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Study of Nitrogen and Phosporus Doses on The Growth and Yield of Rice Plant *(Oryza sativa L.)* Mekongga Variety Used Endophic Bacteria

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Abstract

The rice plant (*Oryza sativa* L.) is the main food commodity in Indonesia, but its production has not shown a significant increase. To increase rice productivity, especially in rainfed areas, it is necessary to optimize the use of nutrients such as nitrogen and phosphorus. Facing the challenges of low fertility and limited water availability, endophytic bacterial consortia can help increase nutrient availability and plant growth. The aim of this research was to determine the effect of nitrogen and phosphorus doses and their interactions on the growth and yield of the Mekongga rice variety in rainfed land where a consortium of endophytic bacteria was applied. The treatments carried out were designed as a factorial experiment in a Randomized Completely Block Design, namely the Nitrogen factor consisting of four dose levels: 0,92, 184, 276 kg/ha and the Phosphorus factor consisting of four dose levels: 0, 72, 144, 216 kg/ha with three repetitions. The results showed that differences in nitrogen doses had a significant effect on the number of grains per panicle of rice plants, but did not have a significant effect on other growth and yield parameters of rice plants. Varying phosphorus doses and combinations of nitrogen and phosphorus doses did not have a significant effect on all growth and yield parameters of the Mekongga rice variety.

Keywords: endophytic bacteria, nitrogen, phosphorus, rainfed land, rice

Introduction

Rice plays a crucial role in the social and economic life of Indonesian society because it can meet the increasing food needs that follow population growth. According to (Lubis *et al*., 2022), Indonesia's population growth from 2020 to 2021 increased by 2.7 million people. If this population growth is not balanced with an increase in food production, it may lead to problems in meeting the food needs of the population in the future.

Given the extremely large population in Indonesia, the aspect of food provision becomes crucial. In Indonesia, rice production reached 54.64 million tons in 2020 with a productivity of 51.28 quintals per hectare. In 2021, production increased to 54.42 million tons with a productivity of 52.26 quintals per hectare, and in 2022, production increased to 54.74 million tons with a productivity of 52.38 quintals per hectare (Central Statistics Agency, 2023). However, the results of the production have not significantly increased from year to year.

Boosting rice productivity in Indonesia can be achieved through optimizing rice cultivation in rainfed lowlands. Rice production in irrigated fields reaches 4.5 to 6.0 tons per hectare, but in rainfed lowlands it is still lower, around 3.0 to 4.0 tons per hectare (Susanto *et al*., 2017). According to Ministry of Agriculture (2018), 3.4 million hectares of rainfed lowlands across the country have the potential to increase national rice production.

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Rainfed lowlands tend to have low fertility due to limited water availability. Generally, the soil has acidic pH and relatively low levels of micro-nutrients (Ca and Mg) and macro-nutrients (N, P, K) (Kasno et al., 2016 in Susanto et al., 2020). This condition contributes to the decline in rice productivity in rainfed lowlands.

Optimizing fertilizer use is one way to increase rice production in rainfed lowlands. Essential nutrients like nitrogen (N) and phosphorus (P) are crucial for rice plant growth and yield. Nitrogen helps in the growth of vegetative parts and the formation of green leaves, which is beneficial for phototropism (Ratnawati, 2016 in Darmawan et al., 2021). Phosphorus plays a significant role in gene regulation and energy transfer. Phosphorus deficiency can cause poor plant growth, poor yields, and reproductive disorders(Agustine et al., 2023).

Boosting rice productivity must be accompanied by the efficient and environmentally friendly use of nutrients. One way to achieve this is through the use of endophytic bacterial consortia. Endophytic bacteria live within plant tissues, including roots, stems, and leaves (Hung et al., 2007 in Irianti et al., 2023). According to Irianti et al., (2023), endophytic bacterial consortia have multiple roles, including their ability to enhance plant growth by producing or providing essential nutrients for plants.

Endophytic bacteria have the ability to form symbiotic relationships with plants. Through these relationships, endophytic bacteria can provide benefits such as increasing nutrient availability, enhancing environmental stress tolerance, and promoting plant growth and yield. One of its advantages is its ability to fix nitrogen from the air and solubilize phosphorus (Kuldau et al., 2007 in Irianti et al., 2023).

