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Research Article

Application of Liquid Organic Fertilizer to Improve Yields in System of Rice Intensification (SRI)

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Abstract

Background and Objective: Organic fertilizer is a source of nutrition for plants which is an alternative to inorganic fertilizer. Liquid organic fertilizer (LOF) which comes from coconut fiber and banana LOF which comes from banana stems from which the fruit has been removed, so that wasted plant residue can be used as fertilizer. The study aimed to obtain the best type of LOF and concentration in increasing the growth and yield of the Batang Piaman rice variety using the SRI method. **Materials and Methods:** The research was conducted from June to December, 2023 in Padang City, West Sumatra. The method used was an experiment with a Randomized Complete Block Design (RCBD) in nested with each treatment consisting of 3 groups. The treatment consisted of LOF types at two levels (banana stems and coconut fiber) and LOF concentrations at seven levels (0, 50, 100, 150, 200, 250 and 300 mL/L). Observational data were analysed by variance analysis with F test at 5% real level, but if there were differences, it was continued with DMRT further test at 5% real level by STAR IRRI Philippine software (Philippine). **Results:** The results obtained were that LOF coconut fiber provided better growth components, yield components and physiological components than banana stem LOF with the best concentration, on the provision of LOF coconut fiber 100 mL/L on the number of rice plant tillers and stomatal density and concentration of 200 mL/L on the number of productive tillers. **Conclusion:** The application of LOF coconut fiber is better for the growth and yield of rice plants of the Batang Piaman variety compared to the administration of LOF banana stems by applying coconut fiber liquid organic fertilizer with a concentration of 100 mL/L, it is recommended to add coconut fiber LOF to rice fields to increase growth and yield.

Key words: Batang Piaman, liquid organic fertilizer, system of rice intensification, yield components, coconut fiber, banana stems

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Rice plants still dominate the agricultural sector with the vast amount of rice field available in Indonesia. This is because the demand for rice is increasing along with the increase in population. The increase in Indonesia's population that occurs every year requires efforts to increase rice production in Indonesia so that domestic needs can be met.

One of the efforts made by the government to increase rice production is to use balanced fertilizers. Fertilizers must be sufficiently given to plants so that plants absorb nutrients according to the needs of these plants. Fertilizers are given to plants in the form of inorganic fertilizers and organic fertilizers. Organic fertilizer is a source of nutrition for plants, an alternative to inorganic fertilizers. In addition to its nutritional content, organic fertilizers contain bioactive molecules that are beneficial for plant growth and productivity[1]. Organic fertilizers have many benefits because they contain macro and micronutrient so the availability of nutrients in the soil is more complete. One of the benefits of organic fertilizers is to improve the physical, chemical and biological properties of the soil so that the soil becomes fertile and plants develop properly.

Organic fertilizers are easily processed and obtained by the community because the raw materials are available around the community environment. Organic fertilizers in the form of solid or liquid can be processed from plants or plant residues that are found around the community. Organic fertilizers are easy and inexpensive because they are easy to obtain raw materials, one example is liquid organic fertilizer (LOF) which comes from coconut fiber and LOF banana stems which comes from banana stems that have been taken for fruit the remaining plants that have been wasted can be used as fertilizer. Coconut fiber contains lignin and cellulose and is rich in potassium and the micronutrients Fe, Mn, Zn and Cu[2]. Coconut fiber contains several elemental compositions including SiO_2, K_2O, Al_2O_3, SO_3, Fe_2O_3, P_2O_5, Cl and other elements that form naturally in the soil[3]. In addition, the macronutrient components included in coconut fiber are essential for boosting soil fertility and promoting plant growth[4]. Administration of LOF coconut fiber can increase soil K levels, plant height and the number of leaves in corn plants[5]. The LOF treatment of coconut fiber at a concentration of 150 mL/pot given to corn plants had a significant effect on plant height, number of leaves, root dry weight and CEC[6].

