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The Effectiveness of Bio-Slurry and Inorganic Fertilizer Combination on the Performance of Rice (*Oryza sativa* L)

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ABSTRACTS

The experiment was aimed to investigate the effectiveness of bio-slurry and inorganic fertilizer combination on the performance of two rice varieties. A completely randomized design of factorial pattern was used throughout the experiment. The first factor was the combination of bio-slurry and NPK fertilizer that consisted of P0: no added fertilizer, P1: NPK fertilizer only, 550 kg/ha; P2: bio-slurry 2.3 tons/ha + NPK fertilizer 400 kg/ha; P3: bio-slurry 4.6 tons/ha + NPK fertilizer 250 kg/ha; P4: bio-slurry 6.9 tons/ha + NPK fertilizer 100 kg/ha; and P5: bio-slurry only, 8.5 tons/ha. Treatments were applied based on nitrogen recommended doses of rice, 165 kg N/ha. The second factor was rice varieties that consisted of V_1: IR-64 and V_2: Ciherang. Each treatment was repeated three times. Parameters observed were plant height, number of tillers, weight of 1,000 grains, and rice production. Data were statistically analyzed using ANOVA and followed by Duncan's Multiple Range Test. On the basis of the experimental results it was concluded that bio-slurry may replace the role of inorganic fertilizer in rice production, especially IR-64 and Ciherang varieties.

Keywords: bio-slurry, ciherang, IR-64, NPK fertilizer, rice

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1. Introduction

Increasing food demand in the last few decades due to the increase of earth population influenced the management of agricultural activity. As consequences, intensive agricultural activities by implementing excessive inorganic fertilizer and mechanization were suspected create problem on both environment and agricultural farmland. Therefore, to avoid the degradation of the environment and agricultural soil proper strategy in practicing agriculture should be taken into account.

Rice is the staple food of most people on earth including Indonesia. With the population of more than 250 millions in 2016, Indonesia only produced about 80 millions of rice. In fact, the consumption of rice was predicted reach 125 kg/person/year in 2017-2019. With the growth rate of population assume 1.2%/year, the consumption of rice during 2017-2019 may reach 80 millions (Ministry of Agriculture the Republic of Indonesia, 2016). Recently, the production of rice in Indonesia is about 5 tons/ha, about 40 to 50% less than its production in 1990s.

Intensive agricultural activity was implemented in producing rice by applying more inorganic fertilizers were suspected decreased the soil fertility and therefore declined rice production. Continuous use of inorganic fertilizer without organic fertilizer application may cause nutrient imbalance in the soil, low fertilizer efficiency, damage of soil structure and decrease the population of soil microorganism. By applying organic matter (OM) such as crop residues, green manure, manure, and compost into agricultural soil may improve the soil fertility. The increase quality of soil directly influences the performance of agricultural soil in producing rice.

Bio-slurry is the end product of sludge-shaped livestock waste that is very useful as a source of nutrients for plants. As an OM, it is predicted that bio-slurry may be used to overcome the nutrient unbalance in the soil. It has been widely used in agricultural areas in Indonesia such as in cropping vegetables (chili, cucumber, tomato), tubers (potatoes, carrots), fruits (dragon fruit, papaya, oranges), food crops (maize, rice, cassava) and other crops (chocolate, coffee, coconut) (Hartanto and Putri, 2013). However, it has not been widely used in the improvement of paddy fields in Indonesia. In fact, it was used as a source of OM in improving rice fields in other countries. It was reported that bio-slurry increased the rice crops production up to 23% compared to the application of inorganic fertilizer containing N, P and K fertilizer (Gnanamani and Bai, 1992). In addition, Bharde *et al. (*2003) reported that the application of bio-slurry showed the same result compared to the implementation of 100% urea fertilizer in rice production. The absorption of N by rice crops due to the application of bio-slurry was lower than that of N, P, K fertilizer application, even though the production of paddy

grain which gained due to the addition of bio-slurry did not differ significantly to the use of inorganic fertilizers (Ghoneim, 2008). At the previous experiment conducted in India, Gnanamani and Bai (1992) found that implementation of bio-slurry and N, P, K fertilizer combination increased rice production by 52% compared to the application either bio-slurry or inorganic fertilizer solely. As an OM generated from livestock, bio-slurry remains rich in nutrients both macro and micro nutrients as sown at Table 1.

