which can be beneficial for nutrient availability. However, it is important to monitor the potential accumulation of heavy metals and other contaminants that may be introduced through floodwater deposition. Regular soil testing and the implementation of phytoremediation techniques can help manage these risks and ensure the safety and productivity of the agricultural land.

Assessing the Resilience of Local Rice Varieties in Peatland West Sumatra

Agronomic Characteristics of Plants

The study conducted a thorough analysis of variance to determine the impact of local rice genotypes on agronomic characteristics, specifically plant height and the number of tillers. The results indicated significant variations among the genotypes, demonstrating that both plant height and the number of tillers were influenced by the genetic makeup of the rice varieties. Such differences highlight the potential for selecting specific genotypes that are better suited to the unique conditions of peatland cultivation in West Sumatra (Tab. IV).

The analysis of variance revealed significant differences in plant height and the number of tillers among the local rice genotypes in the peatlands of West Sumatra. Plant height varied significantly, with values ranging from an average of 59.57 cm to 92.97 cm. The randah kuning genotype exhibited the tallest plants (92.97 cm), while pb 42 showed the shortest (59.57 cm). Other notable genotypes with relatively high plant heights included seratus hari (87.57 cm), bujang merantau (86.87 cm), and kuruik kusuik putiah (85.70 cm). These genotypes showed no significant differences from each other, suggesting that multiple local genotypes possess the potential for substantial growth. Similarly, IV: *Plant Height and Number of Tillers of Local Rice Genotypes*

No	Genotipe	Plant Height (cm)	Number of Tillers
1	Seratus Hari	87.57 ab	17.33 de
2	Anak Daro Kuriak	78.43 abc	36.33 a
3	Batang Nias	83.47 ab	28.67 abc
4	Batang Piaman	70.47 bc	28.00 bc
5	Bm Sigah	71.80 bc	26.00 c
6	Bujang Merantau	86.87 ab	25.67 c
7	Cantik Manis	74.27 abc	34.67 ab
8	Cisokan	70.53 bc	29.00 abc
9	Kuriak Saruaso	81.40 ab	25.67 c
10	Kuriak Supayang	81.27 ab	28.33 abc
11	Kuruik Kusuik Putiah	85.70 ab	22.00 cd
12	Kuruik Kusuik Sirah	81.43 ab	26.00 c
13	Malin Putih	82.12 ab	27.67 bc
14	PB 42	59.57 c	30.33 abc
15	Randah Kuning	92.97 a	17.33 de
16	Redek	89.00 a	25.67 c
17	Rumpun Gadang	77.80 ab	26.67 bc
18	Serang Bimas	88.20 ab	14.00 e
19	Simaung	83.83 ab	27.33 bc
20	Sokan Junjuang	84.93 ab	27.00 bc

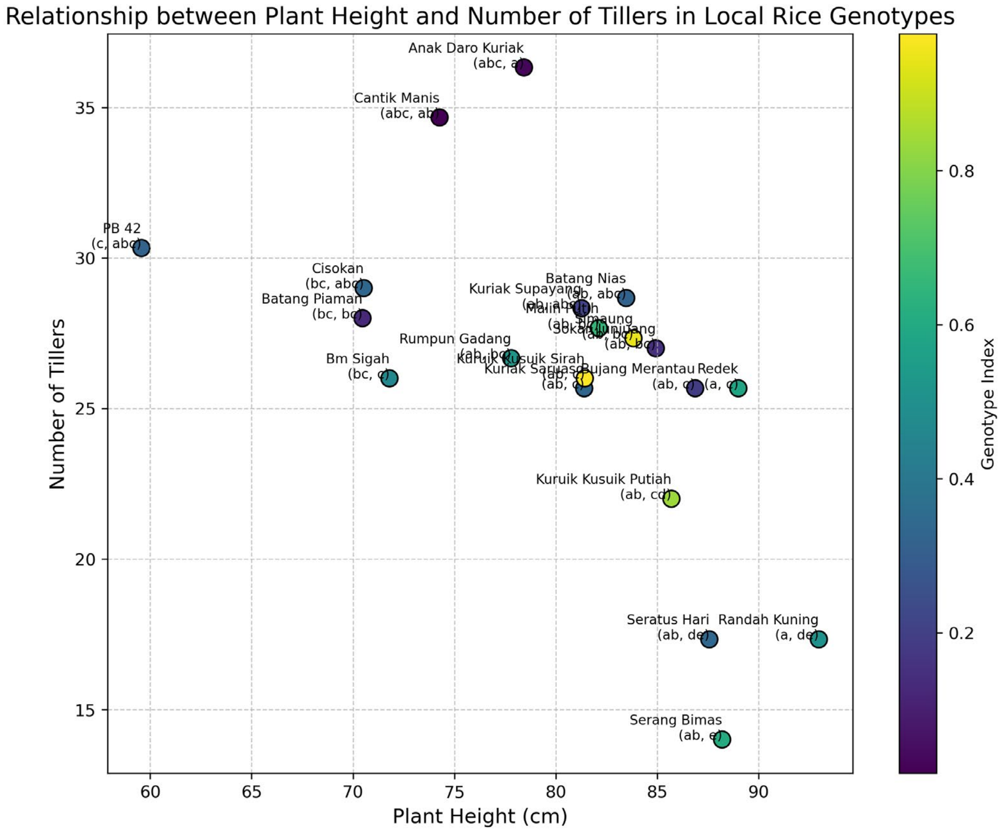
Explanation: Numbers followed by the same lowercase letter in the same column are not significantly different based Tukey's Honest Significant Difference (HSD) test at a 5% confidence level

