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Organic Fertilizer Application on Three Varieties of Irrigated Low-land Rice (*Oryza sativa* L.)

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ABSTRACT

Rice is the main staple in Indonesia and the demand for rice production risees along with population growth. Providing organic fertilizer can overcome fluctuations in rice production by increasing nutrient efficiency and being nutrients availability that contribute crop yield increase. This research was carried out in Kaur Regency, Bengkulu Province in September – December 2023. The objective of this research was to investigate the effect of manure on growth and yield of three varieties of irrigated lowland rice. The first experiment was using a Completely Randomized Block Design (CRBD) with 2 factors. The first factor is 3 types of rice varieties, namely Inpari 48, Inpari 32 and Inpari 38. Meanwhile, the second factor is the type of manure, namely cow manure, goat manure and chicken manure. The results of the research showed that in the first experiment it was concluded that there was no real interaction between rice varieties and manure on rice growth and yield. The best rice variety is Inpari 48 which has better growth and yield compared to Inpari 32 and Inpari 38. The application of chicken manure produces better growth and yield of rice and soil chemical properties and agronomic efficiency compared to cow and goat manure.

INTRODUCTION

Rice (*Oryza sativa* L) is a rice-producing food crop which plays an important role in people's lives, especially the Indonesian population. This is because Indonesian people are dependent on consuming rice as a staple food and it is difficult to replace it with other staple foods. The existence of rice is a top priority in fulfilling the main source of carbohydrates which are able to provide human energy needs. Rice as a food crop is consumed by approximately 90% of the entire Indonesian population as a daily staple food (Donggulo et al., 2017). If national rice production is converted into rice, rice production in 2022 is estimated at 32.07 million tons with the rice harvest area in 2022 estimated at 10.61 million hectares and projected national rice production in January-April 2023 to reach 13.79 million tons or an increase of 0.08 million tons or 0.56 percent compared to the same period in 2022.

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Bengkulu Province's rice production in the last three years has still experienced fluctuations, namely in 2020 it was 292,834 tons, in 2021 it was 271,117 tons and in 2022 it was 290,155.93 tons (Central Statistics Agency, 2023).

Rice food products must always be increased; this is in line with the increase in population, so that the supply of rice which has become the staple food of society in general must be met evenly. The decline in rice production is caused by the decreasing area of rice fields and decreasing soil fertility as indicated by low organic C content without any improvement in quality. Improper and efficient use of chemical fertilizers can cause soil degradation and decrease soil organic matter content. In efforts to deal with several problems that occur, it is necessary to carry out several development strategies to increase rice production, such as through the use of superior seed varieties, proper and balanced fertilization efficiency and the addition of organic materials.

Efficient use of fertilizer nutrients is a very important part of an intensive rice farming system. This system can also increase economic efficiency and have a positive impact on environmental health (because the use of nutrients/fertilizers becomes more rational and controlled) (Soplanit and Nukuhaly, 2012). Nutrient requirements for rice plants must be met in order to increase production and yields. Chicken manure organic fertilizer is an organic material that is widely used as an organic fertilizer which has an influence on the availability of nutrients and improves the structure of soil which is very deficient in organic nutrients and can fertilize spinach plants. That is why applying organic fertilizer to the soil is very necessary so that plants grow in the soil well. Most farmers use chicken manure and goat manure which are usually used to fertilize plants, namely annual and annual plants. Getting this dirt is very easy and cheap. Chicken manure and goat manure contain nutrients needed by plants (Indriyati , 2014).

Research results (Tufaila et al, 2014) state that the nutrient content in manure includes macro and micro elements in chicken manure consisting of: N (1.72%), P (1.82%), K (2.18%), Ca (9.23%), Mg (0.86%). Meanwhile, research shows that chicken manure contains nutrient elements N 1%, P 0.80%, K 0.40% and water content 55% (Susilowati, 2013). Apart from providing chicken manure, several organic fertilizers such as cow manure and cow manure also play a significant role in rice production; this is due to the complex nutrient content contained in organic fertilizers. Cow and goat manure which has nutrient content respectively N 0.40%, P_2O_5 0.20%, K_2O 0.10% and N 0.60%, P_2O_5 0.30%, and K_2O 0.17%. The research results of Azalika et al (2018) showed that applying goat manure at a dose of 5 tons/ha produced the highest number of grains with an average of 413.03 grains per panicle or an increase of 75.53%. Likewise, the application of cow dung manure at a dose of 20 tons.ha^{-1} provides a percentage of rice grains of around 97.26% which is higher when compared to without application of manure.