Table 1. Nutrient content of bio-slurry

No.	Nutrients	Contents	
		%	ppm
1.	Nitrogen (N)	1.39-2.05	
2.	Phosphorus (P)	0.24-2.70	
3.	Potassium (K)	0.02-0.58	
4.	Calcium (Ca)		13,934-28,300
5.	Magnesium (Mg)		800-6,421
6.	Sulphur (S)	1.74	
7.	Ferum (Fe)		3.15
8.	Manganese (Mn)		132.5-1,905
9.	Cupper (Cu)		9-36.2
10.	Zeng (Zn)		40-97

Source : Hartanto and Putri (2013)

Novira *et al.* (2015) reported that bio-slurry contains amino acids, micronutrients, B vitamins, various hydrolase enzymes, organic acids, hormones, antibiotics and humic acid. However, in the short term, bio-slurry may not be applied solely but it should be concurrently applied with inorganic fertilizer. This is due to the fact that the application of organic fertilizer alone in the short term may not be able to meet the nutrient required by plants, because bio-slurry should be decomposed first before it may be absorbed by plants (Leomo *et al.*, 2012). This study was aimed to evaluate the effectiveness of bio-slurry and NPK fertilizer combination on the performance of two varieties of rice, IR-64 and Ciherang.

2. Materials and Methods

2.1. Experimental Site and Material Used

The field experiment was conducted at paddy fields of Wonosalam Village, Wonosalam Sub-district, Demak District (06°43'26" - 07°09'48" SL; 110°27'58" - 110°48'47" EA), Central Java Province, Indonesia. It was carried out during the raining season from March 28 - July 19, 2017. The experimental areas has a daily temperature between 23-34°C, with rainfall ranges between 100 to 3,000 mm/year (Central Bureau Statistics of Demak District, 2016). Chemical and physical analysis were conducted at Ecology and Plant Production Laboratory, Department of Agriculture, Faculty of Animal and Agricultural Sciences, Diponegoro University, Semarang (06°55'34" - 07°07'04" SL; 110°16'20" - 110°30'29" EA). It is about 30 km from the experiment field. The materials used included paddy, soils, Rice varieties of IR-64 and Ciherang, bio-slurry, NPK 30-6-8, SP36 and KCl fertilizers.

2.2 Procedure of Experiment

Experiment was begun by preparing the 2 x 3 m^2 of seedbed as germination site. Ten (10) kg of goat manure were then added into the seedbed. Seeds of rice were soaked into 3% of salted solution. After that seeds were soaked in water for about 48 hours. Seeds then were placed at a wet sack for 2 days to germinate. Furthermore, seeds were germinated by sowing on germinated site for about 15 days. Planting media were made by taking the soil from paddy fields and weighed to 8 kg, then it was put into experimental pot. Bio-slurry then was added into the soil according to the treatment. Planting was carried out by transferring three seedlings of the 15day-old into the experimental pot. Pots that have been planted with seedlings were then set at the rice field with a spacing of 20 cm x 20 cm. Application of NPK fertilizer was conducted in three times with the same doses. One third of doses were implemented each at 7 days, 20 days, and 60 days after planting (DAP), respectively. At the first application of NPK fertilizer, SP36 and KCl fertilizers were also added as basic fertilizer. The existing of weeds were controlled manually, while pest was controlled using pesticides. Harvesting was conducted at 14 weeks after planting.

2.3. Experimental Design and Data Analysis

A completely randomized design of factorial pattern 6 x 2 was used throughout the experiment. The first factor was the combination of bio-slurry and NPK fertilizer that consisted of P0 : no added fertilizer (control), P1: NPK fertilizer only of 550 kg/ha; P2: bio-slurry 2.3 tons/ha + NPK fertilizer 400 kg/ha; P3: bio-slurry 4.6 tons/ha + NPK fertilizer 250 kg/ha; P4: *bio-slurry* 6.9 tons/ha + NPK fertilizer 100 kg/ha; and P5 : bio-slurry 8.5 tons/ha only. The second factor was varieties of rice that consisted of V_1: IR-64 and V_2: Ciherang. Treatments were applied on the basis of the nitrogen recommended doses of rice, 165 kg N/ha. Each treatment was repeated three times. Parameters observed were plant height, number of tillers, the weight of 1,000 grains, and rice production. The parameters of plant height and number of tillers were collected once a week. The weight of 1,000 grains and rice production was determined after harvesting.

2.4. Statistical Analyses

All collected data were analyzed statistically based on ANOVA procedure. A Duncan's Multiple Range Test 5% significance levels were used for further analyses.