significant differences were observed in the number of tillers produced by different genotypes. The anak daro kuriak genotype produced the highest number of tillers (36.33), significantly surpassing other genotypes, while serang bimas had the fewest tillers (14.00). The cantik manis genotype also exhibited a high number of tillers (34.67), with no significant difference from anak daro kuriak, indicating a strong potential for tiller production.

These findings have important implications for the cultivation of rice in the peatlands of West Sumatra. Genotypes with taller plants, such as randah kuning and redek, may be more suitable for deeper or wetter soils. In contrast, genotypes with higher tiller numbers, like anak daro kuriak and cantik manis, might be preferable in more fertile soils. The observed variability in plant height and tiller number among genotypes presents opportunities for selecting varieties that are better adapted to the specific environmental conditions of the peatlands. Furthermore, these results can inform breeding programs aimed at enhancing the productivity and resilience of local rice varieties in this region.

The analysis of the relationship between plant height and the number of tillers in 20 local rice genotypes, (Fig. 2), reveals significant variability among the genotypes. The scatter plot shows that certain genotypes, such as anak daro kuriak and cantik manis, exhibit a high number of tillers (36.33 and 34.67, respectively), suggesting their potential for higher yields. On the other hand, genotypes like randah kuning and redek are distinguished by their considerable plant height (92.97 cm and 89.00 cm, respectively), which might be beneficial in managing water levels in peatland environments.

Conversely, genotypes such as serang bimas and PB 42 show lower values for the number of tillers and plant height, respectively, indicating that these may require specific agricultural practices or breeding programs to enhance their performance. The genotype index, represented by the colour gradient in the graph, provides an additional layer of insight. Higher values on the genotype index indicate superior overall performance and resilience, incorporating multiple agronomic traits such as yield potential, stress tolerance, and adaptability to peatland conditions. For instance, the genotype anak daro kuriak not only shows a high number of tillers but also scores high on the genotype index, indicating its robustness and potential as a high-yielding variety. Similarly, cantik manis, with its significant number of tillers, also scores well on the genotype index, emphasizing its suitability for cultivation in peatland environments.



2: *Relationship between plant height and number of tillers in 20 genotype local rice genotypes. Explanation: Statistical notations (a, b, c, d, e) indicate significant differences among them based on Tukey's Honest Significant Difference (HSD) test at a 5% confidence level.*

