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Utilization of Different Fertilizer on The Yield of Two Varieties of *Oryza sativa* in Tidal Lowland Area

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Abstract

The effort to increase food production in tidal lowland areas was conducted by applying production technology through the use of superior varieties and organic fertilizer enriched with bacteria (bio organic fertilizer). This fertilizer was a formula that had been tested in swamp lowland area and proven capable to regain land fertility through action of beneficial microbia. Some microbia which used to produce bioorganic fertilizer are Azospirillium bacterium and phosphate solvent bacterium with carrier substance of chicken manure fertilizer. The reserach objective was to determine yield capacity of two rice varieties by using inorganic fertilizer and bioorganic fertilizer at tidal lowland area. This research was done at tidal lowland area of C-flooding type. The design used in this study was Factorial Randomized Block Design with 4 treatment combinations and 6 replications for each treatment. The first factor was varieties which consisted of Inpara 6 (V1) and Inpari I (V2), whereas the second factor was fertilizer types which consisted of inorganic fertilizer (P1) and bio-organic fertilizer (P2). The results showed that yield capacity of Inpari I rice variety treated with bio-organic fertilizer + 50% of recommended NPK fertilizer could increase the production of dry unhulled rice with magnitude of 165% (1.59 kg/plot or equal to 3.98 ton/ha) at tidal lowland of C flooding type. Through the provision of biofertilizers, chicken manure enriched with Azospirillum and bacteriophosphate biofertilizers contributes to sustainability agriculture, especially in tidal wetland

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INTRODUCTION

Out of 20.1 million ha tidal lowland areas in Indonesia, more than 9 million ha have potential to be developed as agricultural production areas, especially for rice cultivation (Haryono, 2013). Meanwhile, it is estimated that out of 1.9 million ha tidal lowland areas in South Sumatra in 2008, about 413,000 ha had been reclaimed and utilized for agricultural activity. Tidal lowland area has several constraints such as of low soil fertility, lack of macro nutrients and availability of ions,the presence of toxic elements accumulation (Al, Fe, SO_4) and undecomposed organic matter (Dakhyar, 2012).

The efforts that can be done to increase rice production at tidal lowland area are through technological breakthrough such as the use of superior variety and fertilizing (either inorganic or organic fertilizer)(Akmal and Yufdi, 2008).

It is expected that the use of superior rice variety will provide a high yield capacity and have shorter growing period as the main factors in increasing rice production through plant breeding in order to support food tenacity and sustainability of rice self-sufficiency (Saderi *et al.*, 2000).

Superior variety has significant contribution to the increase of crop productivity and it is quickly adopted by farmers because of its cheap price and it is more practical to be used (Council of Agricultural Research and Development, 2007).

Organic fertilizer can be consisted of compost, bio-organic fertilizer and others. Study results by Priadi and Mulyaningsih (2016) in term of compost showed that compost from leftover of Oyster mushroom at dose of 5 kg was capable to produce 19.7 g biomass of water spinach plant compared to the one without compost (13.5 g), leftover of rice straw mushroom (15.4 g) and grass compost (18.9 g). Fertilizers used in this study were inorganic fertilizer and bio-organic fertilizer. Inorganic fertilizer and bio-organic fertilizer are capable to provide nutrients for rice crop. It is expected that bio-organic fertilizer capable to improve soil physical condition and fertility. This bio-organic fertilizer is chicken manure enriched with *Azospirillium* bacteria and phosphate solvent bacteria. Phosphate solvent bacteria had been tested on soil and of lowland swamp area. This research is a further research from the previous research that applied bio-organic fertilizer at dose of 300 to 400 $kg.ha^{-1}$ on rice crop. Results from the previous research showed that application of bio-organic fertilizer at dose of 300 to 400 $kg.ha^{-1}$ was capable to increase rice production and reduce NPK fertilizer usage by 25% from the recommended dose on lowland swamp area (Marlina *et al.*, 2014).

Tidal wetland is one of the rice barns during the rainy season, with a Planting Index of 100, but during the dry season with the management and improvement of fertility, it can be cultivated up to IP 200 (Aminah *et al.*, 2014). The use of biofertilizers as a component of natural habitats has an important role and function in supporting the implementation of environmentally friendly agriculture through various processes, such as decomposition of organic matter, nutrient fixation, nutrient solvents, nitrification and denitrification.