Each type of plant requires nutrients in different amounts. Inaccuracy in the application of nutrients/fertilizers will also cause plants to not be able to grow and produce optimally and the unbalanced application of inorganic fertilizers will result in a decrease in soil quality, this will have an impact on the growth and yield of rice plants. In order for fertilization efforts to be efficient, applying fertilizer is not enough to just look at the condition of the soil and environment, but must also consider the basic nutritional needs of plants. By knowing the basic nutritional needs of plants, the dose and type of fertilizer can be determined more precisely. In an effort to increase fertilization efficiency, balanced fertilization technology has been developed. According to Setyorini et al. (2004), balanced fertilization is the application of fertilizer to the soil to achieve a balanced and optimum status of all essential nutrients in the soil to increase production and quality of agricultural products, fertilizer efficiency, and soil fertility and avoid environmental pollution. The goal of this research was to investigate the effect of manure on growth and yield of three varieties of irrigated lowland rice.

MATERIALS AND METHODS

This research was carried out in Kaur Regency, Bengkulu Province in September –

December 2023. The rice fields used in this research are the researcher's personal property. The rice field is a simple irrigated rice field located in a workshop area covering 80 hectares in Benua Ratu Village, Kaur Regency. The location of this rice field is at coordinates 4°06'8.81"S and 103°03'1.9"E. The experiment was structured using a Completely Randomized Block Design (CRBD) with 2 factors. The first factor is 3 types of rice varieties, namely Inpari 48, Inpari 32 and Inpari 38. Meanwhile, the second factor is the type of manure, namely cow manure, goat manure and chicken manure. The dose of manure applied is 10 $tons.ha^{-1}$ or the equivalent of 6.25 $kg.plot^{-1}$. Next, these two factors were combined to obtain 9 treatment combinations which were repeated 3 times to obtain 27 experimental units.

This experiment was carried out through several stages, namely land preparation, seed preparation, planting, fertilization, observing vegetative variables, harvesting, and observing harvest yield variables. Biochar preparation involves three types of biochar, namely rice husk biochar, coffee husk biochar, and coconut shell biochar. All types of biochar are ground and sieved to a size of 5 mm. For manure, three types of organic fertilizer are used, namely cow, chicken and goat manure which is dried to a moisture content of 12% and sieved until it passes a size of 5 mm. Initial soil analysis was carried out by taking samples from five research location points to analyze the N, P, K and C-organic content.

The land preparation stage includes cleaning weed vegetation and rice field water channels, mechanical land processing, and making plots. Manure and biochar were applied to the experimental plots at a dose of 10 $tons.ha^{-1}$, then incubated for two weeks. Seedling preparation is done by soaking in salt water, germinating for 48 hours, and sowing in a growth container for 120 hours. Planting is carried out after the preparation of the experimental plot is complete, with the spacing adjusted. Fertilization is carried out twice at the age of 7 and 40 HST using urea and NPK. Harvesting is carried out when the plants show physiological maturity, by observing the dry weight of the plants in the laboratory. After harvest, composite soil samples were taken for final analysis of N, P, K and C-organic nutrient.

The data obtained from this research was analyzed using the F test (Fisher Test) analysis. If the results of the analysis showed a real or very real effect then it was continued with the least significant difference test (BNT) at the 5% level. Next, the agronomic efficiency analysis was calculated using a modification of the method of Singh et al. (1998):

$$Aex = \frac{Y_{fertilizer} - Y_{ox}}{Y_{ox}}\ x\ 100\%$$

Where Aex = agronomic efficiency (%), Yfertilizer = yield with fertilizer application ($tons.ha^{-1}$), Yox = yield without applying fertilizer ($tons.ha^{-1}$) using as a reference the yield of rice tiles in Benua Ratu Village, in December 2023.

RESULTS AND DISCUSSION

The results of the analysis of variance showed that rice varieties had a significant effect on plant height, number of leaves, plant fresh weight and number of grains per panicle, but had no significant effect on the number of tillers, plant dry weight and grain weight per hill. The application of manure had a

Table 1. Summary of variance analysis results on the influence of varieties and fertilizers on rice growth and yield

Research variable	F-count			CV (%)
	Variety	Manure	Interaction	
Plant height	118.50*	4.99*	0.35 ns	2.87
Tiller number	0.69 ns	2.64 ns	0.57 ns	6.45
Number of leaves	7.56*	1.80 ns	0.74 ns	2.28
Plant fresh weight	4.15*	3.16 ns	0.07 ns	16.82
Plant dry weight	2.02 ns	1.94 ns	0.08 ns	24.57
Grain number per panicle	8.21*	3.36 ns	0.07 ns	8.81
Grain weight per hill	1.36 ns	6.26*	0.15 ns	11.65