Based on the concept, it is necessary to conduct research on the effect of nitrogen and phosphorus doses on the growth and yield of Mekongga rice varieties in rainfed lowlands that have been applied with endophytic bacteria. This study aims to better understand the benefits of the interaction between endophytic bacterial consortia and nitrogen and phosphorus doses that can support the growth and yield of Mekongga rice varieties in rainfed lowlands.

Method

This study was conducted from March 2023 to June 2023 at the dry season in Demangan, Sambi, Boyolali at an altitude of ± 130 M asl with Regosol soil type.

Experiment design

The experimental design used is a Randomized Completely Block Design (RCBD) with a factorial. It consists of 2 factors, nitrogen fertilizer and phosphorus fertilizer, which are repeated 3 times. The first factor, nitrogen dose, consists of 4 levels: 0, 92, 184, and 276 kg/ha. The second factor, phosphorus dose, consists of 4 levels: 0, 72, 144, and 216 kg/ha.

Research procedures

The land is applied with cow manure compost at a rate of 10 tons/ha, then left to soak in water until saturated. Soil preparation is done by plowing and harrowing. Rice seeds are soaked in endophytic bacteria for 24 hours before sowing with a ratio of 20 ml bacteria : 2000 ml water. Seedlings are transplanted to the field after 21 days of sowing. Planting is done by placing the root part into the soil to a depth of 1 – 2 cm. Seedlings are planted in each treatment plot with a spacing of 20 cm x 20 cm.. Irrigation is done after the seedlings are planted to a depth of 2-5 cm. Waterlogging is stopped one day before the application of endophytic bacteria and 15 days before harvest. Weeding of weeds is done when the rice plants are 3 weeks old after planting. Weeding is done every 3 weeks with a method of pushing weeds between rice plants.. Endophytic bacteria are applied four times, at ages 2, 3, 4, and 5 weeks after planting. The dosage per plot is 34.56 ml bacteria, with a ratio of bacteria to water 1 : 1000. The application of endophytic bacteria is done by pouring it onto the field that is not waterlogged. Fertilization is done twice, at ages 2 weeks and 5 weeks after planting. The first fertilization is done with nitrogen fertilizer at half the treatment dose and phosphorus fertilizer at the treatment dose. The second fertilization is done with urea fertilizer at half the treatment dose. Pest and disease control is done by applying treatments or pesticides as needed when the plants are infested with pests or diseases. Harvest is done when the rice is yellowish brown or after the rice plants are 110 days old.

Parameters observed

The parameters observed in this experiment are the total number of tillers, fresh weight of the cuttings, dry weight of the cuttings, number of panicles, panicle length, number of grains per panicle, weight of grains per bunch, weight of grains per plot, weight of 1000 grains, and harvest index.

Statistical analysis

The data of observations were analyzed using analysis of variance (ANOVA) at 5% significant levels. The treatment means were compared using Duncan′s new multiple range test (DMRT) at 5% significant levels

Result and Discussion

Rice plant growth parameters

The influence of nitrogen and phosphorus doses, along with their interactions, on the growth of rice plants treated with endophytic bacteria was observed through the following parameters:

Total number of tillers

The analysis of variance results for the total number of tillers show that the different doses of nitrogen and phosphorus, along with their interactions, do not significantly affect the total number of tillers in Mekongga rice varieties. It is believed that the application of endophytic bacterial consortia helps the plants to absorb and utilize unavailable nutrients, making the effect of different nitrogen and phosphorus doses, along with their interactions, non-significant. This finding is consistent with the research by Wuriesyliane (2017), which shows that the application of endophytic bacterial consortia can enhance the vegetative growth of rice plants and increase the availability of nitrogen and phosphorus in the soil. According to Danapriatna et al., (2010), the use of inoculars such as Azospirillum and Azotobacter, either individually or in combination, can increase the total nitrogen content in the soil, nitrogen uptake by plants, and the number of tillers and yield of rice

Fresh weight of the cuttings

The analysis of variance showed that the different doses of Nitrogen and Phosphorus and their interactions showed no significant effect on the fresh weight of the mekongga rice plant stover. It is suspected that the application of a consortium of endophytic bacteria stimulates plant growth and provides nutrients for plants. The application of Nitrogen and Phosphorus fertilizers at different doses and their interactions shows no significant effect on the fresh weight of the stover. This is in line with the research results of Nasahi (2010), Azotobacter sp. and Azospirillum sp. can increase plant growth by nitrogen fixation and growth hormone production. These bacteria increase plant growth by providing phytohormones such as IAA, which stimulates plant growth (Mittal et al., 2008). Another study showed that Azotobacter sp. is not only effective for nitrogen fixation but also produces growth hormones, fungicidal ingredients, siderophores, and the ability to solubilize phosphate, from unavailable forms to available for plants (Jalilian et al., 2012).