3. Results and Discussion

3.1. *Chemical properties of initial soil and bio-slurry*

The results of the analysis of chemical properties of initial soil and bio-slurry were presented at Table 2. Accordingly, it can be concluded that the N content of soil and bio-slurry were moderate and very high, respectively. Meanwhile the C-organic content of soil and bio-slurry were respectively moderate and very high. Therefore, the C: N ratio of soil and bio-slurry were both low. This indicates that bio-slurry may be rapidly decomposed when it is incorporated into soil (Henry et al., 1999).

Table 2. The chemical properties of initial soil and bio-slurry

Media	Nutrients	%	Criteria
Soil	N	0.21	Moderate*)
	P	0.09	Very low*)
	K	1.60	Very high*)
	C-organic	2.44	Moderate*)
	C:N ratio	11.6	Low*)
Bio-slurry	N	1.95	Very high*)
	P	0.61	Very low*)
	K	1.00	Very high*)
	C-organic	24.05	Very high*)
	C:N ratio	12.4	Low*)

*Analyses were conducted at the laboratory of Ecology and Plant Production, Faculty of Animal and Agricultural Sciences, Diponegoro University, Semarang, Indonesia *) Sources : Soil research center, 1983*

3.2. Plant height

Plant height of rice due to the treatment of bio-slurry and mixed bio-slurry-NPK fertilizer and rice varieties were presented at Table 3. The highest height of rice plants was reached by the treatment of NPK fertilizer only (P1) with the average height of rice plant was 75.9 cm. However, it was not significantly different to the treatment of P2, P3, P4 and P5. Treatments of P1, P2, P3, and P4 were significantly different ($p<0.05$) compared to the control (P0), however treatment P5 was not significantly different compared to the control (Table 3). These indicated that either bio-slurry applied solely or in combination with NPK fertilizer increased the growth of rice plants. This finding proved that bio-slurry applied solely and mixed with NPK fertilizer may replace the role of inorganic fertilizer in affecting the performance of rice. Inorganic fertilizer increased the growth of rice plants due to the nutrient released from inorganic fertilizer directly available to plants. Therefore, the nutrients contained in inorganic fertilizer may be used directly to support plant growth. Through mineralization bio-slurry may release the nutrients into soil and increase nutrients availability, and consequently improves soil fertility, and available nutrients meet the nutrient required by plants. This is in accordance with Groot and Bogdanski (2013) who found that bio-slurry was useful in improving the quality of agricultural soil by neutralizing acid condition, increased humus content as much as 10-12% and support the activity of earthworm development and the role of microbial soil on plants. On the other hand, Hartanto and Putri (2013) reported that use of bio-slurry improved the soil physical structure, increased the ability of soil holding water capacity and soil fertility.

Plant height of both rice varieties, IR-64 and Ciherang were not significantly different (Table 3). This is in accordance with the characteristics of both varieties of rice that those two varieties have similar plant height genetically. So statistically those two of rice varieties did not show any difference in plant height. This is in agreement with Suprihatno et al. (2010) who found that the average height of IR-64 and Ciherang reached 115 cm and 107-115 cm, respectively.

3.3. Number of Tillers

The number of tillers due to the treatment of bio-slurry only and mixed bio-slurry-NPK fertilizer and rice varieties were presented at Table 4. Number of tillers of P1 did not significantly different compared to P2, P3, and P4. Treatments of P1, P2, P3, and P4 were significantly different ($p<0.05$) compared to the control (P0), however treatment P5 was not significantly different compared to the control. This shows that the use of inorganic fertilizer combined with bio-slurry has an effect on the growth of IR-4 and Ciherang rice especially on the number of tillers. This is presumably because the addition of bio-slurry may increase the availability of macro and micro nutrients required by those two varieties of rice.

Table 3. Plant height of rice due to the treatment of bio-slurry and mixed bio-slurry-NPK fertilizer and rice varieties

Experimental Codes	Treatments	Rice varieties		Mean
		IR-64	Ciherang	
		----------cm----------		
P0	Control	65.0	74.2	69.6 b
P1	NPK fertilizer 550 kg/ha	77.2	74.5	75.9 a
P2	Bio-slurry 2.3 ton/ha + NPK fertilizer 400 kg/ha	72.7	76.5	74.6 a
P3	Bio-slurry 4.6 ton/ha + NPK fertilizer 250 kg/ha	74.8	73.4	74.1 a
P4	Bio-slurry 6.9 ton/ha + NPK fertilizer 100 kg/ha	74.4	75.2	74.8 a
P5	Bio-slurry 8.5 ton/ha	72.8	72.6	72.7 ab
	Mean	72.8	74.4	