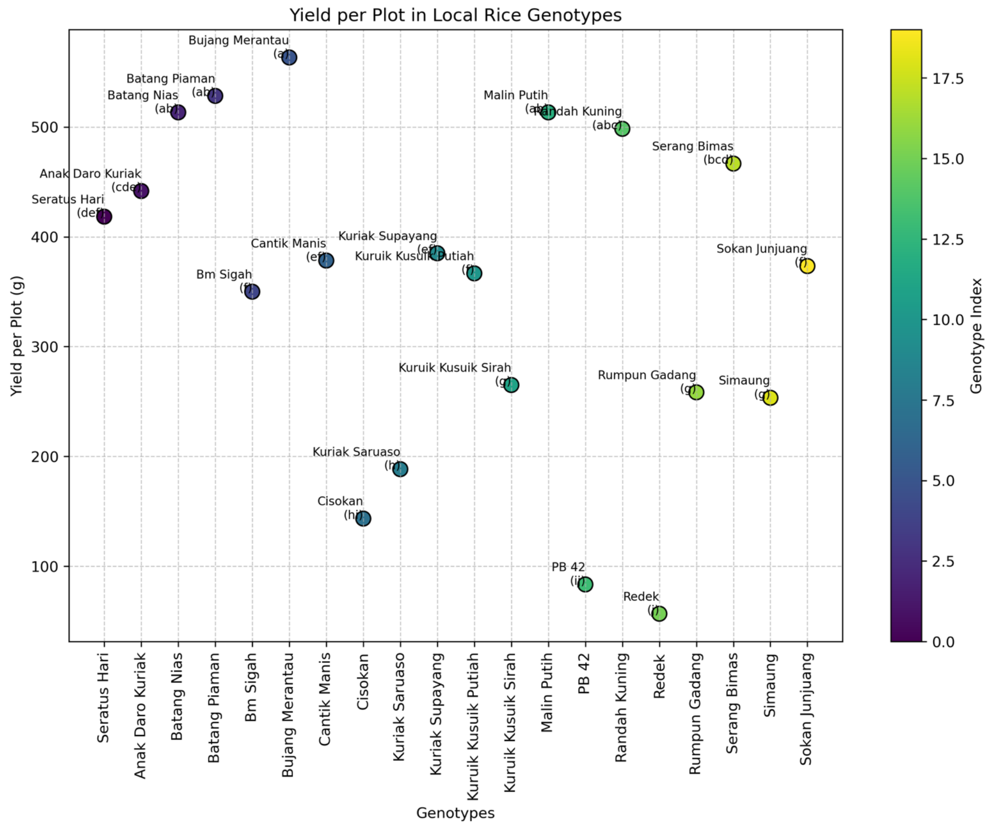
On the contrary, genotypes like serang bimas, despite having fewer tillers, might possess other agronomic benefits not immediately apparent from the scatter plot but reflected in their genotype index.

Yield Characteristics of Plants

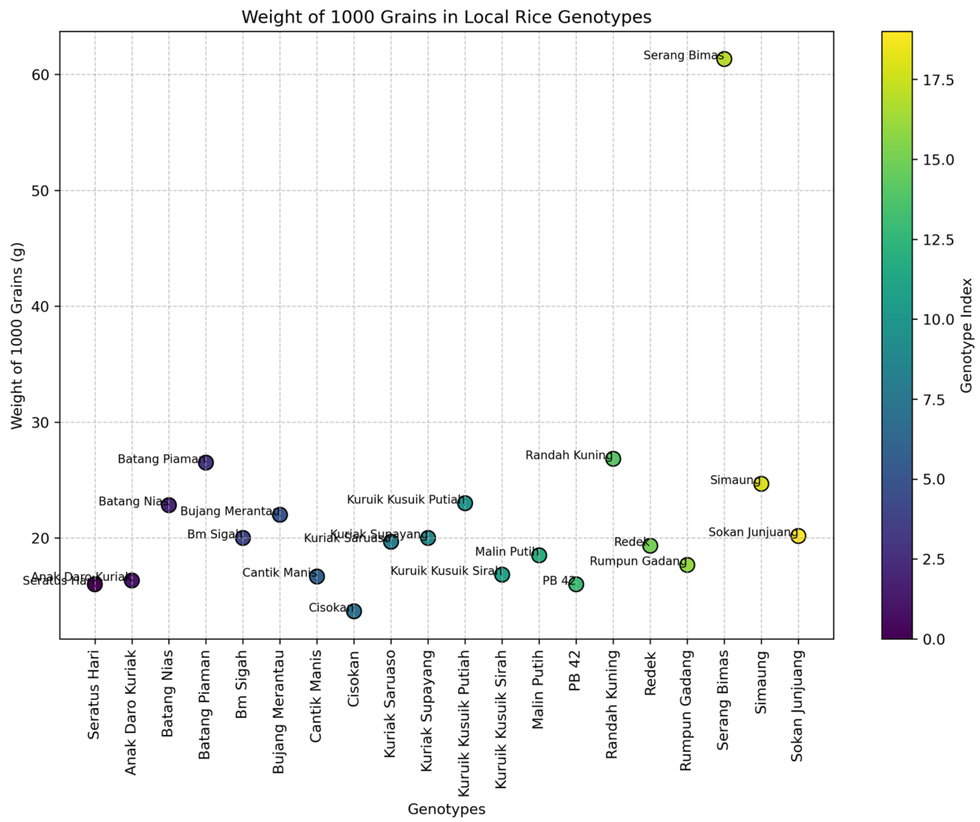
The analysis of variance indicated that the weight of grains per plot was significantly influenced by the local rice genotype. The plot analysis results for various local rice genotypes, as illustrated in Fig. 3, demonstrate significant variation in grain yield among the genotypes. Based on the graph, it is evident that the harvest yield per plot for various local rice varieties in West Sumatra, grown in peat areas, shows significant differences.

