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Substitution of Inorganic Fertilizer and Biofertilizer Application on Wetland Rice (*Oryza sativa*) Varieties Inpari 32

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Abstract— *This research aims to determine the substitution of inorganic fertilizers using organic fertilizers and biofertilizers (PGPR) in an effort to reduce farmers' dependence on inorganic fertilizers and reduce subsidized fertilizers by the government. The research method used in this research is a factorial experiment with 2 factors with 6 treatment combinations. The first factor is biofertilizer (PGPR), R0 = without PGPR, R10 = 10 liters ha-1 PGPR and the second factor is P0 (farmers' habitual fertilization (400 kg ha^{-1} urea + 400 kg ha^{-1} NPK), P1 (100% inorganic (275 kg ha^{-1} urea + 250 kg ha^{-1} NPK)), P2 (75% inorganic (206.25 kg ha^{-1} urea + 187,5 kg ha^{-1} NPK) + 25% organic (1,25 ton ha^{-1})) , P3 (50% inorganic (137,5 kg h^{-1} Urea + 125 kg ha^{-1} NPK) + 50% organic (2,5 ton ha^{-1})), P4 (25% inorganic (68,75 kg ha^{-1}) 1 Urea + 62,5 kg ha^{-1} NPK) + 75% organic (3,75 ton ha^{-1})), P5 (100% organic fertilizer (5 ton ha^{-1})). Variables observed were plant length, number of tillers, grain contents per hill, weight of 1000 seeds, productivity, leaf chlorophyll content and R/C ratio. The result shows that organic fertilizer and PGPR can be used to substitute inorganic fertilizer at 25% to 50% of the recommended dose, especially in its effect on yield. Meanwhile, substitution of 75% and 100% still not shows the effective substitution.*

Keywords— ***biofertilizer, inorganic fertilizer, organic fertilizer, rice***

I. INTRODUCTION

Rice is a key food ingredient and a vital commodity for food sustainability in Indonesia. As a contributor to the highest yield, the yield in East Java has declined from the previous year, from 56.68 kha ha-1 in 2020 to 56.47 kha-ha-1 in 2021 (BPS, 2022). The cause of the decline in yields in Eastern Java needs serious attention. One of the factors that greatly affects the productivity of rice is fertilization. Padi cultivation practices are heavily dependent on government-subsidized inputs of inorganic fertilizers. Modern agriculture with uncontrolled inputs of chemical fertilizers can reduce soil fertility which ultimately reduces grain productivity. (Zhang et al., 2020).

Organic fertilizers can be used to improve the efficiency of the use of inorganic fertilisers. Organic fertilizers can improve soil physical and chemical properties and increase soil productivity. According to Atmaja et al., (2019), organic fertilizers derived from animal debris contain both macro and micro nutrients namely N, P, K, Ca, Mg, and others. Besides containing macro nutrients and micro-organic fertilisers also contain organic acids such as humic acid, fulvatic, organic and also enzymes that are not found in inorganic nutrients.

The continuous use of chemical fertilizers also affects the soil's biological properties, i.e. the presence of microorganisms that are beneficial to soil and plants. Therefore, it is necessary to add fertilizer that is capable of improving soil biology. PGPR is one of the groups of microbes that are beneficial as the best biokontrol agents to avoid the harmful effects of chemicals and help plant

health (Ansari et al., 2019). In addition to being a biofertilizer, the use of PGPR aims to accelerate the transformation of organic material into the nutrient available to plants. Bacteria provide nutrients to plants dissolving organic matter, transforming N air into available forms (Widiyawati et al., 2014). Previous studies have stated that replacing 50% or more of the inorganic fertilizer content with PGPR is sufficient to maintain normal growth and development of plants. The use of PGPR can be combined with conventional grape cultivation methods without reducing harvest yields. (Kobua et al., 2021).

Fertilization technology combining inorganic and organic fertilizer and PGPR is expected to be a solution to fertilization problems and able to restore soil fertility so that grain productivity can be improved.