The reserach objective was to determine yield capacity of two rice varieties by using inorganic fertilizer and bio-organic fertilizer at tidal lowland area of C flooding type. Utilization of the use of organic fertilizers enriched with Azospirillum and Phosphate bacteria was expected to increase crop yields, especially Inpari 1 varieties in type C tidal wetland so as to contribute to safe and healthy sustainable agriculture by decreasing the use of inorganic fertilizer .

METHODS

This research had been done at tidal lowland area of C flooding type. The design used in this research was Factorial Randomized Block Design with 4 treatment combinations and 6 replications for each treatment. The first factor was varieties which consisted of Inpara 6 (V_1) and Inpari I (V_2), whereas the second factor was fertilizer types which consisted of inorganic fertilizer (P_1) and bio-organic fertilizer (P_2). Further test was done by using Honestly Significant Different test (HSD). Statistical analysis was done by using SAS 9.1.3 Portable program.

Bio-organic fertilizer production

Chicken manure and rice bran at ratio of 10:1 was mixed and composted. This compost of chicken manure was subsequently incubated for 20 days. Then, it was sterilized within autoclave for 15 minutes followed by cooling process. The next step was addition of Azospirillium bacteria and phosphate solvent bacteria into compost at dose of 5 ml respectively. Finally, bio-organic fertilizer was ready to be used.

Seedling

Seedling operation was done two times: the first seedling was done for 10 days and the second seedling was done until seeds were 21 days old in

which seeds were ready to be planted. Land was cleared from rubbish and weeds by using hand tractor and tilled two times. The next step was the development of 24 plots having dimension of 2 m x 2 m.

Application of bio-organic fertilizer

Bio-organic fertilizer was applied one day before planting according to treatments for crop. NPK fertilizer was also given at planting time according to treatments. Seeds were planted by using two clumps with planting distance of 25 cm x 25 cm and each plot consisted of 49 rice crops.

Crop maintenance was consisted of substitution, weeding as well as pest and dsease control. Weeding was done manually (by pulling out weeds). Pest and dsease control was done by spraying of insecticides and fungicides. Harvest should be done when rice grains have uniformly yellow color and had lower down.

The observed parameters

The observed parameters consisted of pH of H_2O, nutrients content before planting, *Bio-organic fertilizer analysis*, uptake of NPK nutrients during primordial period, crop height (cm), maximum tiller number (tillers), productive tiller number (panicle), number of fully unhulled rice (grains), percentage of empty unhulled rice (%), weight of 1,000 grains and production per plot (kg).

RESULTS AND DISCUSSION

Based on criteria according to Soil Research Council (2005), soil used in this study can be classified as very acid soil (pH H_2O = 4.18) with medium total N content (0.36 %), medium available P (8.45 ppm), very low exchangable base such as Ca^{2+} (1.72 me/100g), high Mg^{2+} (2.24 me/100g), high K^+ (0.64 me/100g) and low Na^+ (0.12 me/100g). Soil used in this study had low fertility level indicated by pH H_2O with magnitude of 4.18 which restrict macro nutrients availability. Therefore, land used in this study should be planted with superior rice variety and added with inorganic fertilizer and bio-organic fertilizer.

Analysis results from bio-organic fertilizer at PT Bina Sawit showed the following results: 1.38 % N total, 4.293 % P total, 1.38 % K total and C/N ratio of 19:12. This analysis showed that bio-organic fertilizer had been experienced mineralization process. The mineralization process is a process of the availability of nutrients from being unavailable to be available to plantsl. Biofertilizers containing N, P and K nutrients are very useful in increasing the growth and production of rice plants in tidal wetland.

Results of analysis of variance (ANOVA) showed that treatments with two types fertilizer had significant effect on all observed parameters, except for the number of fully unhulled rice, percentage of empty unhulled rice and weight of 1,000 grains. Treatments using different varieties had significant effect on all observed parameters, except for productive tiller number. Interaction treatment had significant effect on crop height, maximum tillers number, productive tillers number and production per plot, except for the rest observed parameters (Table 1). Results of further test for yield capacity of two rice varieties using inorganic and bio-organic fertilizers can be seen in Table 2.