The percentage difference in yield between the varieties Bujang Merantau (500 g/plot) and Kuriak Saruoso (100 g/plot) is particularly striking, with Bujang Merantau's yield being 400% higher than that of Kuriak Saruoso. Varieties such as Bujang Merantau, Batang Piaman, and Batang Nias have the highest yields, around 500 grams per plot, making them excellent choices for grain production cultivation. These high-yielding varieties stand out as optimal candidates for farmers looking to maximize their production on peatlands. The superior performance of these genotypes can be attributed to their better adaptation to the unique conditions of peat soils, which often pose challenges such as poor nutrient availability and waterlogging. Their ability to produce substantial yields under these conditions suggests a robustness that is highly desirable for large-scale agricultural practices. Conversely, varieties like Kuriak Saruoso and Kuriak Kusuik Sirah show the lowest yields, ranging from 100 to 200 grams per plot.

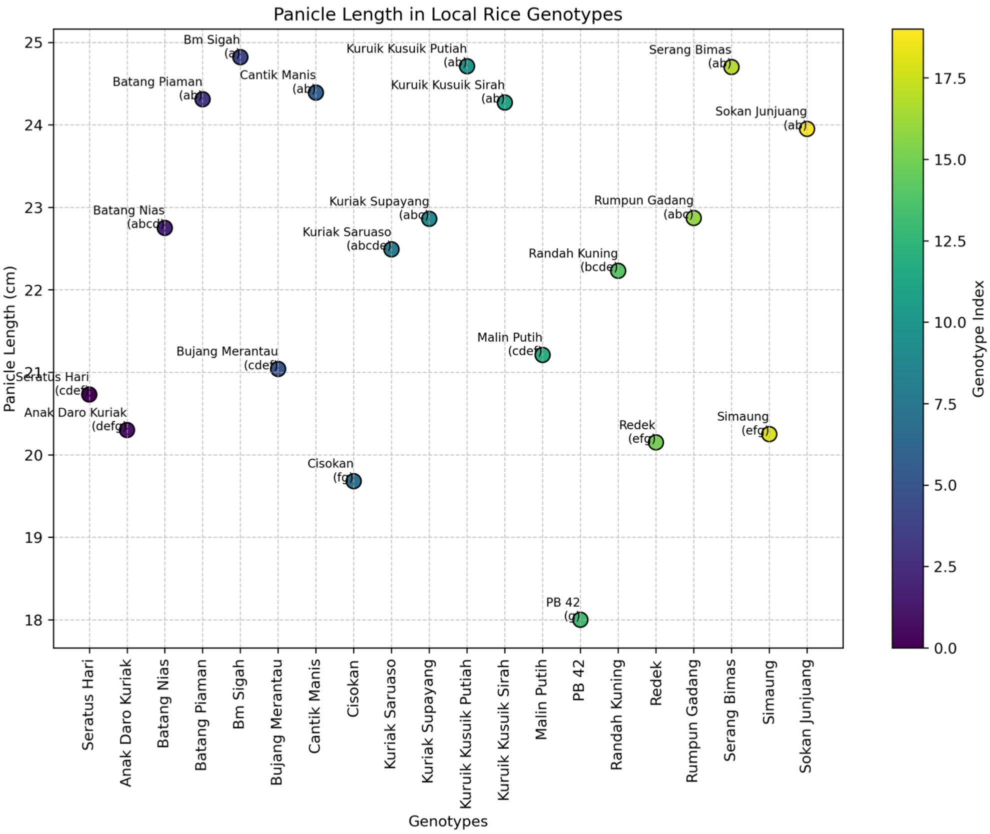
This lower productivity makes them less ideal for cultivation if the primary goal is grain production. However, it is important to consider that these varieties might possess other advantageous traits that are not immediately apparent from yield data alone. For instance, they could have superior qualities such as better taste, nutritional value, or resistance to specific pests and diseases. Thus, while their direct yield is low, they should not be completely disregarded without a thorough evaluation of these other potential benefits. Moreover, varieties such as Serang Bimas, Sokan Junjuang, and Simauang, despite having moderate yields, possess high genotype index values. This indicates that they have other beneficial traits that could be advantageous for cultivation. These traits might include increased resilience to environmental stresses, such as drought or flooding, or enhanced resistance to common rice diseases. The presence of these traits makes them valuable for breeding programs aimed at developing