The introduction of the paper should explain the nature of the problem, previous work, purpose, and the contribution of the paper. The contents of each section may be provided to understand easily about the paper.

II. MATERIAL AND METHODES

The research was conducted between October 2022 and February 2023. The research site is in Jatimulyo experimental land, Brawijaya University Agricultural Faculty in Jatimulyo, Lowokwaru district, Malang city. The tools used in this study are Leaf area meter (LAM), SPAD, oven, analytical scales and cameras. The materials used are grain seeds varieties inpari 32, inorganic fertiliser, organic fertilizer and PGPR “MUPUS” manufactured by HPT University of Brawijaya Laboratory. The inorganic fertilizer used are urea and NPK, and the organic material used is a composite of four organic substances, namely, straw, husks, corn stover and corn cobs that have gone through a compositing process.

This study is a factorial experiment with two factors, the first factor is the aplication of PGPR while the second factor is the substitution of inorganic fertilizer. The research was carried out using a split plot design consisting of a main and a sub plots. The research method used in this study is a factorial experiment with 2 factors with 6 combinations of treatments. The first factor is R0 = without PGPR, R10 = 10 litres of ha^{-1} PGPR and the second factor is P0 (farmers’ habitual fertilization (400 kg ha^{-1} urea + 400 kg ha^{-1} NPK), P1 (100% inorganic (275 kg ha^{-1} Urea + 250 kg ha^{-1} NPK)), P2 (75% anorganic (206,25 kg ha^{-1} Urea & 187.5 kg ha^{-1} NPK) + 25% organic (1,25 tons ha^{-1})), P3 (50% in organic (137,5 kg h^{-1} Urea and 125 kg ha^{-1}, NPK) + 50% organic (2,5 tonnes ha^{-1})), P4 (25% inorganic (68.75 $kgha^{-1}$ Uria & 62.5 kg $ha1^{-1}$ N PK) + 75% organic (3,75 tons ha^{-1})), P5 (100% organic fertilizer (5 tons ha^{-1})). The variables observed are plant length, number of leaves, leaf size, number, dry weight, content per pile, weight of 1000 seeds, productivity, chlorophyll level, plant absorption, and R/C ratio analysis.

III. RESULTS AND DISCUSSION

PGPR treatment and fertilizer substitution, both factors did not show any interaction on the parameters of plant length, number of tillers and leaf chlorophyll content (Table 1). PGPR application did not significantly affect the parameters of plant length and chlorophyll content, but significantly affected the number of tillers, while fertilizer substitution application significantly affected the three parameters.

The results of observations of plant length showed no interaction between PGPR treatment and inorganic fertilizer substitution, likewise there was no significant effect between plant length in the treatment without PGPR and with PGPR application. This is because the bacteria in PGPR in order to provide a direct or indirect impact on plant growth require the formation of colonies in the soil that are dynamic (Khoso et al., 2024). Fertilization treatment produced a significant difference in the inorganic fertilizer substitution treatment of 50%, 75% and 100% organic on plant length in the treatment of farmer's habitual fertilizer doses and recommendations from the Ministry of Agriculture, while the 25% fertilizer substitution showed no significant difference. The use of inorganic fertilizers can be replaced by 25% organic fertilizers, because organic fertilizers contain macronutrients (N, P, K) and micronutrients needed by plants (Haruna et al., 2020).

Plant production is greatly influenced by the number of tillers because of its effect on the number of panicles produced (Deng et al., 2014). The results of observations showed that the application of PGPR significantly increased the number of tillers in rice plants, however, there was no interaction between the use of PGPR and the application of different doses of fertilizer (inorganic fertilizer substitution). Kobua et al (2021) stated that plants treated with PGPR have a better chance of withstanding external pressure, thus ensuring survival and increasing productivity. Plants given a certain amount of PGPR can form tough cells and have better metabolism throughout the stem area (Gray and Smith, 2005). The number of tillers in the fertilizer dose treatment (inorganic fertilizer substitution) was significantly different in the 100% organic treatment compared to other treatments. In the inorganic fertilizer substitution of up to 75%, it was not significantly different from the recommended dose of the Ministry of Agriculture, and the highest number of tillers

