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Potential of Liquid Organic Fertiliser from Maja Fruit (*Aegle marmelos*) for Rice Crops

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ABSTRACT

The difficulty in obtaining fertiliser fuelled creativity to utilise local potentials around farmers. One of them is to utilise the potential of maja fruit, which has been traditionally used only for its peel as a container for coconut sap, while its inner content is discarded. The aim of this research was to exploit the potential of maja fruit waste as liquid fertiliser and to determine the best concentration of liquid fertiliser produced from maja fruits for optimum rice crop production. This research was conducted at the Faculty of Agriculture, Tanjungpura University, and continued in Sungai Rengas Village, Kubu Raya Regency, West Kalimantan. The research was carried out for approximately five months, from May to September 2022. This research was conducted using the completely randomised design which consisted of M_0 = control (synthetic fertiliser), M_1 = 18 mL L^{-1}, M_2 = 24 mL L^{-1}, M_3 = 30 mL L^{-1}, and M_4 = 36 mL L^{-1}, with three replications and a total of three sample plants. Observations were made on plant height, number of tillers, number of productive tillers per clump, bunch weight per clump, number of grains per bunch, and 1000-grain weight. The results showed that plants fertilised with liquid fertiliser derived from maja fruit surpassed the performance of plants fertilised with synthetic fertiliser. Among the different treatments of liquid organic fertiliser from maja fruit, the application of 30 mL L^{-1} concentration proved effective for rice crops, making it a viable alternative to synthetic fertilisers.

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1 INTRODUCTION

The scarcity and difficulty that farmers experienced in obtaining synthetic fertilisers for their rice crops[1], coupled with the high cost of fertilisers, allowed for the exploration of alternative local resources that could be used as fertiliser, one of which was the maja fruit[2]. Maja fruit (*Aegle marmelos*) is an inedible fruit that grows wild as shown in Fig.1. In the village of Sungai Rengas, Kubu Raya Regency, only the peel of the maja fruit is utilised as a container for coconut sap by palm sugar makers, while the inner part is discarded as waste. However, the inner part of the fruit can still be utilised as source material to produce liquid fertiliser.

Fig. 1 Maja fruit.

Rice farmers generally practice conventional farming methods, which involve the use of synthetic fertilisers. The continuous use of synthetic fertilisers from year to year can reduce soil fertility[3]. Farmers in plant cultivation not only rely on synthetic fertilisers but also continue to use herbicides; this practice will further decrease soil fertility[4].

Efforts should be made to improve soil fertility by providing sufficient organic matter and reducing the use of synthetic fertilisers, or even completely eliminating their usage, considering that synthetic fertilisers previously applied still remain in the soil. One of the potential fertilisers that can be used is liquid organic fertiliser derived from maja fruit waste. Research by Bariyyah et al.[5] showed that maja fruit contains nitrogen at a concentration of 12.911 mL L^{-1}, phosphorus at 80.2483 mL L^{-1}, potassium at 1.958 mL L^{-1}, magnesium at 110 mL L^{-1}, and iron at 0.7888 mL L^{-1}, indicating its potential as liquid organic fertiliser. Zulkarnain et al.[6] stated that the use of liquid fertiliser could improve the physical, chemical, and biological properties of the soil, as well as enhancing crop production. Another advantage of maja fruit is that its content of substances such as balsam oil (Sesquiterpene), 2-furocoumarins-psoralen, marmelosin ($C_{13}H_{12}O$), essential oil, pectin, saponin, and tannin[7].

The preliminary research results indicated that liquid fertiliser made from maja waste contained phosphate-solubilising bacterial isolates and had the ability to produce indole compounds (unpublished), in addition to the presence of nutrient content. With the presence of phosphate-solubilising bacteria isolates in the liquid organic fertiliser from maja fruit, further research is needed to investigate their effects on rice plants, as a study by Purwaningsih et al.[8] indicated that phosphate-solubilising bacteria could improve the viability of deteriorated rice seeds.