In addition, the administration of 250 mL LOF of coconut fiber and banana stems responded to the growth and yield of peanuts, namely plant height and number of leaves aged 28 days after planting (DAP)[7]. Important elements found in banana stems include nitrogen (N), phosphorus (P) and potassium (K) and also contain 14.89% carbon, 1.05% nitrogen, 0.04% phosphorus and 0.76% potassium[8]. In addition, banana stems also contain lignin (83%) and cellulose (15-20%)[9]. Nitrogen which is mostly found in banana stems, is essential for the development of the plant's vegetative portions. Banana stems are frequently thrown away and squandered. Plant-beneficial liquid organic fertilizer can be created from this organic waste. Because it contains ingredients that break down easily, liquid organic fertilizer is an organic fertilizer kind that plants may easily absorb. Liquid organic fertilizer for banana stems also helps the plant build its vegetative components, speeds up photosynthesis, forms organic compounds and encourages the growth of microorganisms in the soil. The purpose of the study was to obtain the best type and concentration of LOF to enhance the growth and yield of Batang Piaman variety using the SRI method. The LOF coir supplementation can be recommended for rice plant growth and yield in rice fields.

MATERIALS AND METHODS

Study area: The experiment was performed at irrigated rice fields in Balai Gadang Village, Koto Tangah Sub-District, Padang City, West Sumatra Province (0°49'48 S, 100º21'15E) from June-December, 2023.

Materials: The material in research was banana stems, coconut fiber, seeds of the Batang Piaman variety, fertilizer, pesticide, hand tractor and tools of agriculture.

Methods: The method used was an experiment with a Randomized Complete Block Design (RCBD) in nested with each treatment consisting of 3 groups. The treatments given were the type of LOF (coconut fiber and banana stem) and LOF concentration (0, 50, 100, 150, 200, 250 and 300 mL/L). The observed variables were the growth component, yield component, physiological component and plant P and K nutrient uptake.

Implementation of the research: The implementation of the research started from the nursery which was carried out in the seed bed and after the age of the seedlings in the nursery 15 days, the seedlings were planted in experimental plots with a plot size of 2×5 m with a spacing of 30×30 cm. Seedlings were planted one stem per planting hole in a randomized soil condition. During the vegetative phase, the soil was moist, but in the generative phase, the soil was flooded to a height of 3-5 cm. Weed control was carried out starting at the age of

10 days after planting and repeated every 10 days. Similarly, pest and disease control was controlled as early as possible so that plants are free from pests and diseases. Harvesting is done when it has reached the harvest maturity criteria of Batang Piaman rice variety. The LOF banana stem and LOF coconut fiber treatment were given from the 2nd to the 9th week (phase vegetative until phase generative). Plant growth observations were made during the vegetative phase and observation of yield components was carried out after harvest and observation P and K nutrient uptake plant.

Statistical analysis: Observational data were analyzed by variance analysis with F test at a 5% real level, but if there were differences, it was continued with DMRT further test at 5% real level by STAR IRRI Philippine software (Philippine).

RESULTS

The results of growth components of the Batang Piaman rice variety were displayed in Table 1-4.

Yield component data that has been analyzed with variance was presented in Table 5-6. Yield component data observed were number of productive tillers, panicle length, number of grain, weight of 100 seeds and yield of rice plants.

Fig. 1(a-b) and 2(a-b) showed the appearance of 100 grain and root weight of rice plants with the application of coconut husk LOF and banana stem LOF.

From Fig. 3(a-b), it can be seen that the density of stomata at week 10-12 after planting is significantly different between the type of coconut fiber LOF and banana stem LOF.

Table 1: Height of rice plants with the application of LOF per week

	Week							
Type of LOF	1	2	3	4	5	6	7	8
Coconut fiber	25.93	35.30[a]	39.54[a]	47.29	53.22	64.55[a]	71.63[a]	77.14[a]
Banana stem	24.84	29.35[b]	36.43[b]	44.62	50.91	57.44[b]	61.23[b]	64.98[b]

*Numbers followed by the same letter in the same column and the same treatment factor are not significantly different in the α = 5% of DMRT test

Table 2: Height of rice plants with LOF concentration treatment per week

	Week							
Concentration of LOF (mL/L)	1	2	3	4	5	6	7	8
0	24.67	31.35	36.37	45.31	49.77	58.55	64.07	68.23
50	26.01	32.20	38.93	45.58	51.42	60.54	65.67	70.03
100	24.80	31.84	37.62	45.79	53.45	62.79	68.56	73.18
150	25.53	33.35	30.11	47.67	55.82	64.45	69.88	74.39
200	25.63	32.37	37.56	45.55	51.70	59.88	65.43	70.06
250	24.69	32.67	36.91	45.76	50.87	60.15	65.12	70.63
300	24.41	32.55	39.38	46.00	51.45	60.60	66.28	70.91