Note: * = significant different at α=5%, ns : not significant different, CV: coefficient of variation

Table 2. Effect of varieties on rice growth variables

Variety	Plant height (cm)	Tiller number	Leave number	Straw fresh weight (g)	Straw dry weight (g)
Inpari 48	115.35 a	21.52	23.14 a	299.63 a	193.62
Inpari 32	97.54 b	20.91	22.20 b	241.12 b	153.87
Inpari 38	96.07 b	20.83	22.53 b	291.56 a	188.52

Note: Numbers followed by the same letter in the same column mean that they are not significantly different in the LSD at α=5%

significant effect on plant height and grain weight per hill, but had no significant effect on the number of tillers, number of leaves, plant fresh weight, plant dry weight and number of grains per panicle. Meanwhile, the interaction of rice varieties and manure had no significant effect on all observed variables (Table 1).

Effect of Variety on Rice Growth and Yield

The results of the research showed that there were significant differences between the three rice varieties in plant height, number of leaves, and plant fresh weight. The Inpari 48 variety showed significantly different plant height and the highest number of leaves compared to the Inpari 32 and Inpari 38 varieties (Table 2). This difference is caused by genetic factors, where the Inpari 48 variety has the genetic potential to grow taller than the Inpari 32 and Inpari 38 varieties so that it will produce a greater number of tillers and leaves. According to Yulina et al. (2021), variation in genetic composition is one of the main factors influencing phenotypic diversity in plants. Plants that have superior genetic makeup tend to show more optimal growth. Based on the variety description, the Inpari 48 plant height reaches 124 cm, higher than Inpari 32 and Inpari 38, which respectively have plant heights of 97 cm and 94 cm. The results of the research study are in line with Maintang et al. (2022) that the Inpari 48 variety produces the highest vegetative yield in rice fields with low pH abiotic stress.

The results showed that the Inpari 48 variety produced the highest wet and plant dry weights, although it was not significantly different from the Inpari 38 variety, but was significantly different from Inpari 32 (Table 2). This is because the Inpari variety has a higher plant height, number of tillers and number of leaves so that the weight of the wet and plant dry is heavier. Plants that are taller and have more leaves will tend to have a higher photosynthetic capacity because they can absorb more sunlight, which ultimately supports the growth of greater biomass (Ye et al., 2024). More tillers mean more growth points, which can increase total leaf production and, overall, photosynthetic capacity. This has direct implications for increasing biomass accumulation in the form of plant dry weight (Widyawati et al., 2023).

The results showed that the Inpari 32 variety produced the highest number of grains per panicle which was significantly different from Inpari 38 and Inpari 48 (Table 3). This is because genetically the Inpari 32 variety has a greater number of grains per panicle than the Inpari 38 and Inpari 48 varieties. Based on the plant description, the Inpari 32 variety has a number of grains per panicle of 118 grains and the Inpari 38 variety has a number of grains per panicle of 119 grains, while the Inpari 48

Table 3. Effect of variety on rice yields

Variety	Grain number per panicle	Grain weight per clump (g)	Yield projection (tons.ha^{-1})	Potential Yield (tons.ha^{-1})
Inpari 48	94.52 b	60.37	8.50	9.13
Inpari 32	105.12 a	58.46	8.23	8.42
Inpari 38	111.85 a	55.17	7.77	8.16

Note: Numbers followed by the same letter in the same column mean that they are not significantly different in the LSD at α=5%

variety has a number of grains per panicle of 96 grains. The research results are in line with the statement of Wu et al. (2022) that rice varieties that have superior genetics will produce a greater number of grains per crop.

The Inpari 48 variety has a grain weight per hill and the projected yield tends to be heavier with a higher projected yield even though the number of grains per panicle is lower compared to the Inpari 32 and Inpari 38 varieties (Table 3). This is because the Inpari 48 variety has better growth components compared to the Inpari 32 and Inpari 38 varieties. However, in general the research results show that the projected yield of the Inpari 48, Inpari 32 and Inpari 38 varieties is still low compared to the potential yield. This is because the land used in this research has low soil fertility so that rice yields are less than optimal.

