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Organic fertilizer application to improve bacterial quality and rice production

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Abstract

Organic fertilizers are very useful for increasing the nutrient content needed by plants, increasing plant productivity, stimulating the growth of plant organs and fertilizing the soil. This study aims to determine the increase in the quality of bacteria and production of rice plants (*Oryza sativa*). The research was carried out in paddy fields belonging to the Agriculture Service of Bone Bolango Regency, Gorontalo Province, Indonesia, from September to December 2022. The researchusing Completely Randomized Block Design with 6 treatments 3 replications. The plant used is rice Cakrabuana variety.Plant spacing using the Jajar Legowo system 4: 1 with a spacing of 15 cm x 22 cm and a row width of 40 cm Legowo.The plot size used is (10 x 5) m. The bacterial population was calculated using the SANICHECK kid bacterial test. The dose of Granul organic fertilizer that uses 10 tons and 20 tons/hectare. The research results show thatGranule organic fertilizer 20 tons/hectare can improve the quality of bacteria from 10.13 to 10.17 cfu/ml compared to other treatments. Granular organic fertilizer 20 tons/hectareand recommended NPK is the best treatment that can increase the production of harvested dry grain by 7.4 tons/hectare and dry milled grain by 4.24 tons/hectare.

Keywords: Bacterial quality; Organic fertilizers; Rice plant growth; Rice production

1 Introduction

Organic fertilizers are very useful for increasing the nutrient content needed by plants, increasing plant productivity, stimulating the growth of plant organs and fertilizing the soil (Milosevic *et al*., 2022). According to Weerahewa and Dayananda (2023), organic fertilizers can reduce environmental pollution and improve land quality in a sustainable manner. In principle, the organic farming system is a farming system that adheres to natural principles in building agro-scosystem balance, so that it is beneficial to soil, water, air, plants and all living things, and is able to provide healthy food for human needs (Puech and Stark, 2023).).

The addition of organic fertilizers to the soil, especially in soils with low organic matter, is an effort to ameliorate the soil so that the provision of plant nutrients can be more effective (Chen *et al*, 2022). In general, the application of organic fertilizers to the soil will improve the physical, chemical and biological properties of the soil (Hui *et al*, 2022). According to Gao *et al* (2021), in soils that lack organic matter and degraded soils, organic fertilizer is the main requirement for soil amelioration, so that the provision of nutrient inputs is more efficient and effective.

Technology that can increase fertilization efficiency and the sustainability of rice production systems is microbial fertilizer technology contained in organic fertilizers (Hameed *et al*, 2023). Supply of some of the N, P, K nutrients needed by rice plants can be carried out by rhizosphere bacteria, endophytic, green manure which have the ability to fix N2 from the air, Phosphate solubilizing microbes can help mine Phosphate in the soil, so that it becomes available P for plants (Negi *et al*, 2022). Microbial groups as biological agents that are widely used in organic fertilizers include *Azotobacter* sp, *Lactobacillus* sp, *Alkaligenes* sp, *Rhizobium* sp, *Pseudomonas* sp and Endophytic Bacteria such as *Ovhrobactrum pseudogignonense*, *Azospirillum* sp, and *Penicillium* sp (Allouzi *et al*, 2022).

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According to Sahab *et al* (2021), in paddy fields waterlogging greatly affects the microbial metabolic processes of rice plants, such as; eukaryotic, aquatic weeds, heterotrophic microflora and fauna including roots and rhizosphere which is a place of microbial activity. Microbial activity in paddy soil can cause changes in soil biochemical functions such as; dissolution, binding, mineralization, immobilization, oxidation and reduction (Afzal and Singh, 2022).

Based on the explanation of the various theoretical concepts above, the purpose of this study was to determine the increase in the quality of bacteria and the production of rice plants.

2 Material and methods

2.1 Place and Time of Implementation

The research was conducted in paddy fields belonging to the Agriculture Service of Bone Bolango Regency, Gorontalo Province, Indonesia, from September to December 2022. The types of rice and organic fertilizers used were Cakrabuana varieties and Granul fertilizers. This research was carried out on alluvial soil types which have a high organic matter content, brown to gray in color with slightly loose soil structure. According to Swetha *et al* (2022), alluvial soils fall into the Vertic Endoaquepts classification, with a sandy loam texture class (15% clay and 43% silt on the treated layer, 23% clay and 40% silt on the bottom layer). The soil in the tilled layer (0-20 cm) has a slightly acidic reaction (pH-H2O 5.6). Low total N content (0.3 mg/g), low C-organic (3.2 mg/g), low Bray 1 extracted P (5.06 ppm P), low CEC (6.96 cmol(+)/kg), cations K, Na, Ca, Low exchangeable Mg 0.12 each; 0.24; 3.05; and 0.61 cmol(+)/kg.

