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RESEARCH ARTICLE
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Vegetative Growth Phase of *Mentik Susu* Local Rice Species with the Application of Perokan Fertilizer

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ABSTRACT

It focuses on examining the impact of Perokan liquid organic fertilizer on the vegetative growth phase of the Mentik Susu rice variety grown in acid-sulfate soil. Mentik Susu is a fragrant Indigenous rice that lacks a strong brand identity but is liked by consumers for its taste and texture. Often, yield constraints are faced because of the type of soil used. The treatments we used are 2mL of NASA fertilizer as a control and four levels of Perokan fertilizer at 1, 3, 5, and 7mL/L water. In the case of the 7mL dose of Perokan, there is a highly significant increase in plant height, which is 88.18±1.6cm, and the number of tillers is 14.75, resulting in the highest yield per plant of 40.10±2.6g. In other words, although the phosphorus, potassium, and organic carbon were detected to be low in Perokan, the quality and slightly acidic pH of its nitrogen were all the ingredients for vegetation growth. From the study, it can be concluded that Perokan fertilizer, especially at the level of 7mL, demonstrates a significant potential in improving the growth and yield potential of Mentik Susu rice under low fertility nutrient soil, providing a reliable and effective organic fertilization alternative.

Keywords: Fertilizer, Liquid, Organic, Perokan, Rice, Vegetative

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INTRODUCTION

Indonesia is an agricultural country whose population lives in the agricultural sector; one of the main crops in agriculture is rice. Rice plants are a critical commodity and a staple food in Indonesia (Rahma et al., 2019). The people mainly consider rice to produce. Indonesia is one of the highest rice producers in the world, with a total production of up to 75 million tons per year (Yunus et al., 2018). Based on this information, it is essential to maintain rice production in Indonesia (Indrasari et al., 2020), and efforts can be made to maximize the growth of rice plants. The growth of rice plants in the vegetative phase affects rice yield; the faster the rice growth, the quicker the rice plants will produce grain (Mahmudi et al., 2023). The vegetative phase is a growth phase that increases the tiller's total rice plant height, weight, and leaf (Makarim, 2009). The appearance of panicles marks the last vegetative phase. The vegetative phase determines the yield of rice plants.

Rice is a source of food and nutrition and is cultivated worldwide (de Miranda et al., 2015). High-quality rice can be produced from sound processing or varieties with specific flavors and characteristics (Custodio et al., 2019). Aromatic rice is rice that the public likes because it has a distinctive aroma and taste. One rice variety produces high-quality aromatic rice and has a higher selling value is the *Mentik Susu* local rice variety.

Mentik Susu has a fluffier character, delicious taste, and aroma (Indrasari et al., 2020). The *Mentik Susu* rice variety is resistant and does not collapse easily. The rice is milky white and contains carbohydrates, protein, fat, and fiber, which can meet nutritional needs (Nirmagustina & Handayani, 2023). The *Mentik Susu* rice is organic, so it is healthy to consume. However, *Mentik Susu* rice still has a low production level, and using the System of Rice Intensification (SRI) method is a solution because the seeds used are insignificant compared to general cultivation methods (Yunus et al., 2018).

Rice cultivation has good potential in South Kalimantan, and large land areas are suspected to have acid-sulfate properties. Acid sulfate soil is mostly in Swamp land. Around 2.2% of the land is tidal Swamp land,

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which is a total of five million ha of the land potential of South Kalimantan (Nugroho, 2020; Praveen et al., 2024). The obstacles to developing rice cultivation on acid-sulfate land include needing more essential elements and low organic and soil pH (Febriana et al., 2018). The low pH causes the soil to react with acidic; potassium and magnesium can be exchanged a little, causing poisoning caused by Al, Fe, and Mn (Nugroho, 2020). For this reason, agricultural development on this land requires efforts to improve soil structure, soil pH, and nutrients by providing organic materials and balanced fertilization (Yan et al., 2023; Oseyatoko, 2023).

Organic fertilizer application in acid sulfate soil improves the soil's organic matter content and structure (Xing et al., 2024). The fertilizer used in the present research is a liquid organic fertilizer with the advantage of being easily absorbed by plants and containing macro and micronutrients (Hadisuwito, 2007; Febriana et al., 2018; Yan et al., 2023). The research utilizes fertilizer derived from marine fish innards' waste, which is processed into liquid organic fertilizer Perokan. The experiment fertilizer treatment of skipjack tuna offal fermented for 10 days contained NPK with a ratio of 3.74, 3.02, and 1.48% (Suartini et al., 2018). According to the Decree of the Minister of Agriculture number 261 in 2019, the standards for liquid organic fertilizer must be maintained to be minimum C-organic is 10%, pH 4-9, and $N+P_2O_5+K_2O$ is 2-6% so that nitrogen and phosphorus elements have met the standards.