3: *Yield per Plot in Local Rice Genotypes. Explanation: Statistical notations (a, b, c, d, e) indicate significant differences among them based on Tukey's Honest Significant Difference (HSD) test at a 5% confidence level.*



4: *Comparison of 1000-Grain Weight Across Various Local Rice Varieties*



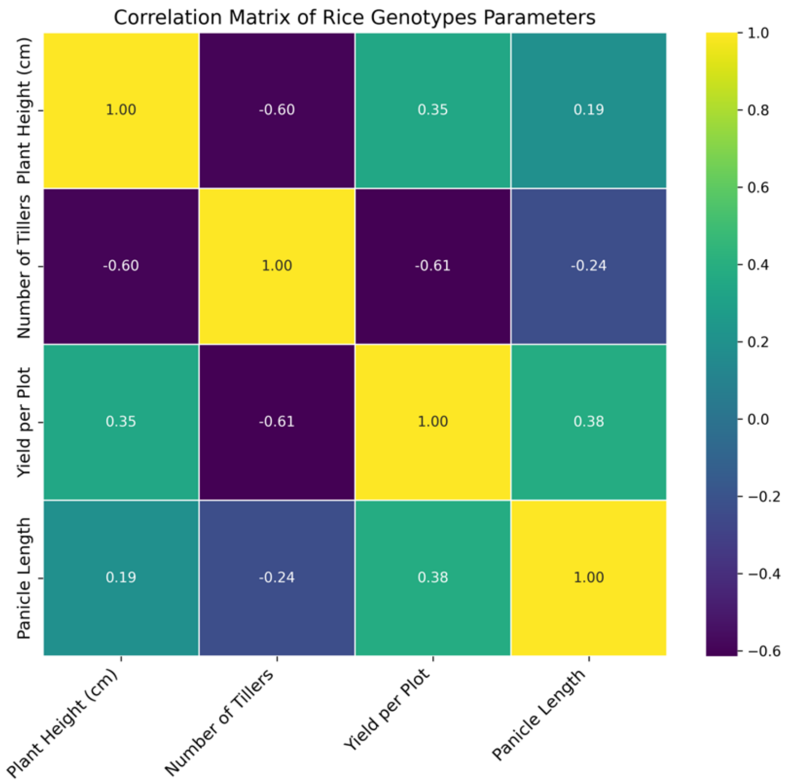
5: *Distribution of Panicle Length Across Various Local Rice Genotypes. Explanation: Statistical notations (a, b, c, d, e) indicate significant differences among them based on Tukey's Honest Significant Difference (HSD) test at a 5% confidence level.*

new varieties that combine high yield with other desirable characteristics.

In the observation of the rice plant yield component section, the graph displaying the 1000-grain weight measurements can be seen in Fig. 4. According to the ANOVA analysis, the 1000-grain weight of the 20 local rice varieties did not differ significantly when planted in peatland areas.