The research results showed that the final soil characteristics of each variety tended to be different. N levels and soil pH in the Inpari 48 variety tend to be higher. Meanwhile, the levels of organic C, P and K in the Inpari 38 variety tend to be higher (Table 4). Differences in chemical properties between plant varieties can be caused by each variety having unique genetic characteristics, which can influence the plant interaction with the environment in which it grows. Different varieties have different preferences when it comes to the type and amount of nutrients needed for optimal growth. Furthermore, each variety has different efficiency in absorbing certain nutrients from the soil. Therefore, differences in nutrient requirements can lead to differences in soil nutrient levels around plant roots.

Effect of Organic Fertilizer on Rice Growth and Yield

The results showed that applying manure made a significant difference to plant height. Providing chicken manure produces higher plant height compared to applying cow and goat manure. Apart from that, the application of chicken manure also resulted in a greater number of chicks and leaves , and the weight of wet and plant dry tended to be heavier compared to cow and goat manure (Table 5). This is because chicken manure can improve the chemical properties of the soil compared to cow and chicken manure. Providing chicken manure produced higher C, N, P, K and soil pH compared to goat and cow manure (Table 7).

The growth and development of rice plants is significantly influenced by the availability of the nutrients nitrogen (N), phosphorus (P), and potassium (K) in the soil. Various studies have shown that these elements play an important role in the processes of photosynthesis, metabolism, plant structure formation, as well as the production and quality of crops. Nitrogen is the main component in the formation of proteins, chlorophyll and nucleic acids, all of which are very important for the process of photosynthesis and the formation of plant tissue. Sufficient nitrogen availability can increase the number of leaves, root growth and crop production in rice plants (Iqbal et al., 2019). Phosphorus is necessary for the formation of energy (ATP) and is an important component of DNA and RNA molecules. Sufficient availability of phosphorus can increase root growth, flower formation and seed formation in rice plants (Kant, 2018). Furthermore, potassium plays an important role in regulating osmotic pressure, opening and closing stomata, and activating enzymes in plant metabolism (Wang et al., 2021).

Application of chicken manure resulted in a higher number of grains per panicle, weight of grain per hill and projected rice yield compared to cow manure and goat manure (Table 6). This is due to the ability of chicken manure to

Table 4. Soil characteristics of 3 rice varieties

Variety	N-total (%)	C-organic (%)	P_{-dd} (ppm)	K_{-dd} (me.(100g)$^{-1}$)	pH
Inpari 48	0.24?	1.32	2.99	0.23	4.34
Inpari 32	0.22?	1.42	3.74	0.36	4.19
Inpari 38	0.23?	1.79	4.07	0.38	4.20
Initial	0.12?	0.47?	1.70	0.08	4.05

Table 5. Effect of manure type on rice growth variables

Types of manure	Plant height (cm)	Number of tiller	Number of leaves	Straw fresh weight ($g.hill^{-1}$)	Straw dry weight ($g.hill^{-1}$)
Cow	101.18 b	20.60	22.40	266.06 b	157.19 b
Goat	102.34 b	20.73	22.61	257.30 b	179.24 ab
Chicken	105.44 a	21.94	22.86	308.96 a	199.59 a

Note: Numbers followed by the same letter in the same column mean that they are not significantly different in the LSD at α = 5%

improve soil chemical properties comparatively to cow and goat manure. The use of chicken manure results in a significant increase in the concentration of carbon (C), nitrogen (N), phosphorus (P), potassium (K), and also soil pH. These changes contribute to improved soil conditions that are more optimal for the growth and development of rice plants, which in turn results in better crop yields. Elements such as nitrogen (N), phosphorus (P) and potassium (K) are the most important nutrients for plant growth and development (Ye et al., 2019). The elements N, P and K can increase plant productivity. Photosynthesis increases so that it can increase seed filling. The research results are in line with Phopaijit et al. (2022) that applying manure can increase plant yields.

The research results showed that the application of cow, goat and chicken manure was able to increase total N, organic C, P-dd, K-dd and soil pH levels (Table 7). This is because manure contains organic material which is rich in nutrients including N, P and K (Putra et al., 2024). The role of organic matter in soil fertility includes mineralization of organic matter which will release plant nutrients. After application to paddy soil, this organic material undergoes decomposition by the activity of soil microorganisms. This decomposition process produces simpler organic compounds and nutrient elements in a form that can be absorbed by plants. Furthermore, organic matter in manure provides an important carbon source for soil microorganisms. This microbial activity increases the decomposition process of organic material and produces simple organic compounds. The accumulation of these organic compounds increases the organic carbon content in the soil (C-organic) and soil pH, which positively influences the fertility of paddy fields (Yuniarti et al., 2019).