was in the farmer's habitual fertilization. This shows that the availability of nutrients greatly influences the formation of tillers. The number of tillers will increase the amount of grain formed on the panicle, this will increase the weight of grain per plot. Seeds come from the results of photosynthate and assimilates that are translocated for seed formation, so that the more photosynthate and assimilates produced, the more seeds will be produced. The number of tillers formed will increase the amount of grain formed on the panicle, thus causing an increase in the weight of grain per plot (Widiyawati et al., 2014).

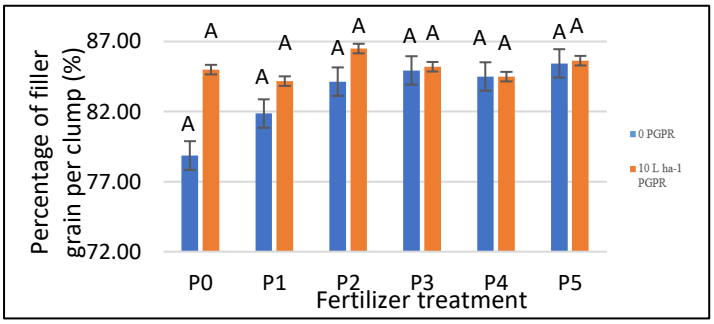
Table 1. Effect of PGPR and inorganic fertilizer substitution on vegetative growth

Substitusi pupuk anorganik dan PGPR)	Plant length per clump (cm)	Number of tillers	Chlorophyll index (mg g^{-1})
R0	90,77	14,3 a	30,1
R10	92,33	17,4 b	26,8
HSD 5%	ns	2,5	ns
P0	97,83 d	18,8 c	32,4 b
P1	96,83 d	17,8 bc	32,2 b
P2	93,17 cd	17,2 bc	32 b
P3	91,17 bc	16 bc	30,1 ab
P4	87,67 ab	14,8 b	29,2 a
P5	82,67 a	11 a	28 a
HSD 5%	5,39	2,1	2,7

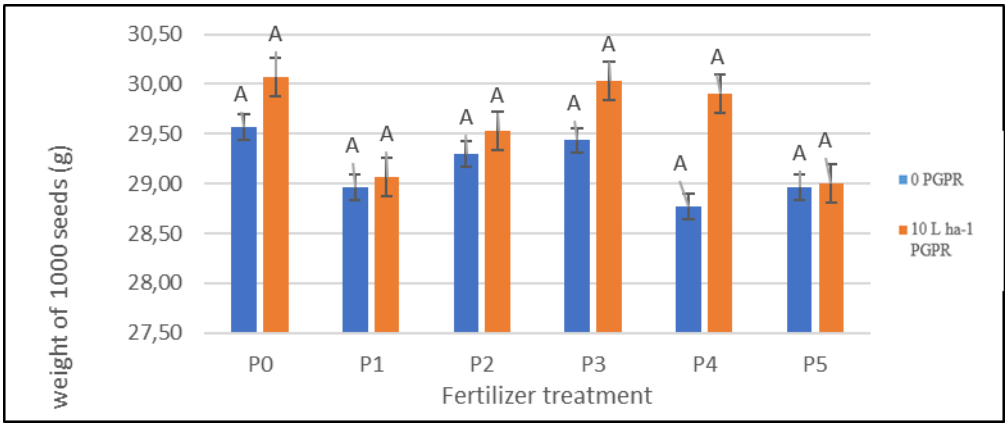
Description: The numbers in the table followed by the same letter do not show significant differences based on the 5% HSD test, HST = Days After Transplanting, HSD = Honestly Significant Difference, tn = not significant. R0 = Without PGPR, R10 = PGPR 10 Lha-1, P0 = farmer's fertilizer dose, P1 = recommended dose of the Indonesian Ministry of Agriculture, P2 = 25% inorganic fertilizer substitution, P3 = 50% inorganic fertilizer substitution, P4 = 75% inorganic fertilizer substitution, P5 = 100% inorganic fertilizer substitution (100% organic)