Dry weight of the cuttings

The analysis of variance showed that different doses of Nitrogen and Phosphorus and their interactions had no significant effect on the dry weight of the Mekongga varietis rice plant stover. It is suspected that the application of a consortium of endophytic bacteria (Azotobacter sp., Azospirillum sp., Bacillus Subtilis sp.) plays a role in helping provide nutrients for plants so that the application of different doses of Nitrogen and Phosphorus and their interactions do not show a real effect on the dry weight of the stover. The use of a consortium of endophytic bacteria (Azotobacter sp., Azospirillum sp., Bacillus Subtilis sp.) in rice cultivation can be beneficial if there is a positive interaction between the endophytic bacteria and the host plant (Nur Maulidya et al, 2014). According to Mohammadi et al (2012), endophytic biofertilizer has the function of reducing nutrient loss in the soil and converting it into a form that can be used by plants.

Yield parameters

The influence of nitrogen and phosphorus doses, along with their interactions, on rice plant yields, observed through the following parameters:

Number of panicles

The analysis of variance indicates that the different nitrogen and phosphorus treatments, along with their interactions, do not significantly affect the number of panicles. It is suspected that the number of panicles in rice plants is indirectly influenced by the total number of tillers. This aligns with the findings of Silitonga & Nasution (2018), which stated that the number of productive tillers is determined by the maximum number of tillers. Additionally, Misran's study (2013) found a positive correlation between the maximum number of tillers and the number of productive tillers produced.

Panicle length

The analysis of variance shows that the different nitrogen and phosphorus treatments, along with their interactions, do not significantly affect the panicle length. In previous discussions, the number of tillers, fresh cut weight, dry cut weight, and number of panicles showed the same influence. These four observations are related to the vegetative phase. The vegetative phase will affect the generative phase, as a good vegetative growth rate will influence the generative phase. This aligns with Sarathi P. (2011), which found that vegetative growth affects the generative phase and plant production.

The length of rice panicles is not only influenced by internal factors of the rice plant, but rather, the most significant factor affecting it is nitrogen. The application of a consortium of endophytic bacteria that play a role in nitrogen fixation can enhance plant growth by increasing biological nitrogen fixation (BNF), increasing availability, or enhancing nutrient uptake. This biological nitrogen fixation can be used as an alternative to partially replace the use of inorganic fertilizers (Sapalina et al., 2022). Therefore, the different doses of nitrogen and phosphorus, along with their interactions, do not show a significant effect on panicle length.

Number of grains per panicle

The analysis of variance shows that the combination treatment of nitrogen and phosphorus doses, as well as the phosphorus dose treatment, do not significantly affect the number of grains per panicle, whereas the nitrogen dose treatment has a significant effect on the number of grains per panicle. It is suspected that the length of the panicle in rice plants can influence the number of grains per panicle. The longer the panicle, the more space available for rice grains, which can increase the number of grains per panicle.

The length of panicles influences the number of grains per panicle. The initiation period of panicles, which includes the critical period of plant growth, significantly affects the plant's ability to form panicles. During panicle formation, nutrient and water deficiencies can cause suboptimal panicle formation, which affects the number of grains to be produced (Jannah et al., 2012). The number of grains per panicle is determined during the reproductive phase. According to (Magfiroh et al., 2017), the length of panicles and the number of branches per panicle determine the number of grains on the panicle.

The analysis of variance for the nitrogen dose treatment shows a significant effect on the number of grains per panicle. The treatment N1 is significantly different from treatments N0, N2, and N3, but there is no difference between treatments N0, N2, and N3. The lowest number of grains per panicle is found in treatment N1, with 112.21 grains, while the highest number is found in treatment N2, with 120.16 grains. This indicates that applying nitrogen fertilizer with a dose of 184 kg/ha can increase the number of grains per panicle. This is consistent with the opinion of Nurmayulis et al., (2011), who found that applying urea fertilizer with a dose of 200 kg/ha, equivalent to 184 kg/N, can provide the best number of grains per panicle and rice plant yield.