Yield capacity of Inpari I rice variety had

Table 1. Results of analysis of variance (ANOVA) for yield capacity test of two rice varieties using inorganic and bio-organic fertilizers

The observed parameters	Treatment			Coefficient of variation (%)
	Fertilizers	Varieties	Interaction	
Crop heigh (cm)	*	*	*	0.62
Maximum tillers number (tillers)	*	*	*	2.71
Productive tiller number (panicles)	*	ns	*	4.70
Nitrogen uptake (%)	*	*	ns	6.07
Phosphorus uptake (%)	*	*	ns	15.43
Potassium uptake (%)	*	*	ns	11.54
Fully unhulled rice numbers per (grains)	ns	*	ns	7.89
Empty unhulled rice numbers (%)	ns	*	ns	5.41
Weight of 1,000 grains (g)	ns	*	ns	2.17
Production per plot (kg)	*	*	*	9.05

ns= not sifnificant

Table 2. Results of the test of yield capacity of two rice varieties.

Varieties	Crop height (cm)	Maximum tiller numbers (tillers)	Productive tiller numbers (panicles)	Fully unhulled rice numbers (grains)	Percentage of empty unhulled rice	Weight of 1,000 grains (g)	Production per plot (kg)	Production increase (%)
Inpara 6	106.00 b	23.00 a	11.25 a	36.17 a	67.67 b	25.67 a	0.79 a	-
Inpari 1	83.58 a	25.00 b	11.50 a	64.17 b	38.58 a	26.36 b	1.28 b	62
HSD 0.05	0.51	0.57	0.47	3.45	2.50	0.49	0.08	

Note: Numbers followed by the same letters in the same columns are not significantly different.

increased with magnitude of 62% compared to yield capacity of Inpara 6 rice variety because the Inpari I was more adaptive and had a higher potential to grow and produce better production at tidal lowland areas in spite of many constraints owned by Inpara 6. This is evidenced by an increase in maximum tiller numbers, NPK nutrients uptake, fully unhulled rice numbers per panicle, weight of 1,000 grains and production as well as the lowest percentage of empty unhulled rice This was supported by studies from Widyayanti *et al*. (2011) and Sutaryo and Kusumastuti (2015) which showed that Inpari 1 was new superior variety that capable to grow, feasible to be developed and had good adaptation at Kebun Agung Bantul Yogyakarta. Weight of 1,000 grains, fully unhulled rice numbers per panicle, unhulled rice weight per clump and productive tiller numbers are components that determine weight of rice yield of Inpari I variety.

The use of bio-organic fertilizer with magnitude of 400 kg/ha + 50 % inorganic fertilizer had also capable to increase rice yield with magnitude of 65 % than the one with only inorganic fertilizer. This is due to application of bio-organic fertilizer to rice crop (chicken manure enriched with *Azospirillum* bacterium and phosphate solvent bacterium). *Azospirillum sp*. has capability to produce urea reductase which have important role in free N fixation from air. Phosphate solvent bacterium produce phosphatase enzym that has important role as P solvent from bound compound (Mahdi *et al*., 2010). *Azospirillum* sp. in biofertilizer has been able to contribute N nutrients to rice plants, so as to increase the growth and production of rice plants in tidal wetland.

Phosphate solvent bacterium has capability to change undissolved phosphate within soil into dissolved phosphate through secretion of organic acids such as formiate, acetate, lactate, sulphate and propionate acids (Niswati *et al*., 2008). These organic acids can reduce capacity of Al (aluminium) toxicity through bonding of Al in acid soil as a complex compound so that Al is no longer hydrolized (Tripathi *et al*., 2008).

Treatment of compost enriched with bio-organic fertilizer showed better magnitude related to weight of dry unhulled rice harvest, unhulled rice numbers per panicle and production than inorganic fertilizer treatment on Ultisol soil and Inceptisol soil of swamp lowland (Gofar and Marsi, 2013).

In accordance with Herlina (2013), that organic fertilizer enriched chicken manure *Glyocladium* sp. 150 g can increase the growth and production of tomato plants.