Chicken manure produces higher levels of N-total, P-dd and K-dd compared to manure from cows and goats . These results highlight the superior potential of chicken manure in providing essential nutrients such as nitrogen (N), phosphorus (P), and potassium (K) necessary for plant growth and development. The high total nitrogen content in chicken manure is a strong indication of an abundant source for protein formation and plant vegetative growth. Meanwhile, higher P-dd and K-dd contents indicate the ability of chicken manure to support a strong root system, grain development, and better crop quality.

The research results are in line with Sari et al. (2016) that chicken manure has significant potential because it not only plays a role in

Table 6. Effect of manure on rice yield

Types of manure	Number of grains per pani-	Grain weight per clump (g)	Estimated yeld ($tons.ha^{-1}$)
Cow	98.42	52.95 b	7.46
Goat	103.47	56.96 b	8.02
Chicken	109.59	64.08 a	9.02

Note: Numbers followed by the same letter in the same column mean that they are not significantly different in the BNT follow-up test at the 5% level

Table 7. Soil characteristics after manure application

Manure	N-total (%)	C-org (%)	P-dd (ppm)	K-dd (me. $(100g)^{-1}$)	pH
Cow	0.19	1.53	3.19	0.25	4.43
Goat	0.22	1.52	3.65	0.34	4.16
Chicken	0.28	1.48	3.96	0.37	4.14
Land of Begin-ning	0.12	0.47	1.70	0.08	4.05

improving the physical, chemical and biological properties of soil, but also has a higher N, P and K nutrient content compared to manure from other sources. Specifically, the nutrient content in chicken manure is N 3.21%, P_2O_5 3.21%, and K_2O 1.57%. In this comparison, cow manure has an N content of 2.33%, P_2O_5 0.61%, and K_2O 1.58%, while goat manure has an N content of 2.10%, P_2O_5 0.66%, and K_2O 1.97% (Ichsani, 2021).

Agronomic Efficiency of Manure Use

Agronomic efficiency is an important parameter in evaluating agricultural practices, which provides an idea of how effective an agricultural input, such as fertilizer, is in increasing crop yields. In this research, the change in agronomic parameters observed was the weight of milled dry grain (MDG). As a comparison, the yield of rice tiles in Benua Ratu Village, District in December 2023 is 4.38 $kg.tile^{-1}$ or estimated to be 5.6 $tons.ha^{-1}$. The results of the study showed that the application of manure for cows, goats and chickens resulted in a higher weight of milled dry grain compared to rice productivity in Benua Ratu Village. Specifically, rice productivity increased by 1.86 $tons.ha^{-1}$ with the application of cow manure, it increased by 2.42 $tons.ha^{-1}$ with the application of goat manure, and increased by 3.42 $tons.ha^{-1}$ with the application of chicken manure. Apart from that, this research also shows an increase in agronomic efficiency from the use of various types of manure. Providing cow manure resulted in an agronomic efficiency of 33.21%. This figure increased to 43.21% with the provision of goat manure, and again increased to 61.07% with the provision of chicken manure (Table 8).

The research results indicate that the use of manure can significantly increase rice productivity compared to the average productivity in Benua Ratu Village, Luas District in 2023. The higher agronomic efficiency of chicken manure indicates that this fertilizer is more effective in increasing crop yields per unit of fertilizer. Given compared to cow and goat manure. This may be caused by the higher nutrient content of chicken manure, especially N, P and K nutrients. Chicken manure produces higher levels of total N, P-dd and K-dd in the soil compared to manure originating from cows and goats, thereby providing more optimal nutrition for rice plants to increase their productivity.

CONCLUSION

The research results showed that there was no real interaction between rice varieties and manure on rice growth and yield. The best rice variety is Inpari 48 which has better growth and yield compared to Inpari 32 and Inpari 38. The application of chicken manure results in better growth and yield of rice and soil chemical properties and agronomic efficiency compared to cow and goat manure.

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Table 8. Grain yield, yield increase and agronomic efficiency of lowland rice when applying 3 different types of manure

Type of manure (dosage 5 $tons.ha^{-1}$)	Milled dry grain yield ($tons.ha^{-1}$)	Farmer's rice production ($tons.ha^{-1}$)*	Yield increase ($tons.ha^{-1}$)	Agronomic efficiency (%)
Cow	7.46	5.6	1.86	33.21
Goat	8.02	5.6	2.42	43.21
Chicken	9.02	5.6	3.42	61.07

Note: * (source: results of rice tiles in Benua Ratu Village, Luas District, 2023)

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