The use of organic fertiliser derived from maja fruit has been widely explored, but not specifically for rice crops. Serdani et al.[4] conducted research on the use of liquid organic fertiliser from maja fruit can increase the growth and yield of melon plants (*Cucumis melo* L.), for mung bean plants, for water spinach plants (*Ipomoea aquatica*), for white oyster mushroom (*Pleurotus ostreatus*) cultivation, and for water

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spinach on suboptimal soil[4,9-12]. With this current research, it is hoped that using liquid fertiliser from maja fruit, containing essential nutrients and phosphate-solubilising bacteria isolates, can enhance the growth and yield of rice plants, serving as an alternative or replacement for synthetic fertilisers.

2 MATERIALS AND METHOD

This research was conducted at the Faculty of Agriculture, Tanjungpura University, and continued in Sungai Rengas Village, Kubu Raya Regency, West Kalimantan. The study was conducted for approximately 5 months, from May to September 2022.

The materials used in the study included local rice seeds called "Menthik Susu", liquid fertiliser from maja fruit, alluvial soil, banana peel compost, a seedling medium consisting of a mixture of soil, compost, and sand in a ratio of 2:2:1, label papers, a pH meter, a thermohydrometer, polybags, documentation tools, and other supporting equipment.

2.1 Experimental Design

This study used a completely randomised design of one factor with five treatments as presented in Fig. 2. The treatments were as follows: M_0 = control (200 kg ha^{-1} or 2.5 g per polybag, SP-36 100 kg ha^{-1} or 1.25 g per polybag, and KCl 100 kg ha^{-1} or 1.25 g per polybag), M_1 = 18 mL L^{-1}, M_2 = 24 mL L^{-1}, M_3 = 30 mL L^{-1}, and M_4 = 36 mL L^{-1}. The number of replications was 4, and there were three plant samples.

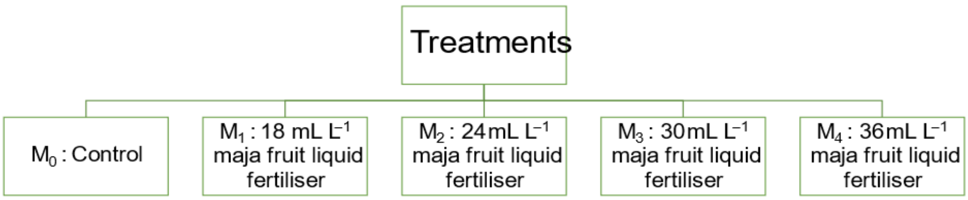

Fig.2 Experimental design diagram in research.

2.2 Pre-treatment Samples

The study started with seed selection, where rice seeds were soaked in a salt solution to obtain high-quality seeds, indicated by seeds that sank in the salt solution. This was followed by the preparation of a seedling medium consisting of a mixture of soil, compost, and sand in a ratio of 2:2:1. The seeds were then sown in the prepared media. The rice seeds used in the study were of the "Menthik Susu" variety. The seedlings were ready for planting after 7 days. The rice seedlings were planted in polybags with a planting media weight of 10 kg, consisting of 9.5 kg of soil and 500 g of banana peel compost. One rice seedling was planted per polybag. The liquid fertiliser from maja fruit was applied by spraying it onto the plants in their respective treatments. The fertiliser was applied at 10, 20, 30, 40, and 50 days after planting (DAP). On the other hand, plants receiving synthetic fertiliser were given urea = 200 kg ha^{-1} or 2.5 g per polybag, SP-36 100 kg ha^{-1} or 1.25 g per polybag, and KCl 100 kg ha^{-1} or 1.25 g per polybag. Maintenance practices included replanting if there were any dead plants 7 days after planting (DAP), weed control throughout the study period whenever weeds or grasses appeared around the plants, and management of pests and diseases. Pest control against caterpillars, rats, stink bugs, and sparrows was carried out using mechanical or manual methods, as well as chemical substances by spraying them on the affected plants. Additionally, nets were used to protect the plants against rat and sparrow pests.