*Numbers the same column are not significantly different in the α = 5% of F-test

Table 3: Number of tillers of rice plants with the application of LOF per week

	Week							
Type of LOF	1	2	3	4	5	6	7	8
Coconut fiber	3.05[a]	5.56[a]	7.28[a]	9.58[a]	12.98[a]	13.45	16.51	24.40[a]
Banana stem	1.68[b]	2.48[b]	4.37[b]	6.91[b]	9.60[b]	12.40	16.02	19.91[b]

*Numbers followed by the same letter in the same column and the same treatment factor are not significantly different in the α = 5% of DMRT test

Fig. 1(a-b): Representative images appearance of (a) 100 grain and (b) Root length with coconut fiber LOF application

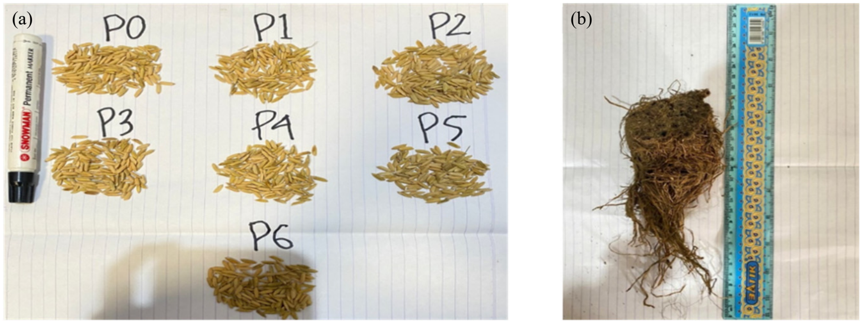

Fig. 2(a-b): Representative images appearance of (a) 100 grain and (b) Root length with banana stem LOF application

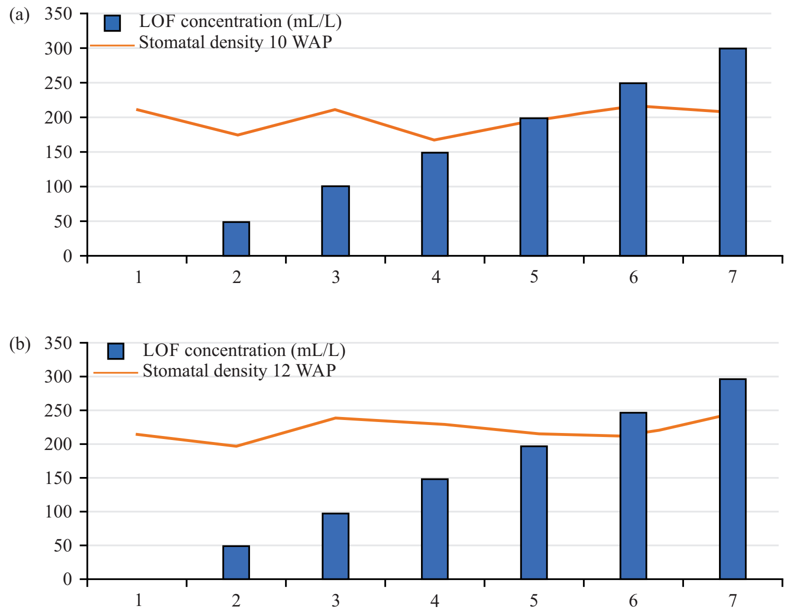

Fig. 3(a-b): Representative images (a) Stomata density 10 WAP and (b) Stomata density 12 WAP

Table 4: Number of tillers of rice plants with the application of LOF concentration per week

	Week							
LOF of concentration (mL/L)	1	2	3	4	5	6	7	8
0	2.42^{abc}	3.89^{ab}	5.82^{ab}	7.50	9.08	10.17	13.11	18.42^{b}
50	2.53^{ab}	4.11^{ab}	5.70^{ab}	8.47	11.00	12.50	15.67	21.11^{ab}
100	2.14^{c}	3.72^{b}	4.70^{b}	7.76	12.47	14.75	18.36	24.67^{a}
150	2.40^{a}	4.47^{a}	6.75^{a}	8.81	11.67	12.70	16.39	22.11^{ab}
200	2.47^{ab}	4.05^{ab}	5.86^{ab}	8.50	12.06	13.60	16.78	24.22^{ab}
250	2.02^{c}	4.03^{ab}	5.57^{ab}	7.75	10.67	12.08	15.33	20.50^{ab}
300	2.33^{abc}	4.17^{ab}	6.39^{ab}	9.03	12.11	14.72	18.33	24.06^{ab}