Different superscript at the same column and rows showed significantly differences at $p<0.05$

Table 4. The number of tillers due to the treatment of bio-slurry only and mixed bio-slurry-NPK fertilizer and rice varieties

Experimental Codes	Treatments	Rice varieties		Mean
		IR-64	Ciherang	
		----------Tillers----------		
P0	Control	10.3	11.5	10.9 b
P1	NPK fertilizer 550 kg/ha	17.6	20.5	19.1 a
P2	Bio-slurry 2.3 ton/ha + NPK fertilizer 400 kg/ha	17.2	20.1	18.6 a
P3	Bio-slurry 4.6 ton/ha + NPK fertilizer 250 kg/ha	17.1	17.6	17.3 a
P4	Bio-slurry 6.9 ton/ha + NPK fertilizer 100 kg/ha	17.9	16.7	17.3 a
P5	Bio-slurry 8.5 ton/ha	16.7	13.6	15.2 ab
	Mean	16.1	13.6	

Different superscript at the same column and rows showed significantly differences at $p<0.05$

Table 5. The weight of 1,000 grains of rice due to the treatment of bio-slurry solely and mixed bio-slurry-NPK fertilizer and rice varieties

Experimental Codes	Treatments	Rice varieties		Mean
		IR-64	Ciherang	
		----------g----------		
P0	Control	15.6.	19.4	17.5 b
P1	NPK fertilizer 550 kg/ha	22.6	23.6	23.1 a
P2	Bio-slurry 2.3 ton/ha + NPK fertilizer 400 kg/ha	23.4	22.9	23.2 a
P3	Bio-slurry 4.6 ton/ha + NPK fertilizer 250 kg/ha	26.6	23.8	25.2 a
P4	Bio-slurry 6.9 ton/ha + NPK fertilizer 100 kg/ha	24.8	24.7	24.8 a
P5	Bio-slurry 8.5 ton/ha	23.6	25.6	24.6 a
	Mean	22.8	23.4	

Different superscript at the same column and rows showed significantly differences at p<0.0

The combination of inorganic and bio-slurry may be able to increase the growth of rice. The nutrients released by inorganic fertilizers and absorbed directly by plants. Leomo et al. (2012) found that the application of inorganic and organic fertilizers simultaneously increased the plant growth. The application of bio-slurry needs to be equipped with inorganic fertilizers due to in the short-term bio-slurry may not be able to meet the nutrients requirement of plant. This is probably due to the fact that as an OM, bio-slurry needs to be decomposed and released nutrients that may be utilized by plants (Novira et al., 2015). It was found that the application of bio-slurry either solely or mixed with inorganic fertilizers did not significantly different in number of tillers, and therefore bio-slurry may be implemented alone without adding inorganic fertilizers.

Treatment of bio-slurry only (P5) was not significantly different to the treatment of P1, P2, P3, and P4, even though it did not differ to the control. This suggests that the application of bio-slurry solely may capable of replacing the role of inorganic fertilizer in enhancing plant growth, since bio-slurry contains macro and micro nutrients that required by plants. This is in accordance with Haque (2013) who stated that bio-slurry contains macro nutrients N, P, K required by plants in large quantities. Bio-slurry also contains micro nutrients such as Zn, Fe, Mg, and Cu which are important in supporting the growth of plants. Groot and Bogdanski (2013) added that bio-slurry contains cellulite microbes, nitrogen-fixing microbes, and phosphate solvent microbes that may improve soil fertility.

Number of tillers of both rice varieties, IR-64 (16.2 tillers) and Ciherang (13.6 tillers) were not significantly different (Table 3). It is assumed that both rice varieties response similarly to the treatment. This finding was incompatible with Suprihatno et al. (2010), who found that the number of tillers of IR-64 and Ciherang varieties ranges between 20-35 tillers and 14-17 tillers, respectively. The number of tillers of the two rice varieties was dominantly influenced by treatment than genetic factors, considering that both rice varieties should respond differently. This is in accordance with Dahlan et al. (2012) found that the diversity due to environmental factors and genetic diversity generally interact with each other in influencing the appearance of plant phenotypes.