3 RESULTS AND DISCUSSION

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The variance analysis revealed that applying liquid organic fertiliser from maja fruit significantly influenced the number of tillers, productive tillers, and grain weight per hill, but had no significant effect on plant height, number of grains per panicle, and 1000-grain weight. The height of the rice plants ranged from 94 to 98 cm. Similarly, the number of grains per panicle ranged from 265 to 270 grains, while the 1000-grain weight ranged from 26 to 28 g. The plant height, number of grains per panicle, and 1000-grain weight were slightly lower compared to the variety description, where the local variety "Menthik Susu" had a plant height of 100 cm, 300 grains per panicle, and a 1000-grain weight of 29 g. However, the differences were insignificant, indicating that genetic factors were more dominant. The differences among the applications of liquid organic fertiliser from maja fruit in terms of the number of tillers, productive tillers, and grain weight per hill can be seen in the Tukey test in Table 1.

Table 1. The effect of liquid organic fertiliser from maja fruit on the average number of tillers, productive tillers, and grain weight per hill of rice plants

Treatments	Number of tillers	Number of productive tillers	Grain weight per hill (gram)
M_0 (control)	23.00^{b}	19.67^{d}	156.30^{d}
M_1 (18 mL L^{-1})	28.00^{ab}	26.00^{c}	209.50^{c}
M_2 (24 mL L^{-1})	29.00^{ab}	28.00^{bc}	225.10^{b}
M_3 (30 mL L^{-1})	34.67^{a}	32.00^{a}	252.30^{a}
M_4 (36 mL L^{-1})	31.33^{a}	29.33^{b}	238.10^{ab}

Note: Numbers followed by the same letter are not real in the 5% Tukey Test

The results of the different tests for applying of liquid waste maja fertiliser in Table 1 indicate that the number of tillers per clump increases with the increasing concentration of liquid waste maja fertiliser. It enhanced the formation of tillers but only up to a concentration of 30 mL L^{-1}, as at 36 mL L^{-1}, the number of tillers per clump decreased. However, statistically, it did not show significant differences compared to other concentrations of liquid organic fertiliser (LOF). The application of LOF with concentrations of 18 mL L^{-1} and 24 mL L^{-1} showed no significant difference compared to the control, meaning that the number of tillers formed in rice plants fertilised with LOF at these concentrations could replace the position of synthetic fertiliser application, especially in the formation of the number of rice tillers per clump (polybag).

The number of productive tillers per hill in Table 1 showed a decrease compared to the average number of tillers per hill. The table shows that the application of liquid fertiliser provided a significant difference compared to the control or synthetic fertiliser. It was observed that the application of liquid organic fertiliser from maja fruit at low to high treatment resulted in a decrease ranging from only 6.38% to 7.14%, while in rice plants treated with synthetic fertiliser, the decrease was 14.67%. This indicates that the number of tillers that did not become productive tillers was smaller when using liquid organic fertiliser from maja fruit, and this difference was significant compared to the control or synthetic-fertilised rice.

The application of liquid organic fertiliser from maja fruit at different treatments yielded varying grain weights per hill, showing a significant difference compared to the grain weight given by synthetic fertiliser treatments. There was also a significant difference between the different treatments of liquid organic fertiliser. The application of liquid organic fertiliser at a concentration of 30 mL L^{-1} showed a significant difference compared to the treatment of 18 mL L^{-1} and 24 mL L^{-1}. Still, it did not show a significant difference compared to a concentration of 36 mL L^{-1}. The application of liquid organic fertiliser at a concentration of 30 mL L^{-1} was the effective concentration in providing a grain weight per hill of 252 g.

Fertilisation using liquid organic fertiliser from maja fruit waste at various treatments has shown positive results in enhancing growth and yield, especially when compared to rice plants fertilised with synthetic fertilisers. The growth of rice plants, even when treated with the lowest concentration of 18 mL L^{-1} of liquid organic fertiliser from maja fruit waste, had shown similar or even better improvement than those treated with synthetic fertilisers. This could be due to the nutrient content in the liquid organic