This research studied the effect of Perokan on the growth of the Mentik Susu rice variety on acid-sulfate soil up to the vegetative phase. It determined the best concentration for this purpose as a best practice for the growth of Mentik Susu rice plants.

MATERIALS & METHODS

The experiment focuses on improving the rice yield of *Mentik Susu* through acid sulfate soil treatment, fish innards, salt, manure, and water. It was conducted from May until August 2023 at the Agroecotechnology Department, Lambung Mangkurat University, and the Laboratory at the Banjarbaru Industrial Standardization and Services Center, South Kalimantan.

This experimental design had five treatments and four replications, thus a total of 20 experimental units. The treatments P0 to P4 contained Perokan 0 (Control), 1, 3, 5, and 7mL/L of water, respectively.

We collect fish innards waste and the entrails of marine fish, including skipjack and tuna waste, at Banjarbaru Central Market. We clean all fish waste and grind the fish innards until smooth. Then, we took 2kg of finely ground fish waste, added 10% Sodium chloride, and stirred until evenly mixed. The waste was filled into bottles (1.5L), fermented for 10 days in sunlight, and then the Perokan fertilizer was ready.

Soil sampled as acid sulfate soil at Martadah Village, Tanah Laut Regency, South Kalimantan, at 0-20cm depth. The total soil sampling was 300kg, then packed every 10kg. The soil weighing 10kg/pack was added with 45g of manure each, and water was stirred until the media became mixed and incubated for 14 days.

Prepared the *Mentik Susu* rice seeds, soaked them for 24 hours in plain water to speed up germination, drained the soaked seeds with a cloth, and left them there for 48 hours or until the germination. Prepare a seedling media by placing acid sulfate soil and manure in a 1:1 ratio and water until moist in a tray. Germinated seeds were evenly placed over the surface of the seedling media and covered with a thin layer of soil, and these seedling media were watered daily to maintain humidity during sowing (Mutakin, 2005).

Planting seeds uses the SRI method: planting young seeds 8-12 days after germination. One seed stalk was planted with a spacing of 30x30cm (Jiang et al., 2022; Yan et al., 2023; Yang et al., 2023). Shallow planting with a depth of 2-3cm. Fertilization was applied eight times weekly to each treatment, as mentioned above. The application was conducted after observation and data collection in the morning by spraying the fertilizer on the leaves given every week at P0. Namely, 2mL/L water of NASA fertilizer was applied to the control group while other treatment groups (P1-P4) received *Perokan* fertilizer. For each treatment (P1-P4), 100mL of coconut fiber fertilizer and up to 1 liter of water were added.

The maintenance conducted was 1) embroidery for a maximum of 14 days, 2) technical/mechanical weeding, 3) pest and disease control using organic farming concepts, mechanical power, and plant and biological pesticides, and 4) observing the water level in the bucket. The parameters studied included increasing rice plant height up to eight weeks after planting (WAP), the number of tillers at the end of vegetative growth, and the daily emergence time. At the end, the yield/plant was recorded.

The obtained data were subjected to homogeneity test analysis using the Bartlett test, and then ANOVA was applied. Means were compared using Duncan's Multiple Range Test (DMRT) at $P<0.05$.

RESULTS & Discussion

The analysis of pH and the macronutrients of N, P, K, and C-organic in *Perokan* was compared with the standards for liquid organic fertilizer based on the applicable regulation presented in Table 1.

Table 1: Macronutrient analysis of *Perokan* fertilizer compared to the standard values

Parameters	Unit	Result	Standard*	Summary
pH	-	5.42	4-9	Meet Standard
N-Total	%	2.26	2-6	Meet Standard
P_2O_5	%	0.57	2-6	Not Meet
K_2O	%	0.21	2-6	Not Meet
C-organic	%	6.68	10	Not Meet

*Standard: Decree of the Minister of Agriculture number 261/KPTS/SR.310/M/4/2019.