*Numbers followed by the same letter in the same column and the same treatment factor are not significantly different in the $\alpha = 5\%$ of DMRT test

Table 5: Components of rice plant yield with the application of LOF coconut husk and banana stem

Type of LOF	Number of productive tillers	Panicle length	Number of grain	Number of full fledged grains per panicle	Seed weight per panicle	100 seed weight	Yield per plot original	Yield per plot transformation
Coconut fiber	19.02	24.08	130.05	122.26	3.63	27.87^{a}	3.02^{a}	2.69^{a}
Banana stem	18.22	24.69	127.29	121.01	3.53	27.69^{b}	0.82^{b}	1.85^{b}

*Numbers followed by the same letter in the same column and the same treatment factor are not significantly different in the $\alpha = 5\%$ of DMRT test

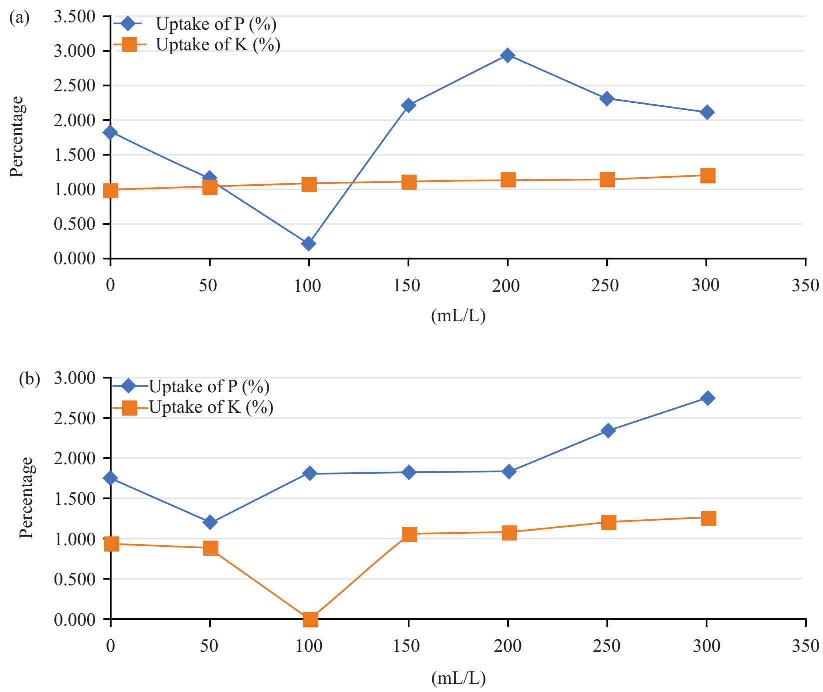

Fig. 4(a-b): Representative images (a) P and K nutrient uptake in shoot rice plant of Batang Piaman variety and (b) P and K nutrient uptake in root rice plant of Batang Piaman variety

Table 6: Components of rice plants yield with the application of LOF concentration

LOF concentration (mL/L)	Number of productive tillers	Panicle length	Number of grain	Number of full fledged grains per panicle	Seed weight per panicle	100 seed weight	Yield per plot original	Yield per plot transformation
0	15.07^{b}	23.84	126.47	117.43	3.48	27.52	1.43	2.13
50	19.06^{ab}	23.55	125.27	121.31	3.58	27.50	2.15	2.31
100	19.06^{ab}	24.91	140.32	130.01	3.75	27.94	2.50	2.47
150	16.72^{ab}	24.23	132.03	121.05	3.53	28.06	1.75	2.21
200	21.29^{a}	24.96	123.03	133.88	4.03	28.18	2.11	2.39
250	20.66^{ab}	25.24	128.75	116.12	3.42	27.63	1.93	2.28
300	18.48^{ab}	23.97	119.93	111.63	3.25	27.64	1.55	2.14

*Numbers followed by the same letter in the same column and the same treatment factor are not significantly different in the $\alpha = 5\%$ of the DMRT test

The data in Fig. 4(a-b) showed that P nutrient uptake in shoot rice plants with concentration LOF coconut fiber and banana stem. The concentration of 100-300 mL/L is higher than 0 mL/L to P nutrient uptake in the shoot rice plant as well as concentration of 100-300 mL/L is higher than 0 mL/L to K nutrient uptake in the root rice plant.