Based on the provided (Fig. 4), the 1000-grain weight of 20 local rice varieties cultivated in peatland areas ranges from approximately 10 grams to over 60 grams. The variety Serang Bimo exhibits the highest 1000-grain weight, significantly surpassing the other varieties with a measurement of around 60 grams. In contrast, varieties like Suntai and Sokan Junjura have weights around or below 20 grams. Most rice varieties fall within the 10 to 30 grams range, indicating that high 1000-grain weight is less common among the local rice varieties in the study. Despite these variations, the ANOVA analysis indicates no significant difference in the 1000-grain weight among the varieties overall, suggesting that peatland conditions may not heavily influence this yield component or that the local varieties possess a similar adaptive capacity to these conditions. Notably, the percentage difference between the highest and lowest varieties is substantial, with Serang Bimo showing a 500% increase over Suntai. Similarly, Simanur and Randeh Kuni have 1000-grain weights that are 250% and 200% higher than Suntai, respectively. This finding implies that farmers can select from a wide range of local varieties without concern for significant differences in grain weight, allowing for flexibility based on other desirable traits.Future research could explore additional yield components, such as total grain yield per plant, grain quality, and growth duration, as well as the environmental and genetic factors contributing to the outliers with significantly higher grain weights. In the observation of Panicle Length, the 20 local varieties differ significantly when planted in peatlands (Fig. 5).

The graph presented above illustrates the variation in panicle length among 20 local rice genotypes cultivated in peatland environments. The observations reveal significant differences in panicle length among these genotypes, as denoted by the statistical notations (a, b, c, d, e) derived from Tukey's test at a 5% confidence interval. Among the genotypes evaluated, Kuruak Kusik Putiah, Sokan Junjuang, and Serang Bima exhibit the longest panicles. Kuruak Kusik Putiah records a panicle length of approximately 25 cm, making it the genotype with the most extended panicles in the study. In comparison, Sokan Junjuang and Serang



6: *Correlation matrix of Rice Genotipe Parameter*

Bima possess panicle lengths of roughly 24.5 cm each, slightly shorter than Kuruak Kusik Putiah. From these measurements, it can be deduced that Kuruak Kusik Putiah's panicles are approximately 2.04% longer than those of Sokan Junjuang and Serang Bima. These three genotypes demonstrate a promising potential for higher yields, particularly in peatland settings. The increased panicle length may contribute to enhanced pollination efficiency and a potentially higher grain count, thus offering farmers the prospect of improved harvest outcomes.

Conversely, the genotypes with the shortest panicle lengths are Sri Ratus Hati and Aka Daro Maruak. Sri Ratus Hati registers a panicle length of about 19 cm, rendering it the genotype with the shortest panicles in this analysis. Aka Daro Maruak measures slightly longer, with a panicle length of around 19.5 cm. When compared to Kuruak Kusik Putiah, Sri Ratus Hati exhibits a panicle length that is 24% shorter, while Aka Daro Maruak is approximately 22% shorter. These disparities suggest that the latter two genotypes have a comparatively lower yield potential than those with longer panicles. In the context of cultivating rice in peatlands, selecting varieties with longer panicles, such as Kuruak Kusik Putiah, Sokan Junjuang, and Serang Bima, appears to be a more strategic approach for enhancing productivity. Genotypes with extended panicles might have a competitive advantage in resource acquisition and could significantly contribute to increased agricultural yields. In contrast, varieties with shorter panicles may necessitate additional agronomic interventions to achieve optimal production levels.

Based on the analysis of the correlation matrix between agronomic parameters of various local rice genotypes, several key observations can be drawn (Fig. 6). Firstly, there is a relatively strong positive correlation (0.60) between plant height and the number of tillers, indicating that genotypes with taller plants generally have more tillers. This suggests that selecting genotypes based on plant height could also increase the number of tillers, potentially enhancing yields.