The nutrients in Perokan fertilizer met the nutritional needs of rice plants. The laboratory testing results for the pH content and N nutrients contained in Perokan fertilizer have met the quality standards for fertilizer criteria (Rahma et al., 2019). This standard indicated minimum N contents to be 2-6% and pH 4-9. In nitrogen testing of Perokan fertilizer at the Banjarbaru Industrial Standardization and Services Laboratory, a value of 2.26% was obtained.

According to Supartha et al. (2012), the nutrient N plays a vital role in plants' growth and development stages. Nitrogen fertilization below optimal levels usually leads to N deficiency in plants. Plants that lack nitrogen will slow down growth, which can cause plants to become stunted, their leaves turning pale green, causing the photosynthesis process to slow down. In the present study, nitrogen in tested fertilizer was slowly becoming available to plants (Setyanti et al., 2013; Yasin, 2016; Mie et al., 2022). The N nutrient content in Perokan can increase rice plant height, number of tillers, and time for panicles to appear in rice plants.

The pH analysis of Perokan met the quality standards according to the Minister of Agriculture Decree, which is 5.42, classified as acid. The pH value of fertilizer complies with standards, making it safe for plants. The pH value can also be used as an indicator of soil fertility.

The P, K, and C-organic macronutrients contained in Perokan fertilizer do not meet the quality standards for liquid organic fertilizer (Rahma et al., 2019), which sets a minimum P and K content of around 2-6% and a minimum organic C of 10%, in the P and K test of Perokan fertilizer at the Banjarbaru Industrial Standardization and Services Laboratory. The tested Perokan fertilizer had low P, K, and C-organic values; those were 0.57, 0.21, and 6.68%, respectively. The low content of organic P, K, and C nutrients in Perokan fertilizer can still increase the rice plant height, the tillers, and the emergence of panicles (Qaswar et al., 2020; Liu et al., 2021).

However, the nutrient N and pH of Perokan fertilizer meet standards, so the fertilizer was found safe for plants, while the low P, K, and C-organic nutrients can impact plant quality. The Perokan fertilizer, which is applied eight times, is likely to meet the nutrient needs of rice plants. The low nutrient of organic content fertilizers could be increased by enriching nutrients or adding certain microbes (Sentana, 2010; Liu et al., 2021; Sun et al., 2022).

Table 2 presents the results of ANOVA examining the effect of 5 different treatments on three dependent variables related to rice plant growth, height, number of tillers, and appearance of the panicles as affected by the combinations of the two factors. Independent variables, i.e., plant height and tiller number, led to significant ($P<0.05$) variations in these traits. The rice plant height and the number of tillers are response traits (Kakar et al., 2021; Yan et al., 2021).

Table 2: ANOVA Results for Different Agronomic Traits

Source of Variation	df	The sum of Squares (SS)	Mean Square (MS)	F-value	P-value
Plant Height					
Treatment	4	350.25	87.56	5.12	<0.05
Error	15	256.50	17.10		
Total	19	606.75			
Number of Tillers					
Treatment	4	80.00	20.00	4.85	<0.05
Error	15	61.80	4.12		
Total	19	141.80			
Panicle Appearance Time					
Treatment	4	7.25	1.81	0.95	>0.05
Error	15	28.75	1.92		
Total	19	36.00			

Perokan Fertilizer Effect on Rice Plant Height

The result of Duncan's Multiple Range Test showed that the increase in rice plant height at the last vegetative phase of growth of *the Mentik Susu* rice variety after applying *Perokan* fertilizer increased significantly ($P<0.05$) in P2-P4 compared to treatment P0 and P1. Treatments P2-P4 did not differ in plant height (Table 3).

Table 3: Rice plant height development of *Mentik Susu* rice varieties using Perokan liquid organic fertilizer

Treatment	Increase in Plant Height (cm)
P0	80.63±2.1a
P1	80.70±2.2a
P2	86.75±1.8b
P3	87.33±1.7b
P4	88.18±1.6b

Values (Mean±SD) bearing different alphabets in a column differ significantly ($P<0.05$). The treatments P0 to P4 contained *Perokan* (organic fertilizer) 0 (Control), 1, 3, 5, and 7mL/L of water, respectively. NASA fertilizer (2mL/L water) was applied to the control group.

During the vegetative period, rice plants require more macro- and micro-nutrients to support photosynthesis. The results of photosynthesis after going through the metabolic process are used by plants for their growth, characterized by increasing rice plant height and yield (Thakur et al., 2018; Makino, 2021). The observations of the increase in rice plant height measured from transplanting to eight weeks after planting showed that the average rise in rice plant height increased every week with Perokan fertilizer application using different doses in the SRI method.