DISCUSSION

From Table 1 it can be seen that there is a significant difference between the LOF of coconut fiber and banana stems on the height of rice plants. The height of the rice plants was higher in the administration of LOF coconut fiber compared to the LOF of banana stems. This is because coconut fiber contains the nutrient K which is very useful for the growth of rice plants, while banana stems contain then nutrient P which is useful for fruit formation. Nutrient P phosphorus can stimulate the root growth of young plants, and accelerate the flowering and ripening of fruit, seeds or grain[10]. In addition, the element P plays an important role in various cellular processes, including maintenance of membrane structures, synthesis of bio molecules, assisting in cell division, activation or inactivation of enzymes and carbohydrate metabolism[11].

The element K plays an important role in various biochemical and physiological processes of plants, in this case, the process of protein synthesis, carbohydrate metabolism and enzyme activity[12]. In addition, it also plays a role in the process of photosynthesis, respiration, homeostasis, opening of stomata, regulating the distribution of water in plant cells and as an enzyme activator and helping the absorption of water and nutrients from the soil[13].

Coconut fiber contains a K element of 10.25% so coconut fiber can replace KCl fertilizers on the market[14]. According to agricultural research, the coconut husk is composed of 30% fiber and 70% pith, with high lignin and phenolic content[15]. Coconut fiber has a thickness of 5-6 cm with a chemical composition consisting of cellulose, lignin, pyroligneous acid, gas, charcoal, tretinoin and potassium.

In Table 2 it can be seen from the LOF concentrations given that the plant heights are almost the same, this is because the LOF concentrations have not affected the height of the plant. It is suspected that this occurs because the levels of K nutrient content in the soil are sufficient for plant growth. After all, the K nutrient content in the soil is relatively high (0.987%), so applying LOF or without LOF, there is enough K nutrient content in the soil that can be absorbed by rice plants. Increasing supply will not increase plant growth if nutrients are already present in sufficient quantities in the soil[15].

In Table 3 it can be seen that the number of tillers of rice plants was significantly different between the applying of coconut fiber LOF and banana stem LOF, where coconut fiber LOF formed more tillers than banana stem LOF. This is because LOF coconut fiber contains the element K which is needed in plant growth, especially in physiological processes. Element K stimulates the growth of plant roots so that when the roots develop properly, the growth of the upper plants will also develop well too. Rice plant tillers are formed during the growth phase, namely the vegetative phase of the plant, where the elements needed for the growth of these plants are elements N and K. Giving potassium can increase the number of tillers per hill in rice plants[16]. The maximum uptake of the nutrient potassium by rice plants occurs during the growing season the elongation stage to the heading stage. While in banana stems LOF contains a lot of P nutrients, where element P is needed in the formation of fruit.

Giving LOF with different concentrations also gives a different number of tillers (Table 4). This is because the tillers of rice plants are more influenced by the amount of nutrients that can be absorbed by plants. The POC concentration of 100 mL/L LOF is better than concentrations of 0, 50, 150, 200, 250 and 300 mL/L. It is suspected that at the LOF concentration of 100 mL/L, the nutrients needed by the rice plants are sufficient to be absorbed by the roots of the rice plants. Nitrogen is the primary component of banana stems and is crucial for the development of the plant's vegetative portions. Furthermore, LOF banana stems are used to generate the vegetative portion of the plant, quicken photosynthesis, create organic compounds and promote soil-dwelling microorganism growth. Yield component data that has been analyzed with variance was presented in Table 5 and 6. Yield component data observed were the number of productive tillers, panicle length, number of grains, the weight of 100 seeds and yield of rice plants.

From Table 5 it can be seen that the type of LOF given affects the weight of 100 seeds and the yield of rice plants per plot but has not affected the number of productive tillers, panicle length and the number of grains. The number of pithy grains and the weight of seeds per panicle. Coconut fiber LOF gives higher results compared to banana stem LOF. This is because coconut fiber LOF from the growth phase of rice plants has provided better growth than banana stem LOF. So the weight of 100 seeds and yield per plot on the provision of coconut fiber LOF also gives higher results.