Secondly, the weak positive correlation (0.19) between plant height and yield per plot shows that taller plants do not necessarily produce higher yields per plot. This implies that other factors, such as genetic traits or environmental conditions, may play a more significant role in determining yield. Additionally, there is a negative correlation (-0.24) between plant height and panicle length, suggesting that taller plants tend to have shorter panicles. This inverse relationship indicates that breeding for one trait may require compromising another, necessitating a balanced selection approach. The number of tillers shows a very strong positive correlation (0.81) with yield per plot, indicating that genotypes with more tillers generally produce higher yields per plot. This relationship is crucial for breeding programs focused on yield improvement, as selecting genotypes with more tillers can directly enhance productivity. There is also a moderate positive correlation (0.35) between the number of tillers and panicle length, suggesting that genotypes with more tillers tend to have longer panicles. This can be advantageous as longer panicles may support more rice grains, contributing to higher yields. Lastly, the weak positive correlation (0.24) between yield per plot and panicle length indicates that genotypes with longer panicles may have slightly higher yields per plot. Although the relationship is not strong, it suggests that panicle length can still play a role in increasing yields.

DISCUSSION

This study explores the potential of various local rice varieties from West Sumatra in facing the challenges of cultivation on peatlands, particularly in Padang Pariaman Regency. A total of 20 varieties were previously explored by (Zul *et al*., 2024), who documented their genetic diversity and environmental adaptation. Overall, the results of this study show that from the 20 genotypes tested on peatlands, several of them hold promising potential for future cultivation.

The peatland at the research site presents highly challenging chemical characteristics, such as high acidity, low ash content, and limited availability of essential nutrients. Soil chemical analysis revealed highly acidic pH, high organic carbon content, and low levels of nitrogen, phosphorus, and potassium. The high acidity is primarily caused by the accumulation of organic acids produced from the decomposition of organic matter, such as citric acid and oxalic acid, which affect nutrient availability and soil microorganism activity (Clarholm *et al*., 2015). The testing of 20 rice varieties aimed to identify which varieties could adapt to the low fertility of peat soils. The high acidity of the peat soil at the three research sites is largely due to organic acids produced from the decomposition of organic matter such as litter and plant residues (Adeleke *et al.,* 2017). These organic acids contain carboxyl (-COOH) and hydroxyl (-OH) groups from phenols, which are weak acids that dominate the ion exchange complex in the soil (Qiao *et al*., 2024). The dissociation of these acids releases large amounts of H^+ ions, contributing to the high acidity of peat soils (Dasgupta *et al*., 2015).

The relationship between soil acidity and nutrient efficiency is one of the main challenges in improving productivity on peatlands. High acidity, for example, reduces phosphorus availability by binding it into compounds that cannot be absorbed by plant roots, worsening nutrient deficiencies (Barrow and Hartemink, 2023). Furthermore, low pH can inhibit the activity of soil microbes involved in the nitrogen and phosphorus cycles, slowing down essential mineralization processes for plants (Neina, 2019).

This research was conducted at three different sites (LP-1 Sunua Nan Sabaris, LP-2 Pungguang Kasik, and LP-3 Parak Pisang). Among these, LP-1 was selected as the main location for testing the 20 local rice varieties. The results showed that varieties like Batang Piaman and Cisokan adapted well to the acidic and nutrient-poor peat soils. This adaptation was evident in their superior agronomic traits, such as optimal plant height, high tiller number, and satisfactory grain yield. Furthermore, these varieties also showed tolerance to high temperatures (Sari *et al.,* 2019), which is a crucial characteristic for rice cultivation in marginal peatland areas. The relationship between high temperature tolerance and adaptation to peatland conditions reflects the plants' physiological resilience, enabling them to withstand extreme environmental conditions (Osaki *et al.,* 2021).

However, existing peatland management strategies, such as drainage-based systems, face significant challenges. While these methods are often used to reduce water levels and enable crop cultivation, their environmental impact is substantial (Ferré *et al*., 2019). Excessive drainage systems have been shown to accelerate subsidence (land sinking), increase the risk of fires, and accelerate carbon emissions in the form of CO_2 into the atmosphere (Huning *et al*., 2024). This contributes to overall peatland degradation. As an alternative, a paludiculture-based approach has been proposed as a solution to maintain peatland ecosystems while supporting agricultural sustainability. Studies in Central Kalimantan have shown that crops such as sago (*Metroxylon sagu*), bananas (*Musa paradisiaca*), pineapples (*Ananas comosus*), kelakai (*Stenochlaena palustris*), and dragon fruit (*Hylocereus undatus*) can grow without intensive drainage, providing benefits both to farmers and the peatland ecosystem (Uda *et al.,* 2020). Furthermore, other research suggests that paddy land use has a lower impact on peatland subsidence (Yokochi *et al*., 2020). Wetland peat or rewet peatland for agriculture may be a valid option for sustainable management. This approach could more effectively mitigate soil subsidence and the loss of peat layers (Yokochi *et al*., 2020).