The growth of rice plants is thought to be influenced by the nutrients provided to the plants, such as Perokan fertilizer, which contains macronutrients such as N, P, and K elements, which can support the growth of rice plants, significantly increasing plant height, the N element which is very necessary for the development of leaves, stems, and plant roots (Hsieh et al., 2018; Zhang et al., 2020; Luo et al., 2020). Based on laboratory results in this research, the N element in Perokan fertilizer meets the standards for liquid organic fertilizer. Krisna (2002) stated that nitrogen is crucial in plant growth during the vegetative phase.

Effects of Perokan Fertilizer on the Number of Rice Tillers

The results of further tests by Duncan's Multiple Range Test showed that the increase in plant height at the end of the vegetative phase of growth of *Mentik Susu* rice plants after applying Perokan fertilizer gave meaningful results. The treatment of P0 was significantly ($P<0.05$) different from P1, P2, P3, and P4, while treatment P1 did not differ significantly from P2 and P3. However, it was significantly different from P4. Treatment P2 was non significantly different from P3 but was significantly ($P<0.05$) different from P4. The treatment of P3 was significantly different from P4 (Fig. 1). The number of tillers is also a part of the vegetative phase, which determines the yield of rice plants. In the present study, one rice seedling was planted in the media; however, Nugroho (2020) recommended using 1-3 stalks per planting point in lowland rice seedlings. In SRI (System of Rice Intensification) technology, the number of seeds used is one stem per planting point. It can avoid inter-species competition and reduce production costs because fewer seeds are used (Kasim, 2004). Based on observations of the number of rice tillers from transplanting to eight weeks after planting showed that the number of tillers has increased in the present study.

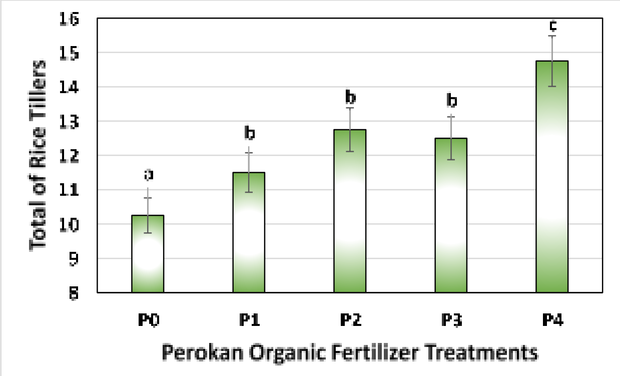

Fig. 1: Total number of tillers of the *Mentik Susu* rice varieties under the treatment of Perokan organic fertilizer. The bar/treatment bearing a similar alphabet indicates no difference (P>0.05). The treatments P0 to P4 contained Perokan (organic fertilizer) 0 (Control), 1, 3, 5, and 7mL/L of water, respectively. NASA fertilizer (2mL/L water) was applied to the control group.

Based on the results of further tests by Duncan's Multiple Range Test, applying Perokan fertilizer using the SRI method from one week after planting to eight weeks post-planting significantly increased the number of rice tillers. Providing Perokan fertilizer at a dose of 7mL has the best effect. It supports rice plants' needs by showing the increasing tillers totals. Subandi (2013) stated that giving fertilizer doses that suit plant needs can increase growth. The study by Rahma et al. (2019) reported that the number of tillers was influenced by the space available in a clump. Using the SRI method supports increasing the number of seedlings because it has the principle of planting one seed in one hole to give the plant more freedom to develop, receive light, and absorb nutrients.

Panicles Appearance Time of Mentik Susu rice

Mentik Susu rice panicles emerged in P3 (5mL of Perokan fertilizer) at 58.25 days (Fig. 2), which was significantly (P<0.05) faster than other treatments (P0, P1-P2, and P4). In P0, panicle emergence was significantly (P<0.05) longer than in other treatments, while this time was non-significantly different in other treatments (P1-P2, and P4). Significantly faster panicle emergence in P3 could be because the nutrients N, P, and K contained in a dose of 5mL of Perokan fertilizer are sufficient to meet plant needs. In the laboratory test results, the N nutrient contents in Perokan fertilizer have met the quality standards for liquid organic fertilizer (Table 1). Patti et al. (2013) explained that one of the essential roles of nitrogen is panicle formation, where the total N-plant during panicle formation ranges from 1.31-1.42%. So, the emergence of panicles cannot be separated from nitrogen availability.