2.2 Research Implementation

The study was arranged in a randomized block design with three replications and six treatments which included:

- No fertilizer
- NPK recommendation
- Granular Fertilizer 10 tons/hectare
- Granular Fertilizer 10 tons/hectare + recommended NPK
- Granular Fertilizer 20 tons/hectare
- Granular Fertilizer 20 tons/hectare + recommended NPK

The recommended dose of inorganic fertilizer for alluvial rice field soil in Gorontalo is 112.5 kg N; 45 kg P_2O_5; 60 kg K_2O/hectare. Plant spacing using the Jajar Legowo system 4: 1 with a spacing of 15 cm x 22 cm and a row width of 40 cm Legowo.

The first stage of fertilizer application was carried out 10 days after planting for P fertilizer at once, 1/3 dose N, and ½ dose K. The second stage fertilizer application was carried out 21 days after planting for 1/3 dose N and ½ dose K, and the second stage was given the third is done 42 days after planting for 1/3 dose of N. Granular organic fertilizer is given simultaneously with soil processing.

2.3 Observed variable

- Bacterial quality, calculated using a kid bacterial test
- Plant height, measured from 12 clump samples until just before harvest
- The number of tillers, measured from 12 samples of clumps until just before harvest
- Production of dry harvested grain and dry milled grain, measured by the size of the tiles (3m x 3m) m.

3 Results and Discussion

3.1 Rice Plant Growth

Plant growth depends on genetic characteristics and the ability to adapt to environmental conditions of cultivation (Jiang *et al*, 2022). Observations of plant height during the rice growth period were observed from plants aged 14 days after planting until harvest. The growth of rice plant height from the age of 14 days after planting increased, the rice plant age increased, but after the plant was 94 days after planting, the rice plant height began to decrease, because the growth of rice grains had begun to bend and turn yellow. The best growth in rice plant height was in the treatment of granulated organic fertilizer 20 tons/hectare + NPK.

The increase in plant height growth is due to the addition of organic matter to the soil. The higher the dose of organic fertilizer used, the higher the plant growth, when compared to the control treatment. The ability of organic fertilizers to bind water and increase soil porosity will improve soil respiration, so that it can support root growth to help plant height growth. The high growth of rice plants is described in Figure 1.

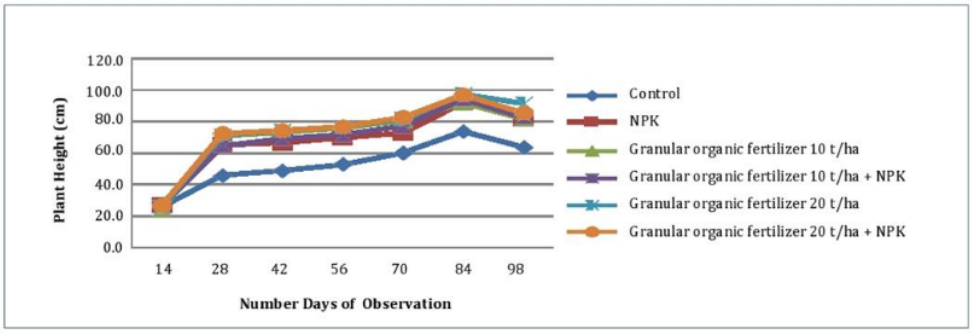

Figure 1 Growth of rice plant height at various plant ages and all treatments

The increase in rice plant height growth was in line with the growth in the number of tillers at various plant ages. The highest number of tillers was in the treatment of using granulated organic fertilizer 20 tons/ hectare + NPK, followed by the treatment using granulated organic fertilizer 20 tons/hectare. Organic fertilizers contain lots of humic acid and folic acid as well as growth regulators which can accelerate the growth of rice tillers (Brambilla *et al*, 2022). According to Jiang *et al* (2023), the application of organic fertilizers is beneficial in providing and absorbing nutrients, as well as activating soil microorganisms, so that the soil structure becomes crumbly which causes an expansion of root reach and increases the number of rice tillers. The growth of the number of rice tillers is described in Figure 2.

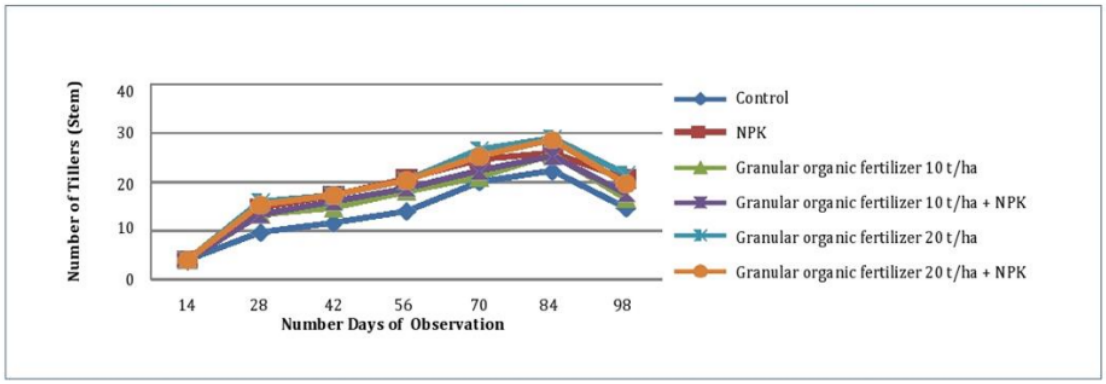

Figure 2 The growth of the number of rice tillers at various ages of observation and all treatments