The high organic carbon content in peatland soils is also an important factor in understanding the dynamics of these lands (X. Wang *et al*., 2022). The proportion of undecomposed organic material indicates a high potential for carbon storage, but it also poses a challenge because this organic material tends to produce acidic organic compounds during decomposition (Senesi and Loffredo, 2018). The eutrophic nature of the peat soil at the research site, with ash content ranging from 16.27% to 39.13%, also suggests mineral enrichment that may come from river runoff or flooding (Webster *et al*., 2015). The relationship between this mineral enrichment and the potential for plant productivity requires further exploration. For example, careful management of pH and drainage could improve nutrient use efficiency and prevent damage to the peatland ecosystem.

To maximize the potential of local rice varieties on peatlands, breeding strategies should focus on improving tolerance to acidity and nutrient use efficiency (Weltzien and Christinck, 2017). This can be achieved through the crossbreeding of superior genotypes with specific adaptation traits for peatland environments. The optimization of agronomic techniques, such as the use of organic fertilizers, biofertilizers, and efficient irrigation management, is also essential (Sharma *et al*., 2024). Additionally, biotechnology-based approaches, such as the development of acid-tolerant rice through genetic engineering, hold great potential to support the sustainability and productivity of peatland cultivation (Smith *et al*., 2024).

The identification of superior genotypes such as Batang Piaman and Cisokan offers great hope for developing sustainable rice production systems on peatlands. The relationship between variety adaptation to difficult peatland conditions and innovative management techniques is key to success. By focusing efforts on high-performing genotypes and integrating environmentally friendly agronomic practices, West Sumatra can not only enhance rice production on peatlands but also support the livelihoods of local farmers, strengthen regional and national food security, and reduce harmful environmental impacts.

To effectively manage peatlands in Sumatera Barat, it is crucial to adopt integrated, cross-sectoral approaches that engage all stakeholders in transparent and inclusive dialogues. As highlighted by (Hergoualc'h *et al*., 2018), the conservation of remaining peat swamp forests and the sustainable management of peatlands require collaboration between local communities, government bodies, and the private sector. Key to this is defining clear strategies for restoration versus rehabilitation, ensuring transparency in the status of protected areas, and enhancing local economies through community empowerment and capacity-building in peatland management. To incentivize sustainable practices, the development of wetland-adapted livelihoods and agro-business models that are financially viable is essential. Additionally, a rigorous analysis of the environmental, economic, and social impacts of these alternatives, along with coordinated actions at both local and larger scales, will be vital in mitigating the degradation of peatlands and reducing greenhouse gas emissions. By aligning the management of peatlands with these comprehensive recommendations, Sumatera Barat can work towards achieving both agricultural sustainability and environmental conservation.

CONCLUSION

This research reveals that peat soils in West Sumatra, particularly in Padang Pariaman Regency, exhibit poor fertility characteristics, with high acidity levels and low nutrient availability. Certain local rice varieties, such as Batang Piaman and Cisokan, demonstrate good tolerance to planting conditions in peatland, with optimal plant height, numerous tillers, and satisfactory grain yield. Selecting appropriate varieties and implementing soil management techniques, such as liming and organic matter application, can enhance rice productivity in these peatlands. Furthermore, the adoption of integrated, cross-sectoral approaches is critical to ensuring sustainable peatland management. This includes fostering local community empowerment, incentivizing wetland-adapted livelihoods, and coordinating efforts across various stakeholders. These findings recommend the development of local rice varieties suitable for peatlands, along with the improvement of breeding programs, more effective cultivation strategies, and the implementation of sustainable land management practices to support both agricultural productivity and environmental conservation in peatland areas.

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Contact information

Irfan Suliansyah: irfansuliansyah@agr.unand.ac.id (corresponding author)