3.4. The weight of 1,000 Grains

The weight of 1,000 grains of rice due to the treatment of bio-slurry solely and mixed bio-slurry-NPK fertilizer and rice varieties were presented at Table 5. The weight of 1,000 grains rice of P1 did not significantly different compared to P2, P3, P4 and P5. Meanwhile, those all of the treatments were significantly different ($p<0.05$) compared to the control (P0) (Table 5). This shows that the use of inorganic fertilizers combined with bio-slurry has an effect on the growth of IR-4 and Ciherang rice especially on the weight of 1,000 grains. This suggests that the application of mixed bio-slurry-inorganic fertilizers as well as single bio-slurry were capable in producing the same results as single application of inorganic fertilizers. Bio-slurry contains micro nutrients such as B vitamins, organic acids, growth hormones and humic acids that are beneficial to the growth and development of plants. This is in accordance with Hossaen et al. (2011) found that bio-slurry improved soil fertility and soil structure, increased the activity of microorganisms in the soil, then influenced the growth and yield of crops. In addition, Rhaman et al. (2016) stated that crop growth is depending on root development due to the implementation of organic fertilizer. This is due to the fact that organic fertilizers may improve soil physical properties and increase the available of N, P and K in the soil. The production of grain that determines the weight of 1,000 grains is influenced by rate of assimilation. Increasing assimilation

Table 6. Rice production due to the treatment of bio-slurry solely and mixed bio-slurry-NPK fertilizer and rice varieties

Experimental Codes	Treatments	Rice varieties		Mean
		IR-64	Ciherang	
		----------ton/ha----------		
P0	Control	3.9	4.5	4.4 b
P1	NPK fertilizer 550 kg/ha	5.6	5.9	5.8 a
P2	Bio-slurry 2.3 ton/ha + NPK fertilizer 400 kg/ha	5.9	5.8	5.8 a
P3	Bio-slurry 4.6 ton/ha + NPK fertilizer 250 kg/ha	6.7	5.9	6.3 a
P4	Bio-slurry 6.9 ton/ha + NPK fertilizer 100 kg/ha	6.2	6.2	6.2 a
P5	Bio-slurry 8.5 ton/ha	5.9	6.4	6.2 a
	Mean	5.7	5.8	

Different superscript at the same columns and rows showed significantly differences at p<0.05

consequently produced more carbohydrates and then it was converted into sugar, and transported to the seed tissue and therefore increased the weight of the seed (Hardjadi 1991).

The weight of 1,000 grains both IR-64 (22.8g) and Ciherang (23.4g) varieties were not significantly different (Table 5). Rice production is closely related to the number of tillers, panicles, and grains. The more number of tillers, panicles and grain of rice determine the higher production of grain. In addition, environmental factors also affect the weight of 1,000 grains. This is in accordance with Agustamar (2007) who stated that the number of productive tillers was a major role in contributing to yield of 48%, almost half of the dry milled grain was determined by the number of productive tillers.

3.5. Rice Production

Rice production due to the treatment of bio-slurry solely and mixed bio-slurry-NPK fertilizer and rice varieties were presented at Table 6. Production of rice at P1 did not significantly different compared to P2, P3, P4 and P5. Meanwhile, those all of the treatments were significantly different ($p<0.05$) compared to the control (P0) (Table 6). This suggests that the use of either single bio-slurry or mixed bio-slurry-inorganic fertilizer was capable in producing statistically similar yields with inorganic fertilizers solely. The application of bio-slurry increased the index of leaf area, root density, plant height of rice (Garg et al., 2005), and rice production (Garg et al., 2005; Basak et al., 2016). Control (No added fertilizer, P0) produced the lowest grain of rice. This is may be due to the fact that rice plants experiencing nutritional deficiencies. Macro nutrients such as N, P, K concurrently influence photosynthesis, and determine the yield of grain. The function of N is to improve vegetative growth of plants and involved the process of protein formation; the phosphorus is very useful for the formation of new cells in the growing tissue, stimulating root growth, protein base ingredients, strengthening plant stems and assisting assimilation and respiration; and potassium function to improve the synthesis and translocation of carbohydrates, thereby accelerating the thickening of cell walls and the stem, branch and fruit (Sonbai et al., 2013; Liferdi, 2010; Taiz and Ziger, 2002).

4. Conclusion

The experiment resulted that the application of bio-slurry solely or mixed bio-slurry-inorganic fertilizer showed the same result to single application of NPK fertilizer on the performance of rice. On the basis of the results, therefore, it was concluded that bio-slurry may replace the role of inorganic fertilizer in rice cultivation, especially IR-64 and Ciherang varieties.

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Conflict of interest: Non declare