Leaf chlorophyll levels in plants that were given PGPR applications and those that were not showed no significant difference. Chlorophyll levels in the treatment of farmer's customary fertilizers and the Ministry of Agriculture's recommendations were the highest. This is in accordance with the high nutrient content, especially the higher N content compared to other treatments, likewise the leaf chlorophyll levels in the organic fertilizer treatment alone were the lowest. This difference in chlorophyll levels will certainly have an impact on the difference in the formation of photosynthates produced, thus affecting both vegetative and generative growth. Chlorophyll in leaves affects the reflection of infrared light which is one of the factors in increasing plant production (Mukhlisin and Soemarno, 2020). Research reveals a direct positive correlation between N fertilizer and total leaf chlorophyll content. Nitrogen is an important component of protein and nucleic acids for cell formation and the function of chlorophyll in carbohydrate synthesis (Mondal et al., 2023).

Interaction on the percentage of filled grain per hill (%) parameter did not occur between PGPR and fertilizer substitution treatments. There was no significant difference between PGPR and no PGPR treatments on the percentage of filled grain per hill. Likewise, in the fertilizer substitution treatment, the percentage of filled grain per hill ranged from 81.9% - 85.5%. The percentage of filled grain per hill above 80% indicates the ability of plants to provide assimilates which is certainly influenced by several factors.



(A)



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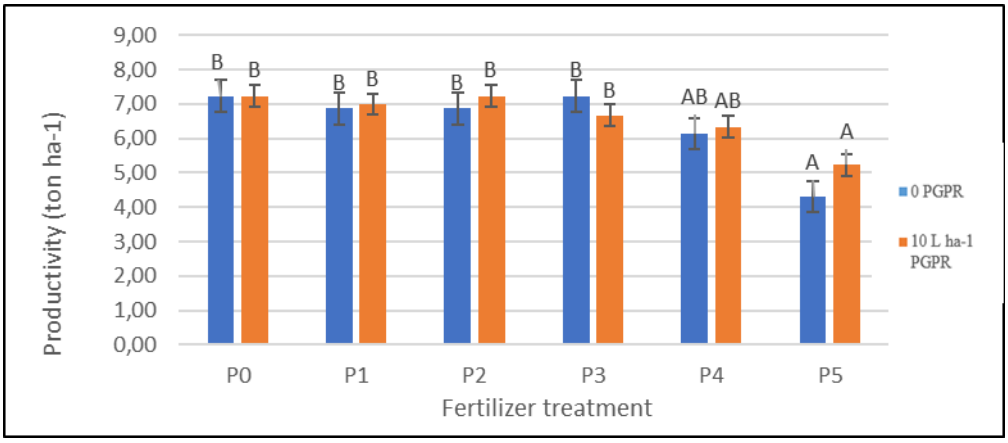

(C)

Fig.1. Effect of fertilizer treatment and PGPR administration on yield parameters including percentage of filled grain per hill (%), weight of 1000 seeds (g) and productivity. (A) Effect of fertilizer treatment and PGPR administration on percentage of filled grain per hill (%). (B) Effect of fertilizer treatment and PGPR administration on weight of 1000 seeds (g). (C) Effect of fertilizer treatment and PGPR administration on rice productivity (ton ha-1). P0 (farmers' habitual fertilization (400 kg ha^{-1} urea + 400 kg ha^{-1} NPK), P1 (100% inorganic (275 kg ha^{-1} Urea + 250 kg ha^{-1} NPK), P2 (75% inorganic (206.25 kg ha^{-1} Urea + 187.5 kg ha^{-1} NPK) + 25% organic (1.25 ton ha^{-1}), P3 (50% inorganic ik (137.5 kg ha^{-1} Urea + 125 kg ha^{-1} NPK) + 50% organic (2.5 tons ha^{-1}), P4 (25% inorganic (68.75 kg ha^{-1} Urea + 62.5 kg ha^{-1} NPK) + 75% organic (3.75 tons ha^{-1}), P5 (100% organic fertilizer (5 tons ha^{-1}).