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fertiliser, which, although not as high as in synthetic fertilisers, is easily absorbed by the plants[13]. Another contributing factor could be the potential action of phosphate-solubilising bacterial isolates in the liquid organic fertiliser from maja fruit waste. These bacterial isolates work to convert unavailable phosphates into forms that are readily available for plants[14]. As known, phosphorus (P) is essential for plant growth and development, playing a role in physiological activities such as cell division, photosynthesis, root system development, and carbohydrate utilisation[15]. The process of nutrient availability, particularly phosphorus, facilitated by bacterial isolates, is believed to involve the release of organic acids. Although this study did not specifically investigate the organic acids released by the bacterial isolates, previous research has shown that the solubilisation of phosphate is attributed to the presence of these organic acids. For example, Purwaningsih et al.[8] found that phosphate solubility is caused by butyric acid, succinic acid, and acetic acid. At the same time, other studies have examined various organic acids, such as gluconic acid[16,17].

The ability of phosphate-solubilising bacterial isolates in the liquid organic fertiliser from maja fruit waste to produce indole compounds could be another factor that supports the superior performance of using this organic fertiliser. Indole compounds are phytohormones produced by microorganisms, commonly in the form of auxins[18], cytokinins[19], and gibberellins[20]. These phytohormones are known to stimulate plant growth. Soil or media factors also play a supporting role. The good growth and yield of rice plants in this study were supported by soil improvement through the application of banana peel compost before planting the rice seedlings. The banana peel compost helped improve the physical properties of the alluvial soil used in this study since alluvial soil tends to be compacted, and the addition of compost made it more porous, allowing for better root development and increased rice tiller formation. Furthermore, the application of compost also increased the soil pH, as the pH of the banana peel compost used in the study was 8.9 (according to analysis results). The initial soil pH in this study was 4.2, which increased to 4.9-5.5 after compost application. This was in line with the findings of Fitriyanto[2] that compost addition can increase the pH of the medium, thereby improving the availability of nutrients for plants.

Fertilising rice plants with synthetic fertilisers in this study still could not match the results achieved by using liquid organic fertiliser from maja fruit waste, especially in terms of productive tiller count and grain weight per hill. Although the number of tillers per hill did not show a significant difference compared to the application of maja fruit waste liquid organic fertiliser at the treatment of 18 mL L^{-1} and 24 mL L^{-1}, the reason for this could be due to the fertiliser applied to the soil was not sufficiently available to the plants due to the high soil acidity or low soil pH (pH 4.2). At low pH, nutrients, particularly phosphorus, are bound by aluminium or iron, forming aluminium phosphate and iron phosphate, while phosphorus is crucial for plant growth and development. Therefore, it is reasonable that the application of organic fertiliser resulted in better outcomes.

The use of synthetic fertilisers alone can decrease soil organic matter content. In contrast, while organic matter is crucial for soil as it helps retain water and enhances biological activity in the soil, as stated by Leszczynska and Kwiatkowska-Malina[21]. Organic fertilisers can also be considered compound fertilisers since they contain macro and micronutrients, making them a complete fertiliser. The presence of compost as an organic material and fertiliser provides sufficient and balanced nutrients for rice plants, in agreement with the findings of Tufalia et al.[22] that applying bokashi to rice plants in paddy fields increases the maximum number of tillers and productive tillers.

4 CONCLUSION

The application of liquid organic fertiliser from maja fruit waste can enhance the growth and yield of rice plants beyond the use of synthetic fertilisers. The concentration of 30 mL L^{-1} of liquid organic fertiliser from maja fruit waste is an effective concentration for improving the growth and yield of local rice plants, specifically the "Menthik Susu" variety. Liquid organic fertiliser from maja fruit waste can be an alternative fertiliser for rice plants.

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CONFLICT OF INTEREST

The authors report there is no conflict of interest in this work.

AUTHORS' CONTRIBUTIONS

Conceptualization: S. Rahayu
Data curation: Purwaningsih
Methodology: A. Suyanto
Formal analysis: A. Suyanto
Visualisation: S. Rahayu
Software: Purwaningsih
Writing (original draft): Purwaningsih
Writing (review and editing): A. Suyanto
Validation: S. Rahayu
Supervision: S. Rahayu
Funding acquisition: S. Rahayu
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