Subandi (2013) reported the formation of panicles for rice plants 50 days after planting. The reproductive stage of rice plants starts from the emergence of panicles and continues until flowering. The reproductive period of rice plants is divided into four phases: panicle growth, shoot elongation, panicle emergence, and flower emergence. The late emergence was found in treating 2mL of NASA fertilizer (control). It can be interpreted that Perokan fertilizer stimulates and accelerates the emergence of panicles, as observed in P3. Setyanti et al. (2013) reported that providing sufficient nutrients will influence photosynthesis and plant metabolism so that they grow smoothly. The photosynthesis results will stimulate vegetative growth in plants so that if their growth is optimal, they will immediately enter the regenerative phase, marked by the release of the panicles of the rice plants.

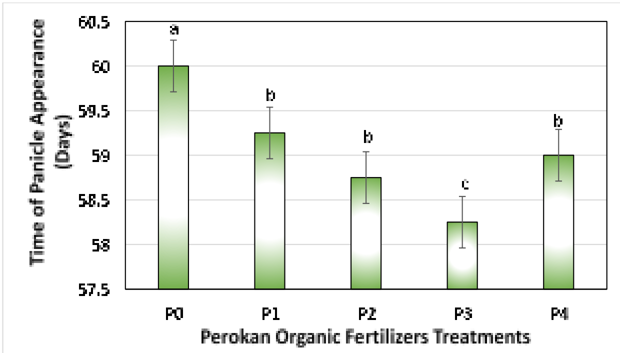

Fig. 2: A total of panicles appear in Mentik Susu Rice Varieties. The bars bearing the same alphabet differ non-significantly. The treatments P0 to P4 contained Perokan (organic fertilizer) 0 (Control), 1, 3, 5, and 7mL/L of water, respectively. NASA fertilizer (2mL/L water) was applied to the control group.

Effect of Perokan Fertilizer on Rice Plant Yield

The yield of Mentik Susu rice was the highest in P4 (7mL of Perokan fertilizer), which was significantly (P<0.05) higher than in control and P1 (Table 4). A non-significant difference was observed in the yield of P2 to P4. The high yield in treatment P4 suggested that the treatment improved yield against the control group. Rice plants must absorb enough N, P, and K during growth to obtain optimum growth characteristics and yield (Moe et al., 2019). Chemical fertilizers (CF) have been widely used to enhance rice yield. However, the application of large amounts of CF has led to the degradation of agricultural land and declining crop yields. Therefore, we applied organic fertilizer (Perokan) that supplies sufficient N, P, and K for rice growth and better yield (Nishio, 2007; Salam et al., 2021).

Table 4: Yield/plant of Mentik Susu rice varieties under different Perokan liquid organic fertilizer treatments

Treatment	Yield/Plant (g)
P0	32.50±3.5a
P1	33.20±3.3a
P2	38.75±2.8b
P3	39.50±2.7b
P4	40.10±2.6b

Values (Mean+SD) bearing different alphabets in a column differ significantly (P<0.05). The treatments P0 to P4 contained Perokan (organic fertilizer) 0 (Control), 1, 3, 5, and 7mL/L of water, respectively. NASA fertilizer (2mL/L water) was applied to the control group.

Conclusion

This research evaluated the effect of Perokan liquid organic fertilizer on the vegetation of Mentik Susu rice on acid-sulfate soil. P4, which was Perokan with the application of 7mL gave, had the highest plant height at 88.18±1.6cm, as well as the highest number of tillers of 14.75, hence a better performance as compared to other treatments. The yield per plant was also highest at this dose, 40.10±2.6g. Thus, the content of phosphorus (P), potassium (K), and organic carbon (C-organic) were in Perokan still lower than the standard, while nitrogen (N) content and pH were within the permissible range, providing excellent growth of vegetation. There was no significant difference in the panicle appearance time of all the treatments, though there was an early panicle appearance time in the P4 treatment at 58 days. The study shows that using Perokan fertilizer, especially at 7mL, significantly increases vegetative growth and yield in Mentik Susu rice under acid-sulfate soil conditions. This makes it a reasonable candidate for an organic fertilizer that can be used in the long run, but it still requires optimization of the nutrient value.

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