The concentration treatment gave significant results on the number of productive tillers but the LOF concentration given did not affect panicle length, the number of grains and the number of filled grains per panicle as well as the weight of seeds per panicle, the weight of 100 seeds and the yield per plot. The highest number of productive tillers was found in the application of LOF concentration of 200 mL/L. The concentration of 200 mL/L has been able to form the most productive tillers due to the fulfilment of P nutrients needed by rice plants. The Fig. 1(a-b) and 2(a-b) showed the appearance of 100-grain grain and root weight of rice plants with the application of coconut husk LOF and banana stem LOF.

From Fig. 3(a-b) above, it can be seen that the density of stomata is higher in the application of coconut fiber LOF than banana stem LOF. This is because the element K affects the density of stomata more than the nutrient P. The nutrient K affects the stomata while the nutrient P affects fruit formation. Giving banana stems that have been crushed and then made extracts and poured into the soil greatly helps the addition of P nutrients into the soil. Potassium (K) is one of the minerals found in coconut husk. Plants use the K element in coconut husk to activate enzymes that are necessary for the synthesis of proteins and carbohydrates.

The provision of different LOF concentrations also affects the density of stomata at week 10 and 12 after planting, but 14 weeks after planting the provision of LOF has no effect. This is because the provision of LOF can affect the number of stomata until week 12 with the highest number of stomata at a LOF concentration of 300 mL/L. The nutrient content of banana stems varies, as dry matter content ranges from 3.60-9.80%, crude protein ranges from 2.40-8.30%, crude fat ranges from 3.20-8.10%, extract material without nitrogen range from 31.60-53.00%, ash ranges from 18.4-24.70%, crude fiber ranges from 13.40-31.70%, neutral detergent fiber ranges from 40.50-64.10%, acid detergent fiber ranges from

35.60-45.50%, cellulose ranges from 19.70-35.20%, hemicellulose ranges from 4.90-18.70% and lignin ranges from 1.3-9.20%[17]. The plant P and K nutrient uptake was shown in Fig. 4.

The data in Fig. 4(a-b) showed that the concentration 100-300 mL/L is higher than 0 mL/L to P nutrient uptake in the shoot rice plant as well as concentration 100-300 mL/L is higher than 0 mL/L to K nutrient uptake in the root rice plant. Forever, a concentration of 100-300 mL/L is higher than 0 mL/L to P nutrient uptake in root rice plants and then a concentration of 100-300 mL/L is higher than 0 mL/L to K nutrient uptake in root rice plants. The P nutrient uptake 0-100 mL/L is decreases but 100-300 mL/L increases. However, K nutrient uptake of 0-300 mL/L tends to increase in the shoot plant. The P nutrient uptake 0-50 mL/L in root plants decreases but 50-300 mL/L increases. A part from increasing the availability of nutrients, it is also able to increase the efficiency of nutrient uptake by plants so that fertilization efficiency increases[18].

This research implies that for farmers in the field, POC can be obtained as a substitute for inorganic fertilizer up to half the recommended dose. Application in the field of the results of this research can be applied to the field so that it can reduce the cost of purchasing inorganic fertilizers which farmers have complained about because they are expensive. The recommendation is that the results of this research be applied to lowland rice farmers. The limitation of this research is that further research is still needed on different types of soil and locations.

CONCLUSION

The provision of coconut fiber LOF is better for the growth and yield of the rice Batang Piaman variety compared with the provision of banana stem LOF. Giving coconut fiber LOF with a concentration of 100 mL/L is better. The benefit of this research is to utilize liquid organic fertilizers to reduce scarce inorganic fertilizers. From the above conclusions, it can be suggested to add coconut husk LOF to paddy fields so that the growth and yield of rice plants can increase.

SIGNIFICANCE STATEMENT

This research implies that for farmers in the field, POC can be obtained as a substitute for inorganic fertilizer up to half the recommended dose. Application in the field of the results of this research can be applied to the field so that it can reduce the cost of purchasing inorganic fertilizers which farmers have complained about because they are expensive. The recommendation is that the results of this research be applied to lowland rice farmers. The limitation of this research is that further research is still needed on different types of soil and locations.

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