Anhar et al., (2016), stated that sufficient nitrogen supply is necessary for good plant growth and high yields. To maintain the balance of nutrients in the soil, plants must be fertilized with the appropriate dosage. This will allow plants to grow and develop well and produce optimal results. High doses of nitrogen fertilizer can hinder plant growth and reduce rice yields, including the number of grains per panicle. This is consistent with the opinion of Toharudin & Sutomo, (2013), that the relationship between fertilizer dosage and crop yield follows a quadratic pattern. Providing fertilizer up to a certain dosage can increase crop yields, but providing excessive fertilizer can decrease yields. The additional results are presented in Table 1.

Table 1. Result of Further Tests on The Number of Grains per Panicle of Rice Plants Treated with Nitrogen

Treatment	Average (grain)
N0	118.53 b
N1	112.21 a
N2	120.16 b
N3	118.42 b

Note: Treatment in the same column followed by the same letter shows no significant difference

Weight of grains per bunch

The analysis of variance shows that the different nitrogen and phosphorus treatments, along with their interactions, do not significantly affect the weight of grains per hill. It is suspected that the total number of tillers and the number of panicles produced influence the weight of grains per hill. This is consistent with the findings of Riyanto et al., (2012), who found that the total number of tillers and the number of productive tillers per hill are positively correlated with the weight of grains per hill. The same result was also obtained by Rachmawati. R.Y. et al., (2014), who found that an increase in the number of tillers is followed by an increase in grain yield. The number of tillers per plant is positively correlated with the number of panicles per hill, the number of grains per panicle, the weight of 1000 grains, the harvest index, and the weight of grains per hill (Safriyani et al., 2018).

Weight of grains per bunch

The analysis of variance shows that the different nitrogen and phosphorus treatments, along with their interactions, do not significantly affect the weight of grains per plot. It is suspected that the weight of grains per hill influences the weight of grains per plot because the more grains per hill, the higher the weight of grains in each plot.

The number of tillers produced will increase the number of panicles, which in turn will increase the weight of grains per hill, resulting in higher weight of grains per plot. Additionally, the amount of photosynthate and assimilate produced will determine the formation of the number and size of grains. According to Khan et al., (2009), there is a correlation between the yield of grains per hill and the yield of grains per plot

Weight of 1000 grains

The analysis of variance shows that the different nitrogen and phosphorus treatments, along with their interactions, do not significantly affect the weight of 1000 grains. It is suspected that the weight of 1000 grains is influenced by the size and shape of the grains produced by the rice variety. This is consistent with the findings of Fitriana et al., (2022), which found that the average weight of grains is largely determined by the shape and size of grains in varieties. According to Ridha. R. et al., (2018), the weight of 1000 grains of unhusked rice is relatively constant because it depends on the size of the lemma and palea, which reaches its maximum size five days after flowering according to its genetic makeup.

Harvest index

The analysis of variance shows that the different nitrogen and phosphorus treatments, along with their interactions, do not significantly affect the harvest index. This is because there is no interaction between the internal factors, such as the genetic makeup of the rice variety Mekongga, and the external factors, such as sunlight, water, and the main nutrient. This is consistent with the statement by Yulina. N. et al., (2021), which states that the appearance of a plant is the result of the interaction between genetic and environmental factors.

The harvest index is a comparison between the dry weight of biological yield (dry biomass) and economic yield (grains). The harvest index is influenced by the magnitude of photosynthate translocation. The higher the harvest index of a plant, the more photosynthate is translocated to the grain, which will increase the yield of grains produced. An increase in the harvest index will be followed by an increase in grain yield. The higher the harvest index, the greater the storage of nutrients translocated to the grain (Safriyani et al., 2018). An increase in the harvest index will be followed by an increase in grain yield.

Conclusions

Based on the results and discussion, it can be concluded that: different nitrogen dosage treatments have a significant effect on the number of grains per panicle of rice plants, but do not have a significant effect on other growth and yield parameters of rice plants. Varying phosphorus doses and combined doses of nitrogen and phosphorus did not have a significant effect on all growth and yield parameters of the Mekongga rice variety.

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