Provision of organic fertilizers can improve the quality of bacteria in the soil. Granul organic fertilizer dosage has a significant effect on improving the quality of bacteria in the soil. Soils that are not given organic matter of bacterial quality tend to be low, because the availability and activity of bacteria is needed in the process of absorbing and providing nutrients for plants. Organic fertilizers play an important role in the mineral cycle, especially the nitrogen, phosphorus, sulfur and carbon cycles (Cheng and Wan, 2023). Bacteria that play a role in the nitrogen cycle include Azotobacter and Azospirillum, these bacteria are non-symbiotic nature that are able to bind free N2 which has an influence on the physical and chemical properties of the soil so as to increase soil fertility (Harindintwali *et al*, 2022).

The quality of the bacteria at the beginning of the treatment ranged from 10^2 to 10^3 and the quality of the bacteria continued to increase after being given treatment. The treatment of using granular organic fertilizer 20 tons hectare^{-1} can improve the quality of bacteria from 10.1^3 cfu/ml to 10.1^7 cfu/ml. In this study it was seen that the more doses of organic fertilizer given to the soil, the higher the quality of the bacteria produced. According to Zainuddin *et al* (2022), the application of organic fertilizers in the long term increases the amount of nutrients such as available nitrogen, available phosphorus and total zinc in the soil and will increase the number and diversity of bacteria in the soil for plant growth and production processes. The increase in the quality of bacteria at the beginning and end of the study is described in Table 1.

Table 1 Bacterial quality at the beginning and end of the study

No	Treatment	Initial bacterial quality (cfu/ml)	Final bacterial quality (cfu/ml)
1	No fertilizer/control	10.2^2	10.2^2
2	NPK recommendations	10.2^2	10.2^2
3	Granular Fertilizer 10 tons/hectare	10.1^3	10.1^6
4	Granular Fertilizer 10 tons/hectare + NPK recommendation	10.1^3	10.1^6
5	Granular Fertilizer 20 tons/hectare	10.1^3	10.1^7
6	Granular Fertilizer 20 tons/hectare + NPK recommendation	10.1^3	10.1^7

3.2 Rice Production

The use of organic fertilizers can restore and increase soil fertility in addition to increasing crop production. Rice plant production through grain yield indicators is the role of organic fertilizer application which can facilitate the physiological processes of plant growth and production. The production results of rice plants are described in Figure 3.

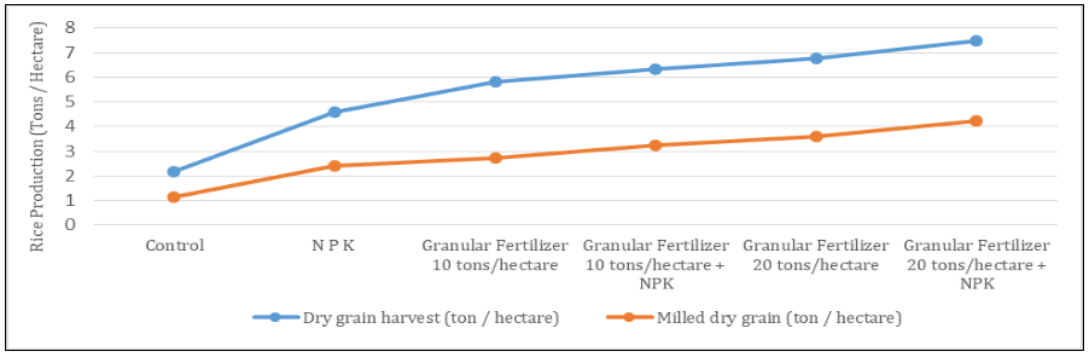

Figure 3 Production of harvested dry unhulled rice and dry milled unhusked rice (tonnes/hectare)

Figure 3 explains that the highest rice production was found in the treatment of granular organic fertilizer 20 tons/hectare + NPK with a production of 7.4 tons/hectare harvested dry grain, and 4.24 tons/hectare dry milled grain. The weight production of harvested dry grain and dry milled grain in rice plants reflects the accumulation of organic compounds that plants have successfully synthesized from organic compounds, water and carbon dioxide which will contribute to plant dry weight (Alvarez *et al*, 2021). Active division of meristem cells in roots will spur good root development, so that active microbial activity in the root area and energy generated from the respiration process becomes more and supports plant canopy growth, thereby increasing plant dry weight (Olenska *et al*, 2020).

4 Conclusion

Granular organic fertilizer application 20 tons/hectare can improve the quality of bacteria from 10.1^3 to 10.1^7 cfu/ml compared to other treatments. Granular organic fertilizer 20 tons/hectare and recommended NPK is a treatment that can increase the production of harvested dry grain by 7.4 tons/hectare and dry milled grain by 4.24 tons/hectare., when compared to production in the organic fertilizer treatment Granul 20 ton/hectare, as well as the recommended NPK fertilizer treatment.

Compliance with ethical standards

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Disclosure of conflict of interest

The author declares no conflict of interest.

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