In the 1000 seed weight parameter, there was no interaction between PGPR treatment and fertilizer substitution (Table 2). The weight of 1000 seeds in the PGPR treatment and without PGPR was not significantly different, namely 29.2 g in the treatment without PGPR and 29.5 g in the treatment with PGPR. Likewise, in the fertilizer substitution treatment, there was no significant difference in the results of the 1000 seed weight. The 1000 seed weight parameter describes the physical quality of the seeds produced by rice plants. The weight of 1000 seeds of Inpari 32 rice is 27.1 (Wahyuningrum et al., 2022). The results of the study on the weight of 1000 seeds showed no significant difference between the fertilizer substitution treatment and the PGPR treatment and all showed results above 27.1 g, namely in the range above 29 g, which means that the physical quality of the seeds produced is very good. Factors of the rice grain filling process and genetics (palea and lemma size) cause the fertilizer dose to have no effect on the weight of 1000 seeds (Widiyawati et al., 2014).

Fertilization treatment significantly affected productivity, but PGPR administration and its interaction did not significantly affect the variable (Figure 2.). Fertilization treatment affected plant productivity, but was not significantly different. Reducing chemical fertilizers by 75% did not reduce rice plant productivity.

Table 2. Farming business analysis

No.	Treatment	Total Cost (IDR)	Revenue (IDR)	R/C
1.	**Farmer's fertilizer dose**	**25.900.000**	**49.920.000**	**1,92**
2.	**Recommended dosage**	**25.234.750**	**47.840.000**	**1,89**
3.	**25% Inorganic fertilizer substitution**	**26.182.812**	**49.270.000**	**1,88**
4.	**50% Inorganic fertilizer substitution**	**27.156.250**	**48.490.000**	**1,72**
5.	**75% Inorganic fertilizer substitution**	**28.060.937**	**43.030.000**	**1,53**
6.	**100% organic**	**29.000.000**	**33.280.000**	**1,14**
7.	**100% organic (sold as organic rice)**	**29.000.000**	**61.440.000**	**2,11**

* According to BPS (Indonesian Central Statistics Agency) data in 2018, the conversion of dry grain harvest to ground dry grain was 83.17%, while ground dry grain to rice was 64.10%, with the calculation of the price of medium quality rice being IDR 13,000.00.

R/C ratio analysis is a comparison of profits and costs used to determine business feasibility. The input-output data observed consists of the quantity and price of production inputs and the quantity and price of rice produced (Arianti et al., 2022). The calculation of the R/C value in this study was carried out without adding PGPR costs considering that there was no significant difference between treatments using PGPR and those that did not. From Table 3. Above, the highest R/C value was obtained in the treatment of farmer's habitual fertilizer, which was 1.92, then the treatment of the recommended fertilizer dose from the Indonesian Ministry of Agriculture was 1.89. Substitution of inorganic fertilizers of 25%, 50% and 75% resulted in R/C values of 1.88; 1.72; and 1.53. The lowest R/C value was in the organic fertilizer treatment, which was 1.14. Overall, all fertilization treatments are still feasible because they have an R/C value> 1.

The first paragraph under each heading or subheading should be flush left, and subsequent paragraphs should have a five-space indentation. A colon is inserted before an equation is presented, but there is no punctuation following the equation. All equations are numbered and referred to in the text solely by a number enclosed in a round bracket (i.e., (3) reads as "equation 3"). Ensure that any miscellaneous numbering system you use in your paper cannot be confused with a reference [4] or an equation (3) designation.

IV. CONCLUSION

The results of the study showed that organic fertilizer and PGPR can be used to substitute inorganic fertilizer 25% to 50% of the recommended dose, especially its effect on yield. While 75% and 100% organic fertilizer are not effective in substituting inorganic fertilizer.

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