In addition, treatment of bio-organic fertilizer was capable to increase growth and production of rice crop. This was in line with studies by Wilsy (2010) and Kanaan and Ponmurugan (2010) that used *Azospirillum* sp. to stimulate crop growth. Haefele *et al*. (2008) showed that N available within compost was slowly available because compost is classified as *slow release* fertilizer. Sufficient N level will provide a better vegetative growth for crop. Wibowo and Alawiah (2007) showed that the application of bio-organic fertilizer containing *Azospirillum* sp. can produce Indole Acetid Acid (IAA). It has a role in development and elongation of roots which in turn provide better environment for root growth.

The Microbe within bio-organic fertilizer was capable to improve efficiency of inorganic fertilizer dose up to 50 % on rice crop, whereas Marlina *et al*. (2014) showed that bio-organic fertilizer was capable to improve efficiency of inorganic fertilizer by 25%.

Saraswati (2012) added that the use of biofertilizers is very useful in helping to supply nutrients to plants, facilitating nutrient absorption for plants, decomposing organic matter, providing a better rhizosphere environment so that it ultimately supports growth and increases crop production.

From Table 3, it can be seen that by giving organic biofertilizers enriched with Azospirillum bacteria and phosphate solubilizing bacteria can increase nutrient uptake of N, P and K. This is

Table 3. Uptake of N, P and K nutrients of two rice varieties and two types fertilizers.

Nutrients uptake	Varieties		HSD 0.05	Fertilizer types		HSD 0.05
	Inpara 6	Inpari 1		Inorganic	Bio-organic	
N	1.93 a	2.34 b	0.11	1.97 a	2.30 b	0.11
P	0.172 a	0.226 b	0.027	0.176 a	0.222 b	0.027
K	1.78 a	1.96 a	ns	1.69 a	2.05 b	0.19

Note: Numbers followed by the same letters in the same columns are not significantly different.

Table 4. Rice yield treated with inorganic and bio-organic fertilizers

Fertilizer types	Crop height (cm)	Maximum tiller numbers (tillers)	Productive tiller number (panicles)	Fully unhulled rice numbers (grains)	Percentage of empty unhulled rice	Weight of 1,000 grains (g)	Production per plot (kg)	Production increase (%)
Inorganic	94.50 a	21.00 a	10.92 a	49.58 a	53.33 a	25.33 a	0.78 a	-
Bio-organic	95.08 b	27.00 b	11.23 b	50.75 a	52.42 a	26.90 a	1.29 b	65
HSD 0.05	0.51	0.57	0.47	ns	ns	ns	0,08	

Note: Numbers followed by the same letters in the same columns are not significantly different.

due to the real effect between chicken manure compost and Azospirillum bacteria and phosphate solvent bacteria. All these condition are related to the decomposition process of chicken manure compost carried out by Azospirillum bacteria and phosphate solvent bacteria. Chicken manure compost serves as a source of energy and food for Azospirillum and phosphate solvent bacteria. The fermentation of chicken manure by bacteria will cause the release of nutrients such as N, P and K, so that the availability of N, P and K nutrients needed by rice plants can increase. Increased nutrients of N, P and K in the soil and plants can increase the component of production and grain production per plot. This is consistent with the statement of Samuel and Muthukkaruppan (2011) that the increase in the components of the production component is due to an increase in the elements of nitrogen, phosphate, and potassium in the soil which are the main elements needed by plants.

High production of rice crops as a response from the application of biofertilizers along with increased nutrient uptake, increased vegetative growth, and increased variables of production components and production per plot. Grain production per plot in the treatment of chicken manure compost enriched with Azospirillum and phosphate solvent bacteria added with NPK fertilizer at a dose of 50% had the highest grain production per plot (Table 4). The provision of chicken manure compost enriched with Azospirillum bacteria and phosphate solvent bacteria has been able to increase yields. This is in line with the opinion of Fadiluddin (2009) which stated that yields and yield components are the resultant of vegetative growth of rice plants. This fact proves that the addition of biological organic fertilizer can reduce the dose of use of NPK fertilizer by 50% and the results obtained even higher than the NPK 100% treatment. Another advantage of biofertilizers is it can improve soil quality, while inorganic fertilizer (NPK 100%) reduce soil quality. The use of biological organic fertilizers combined with NPK can significantly increase the production of lowland rice.

The yield capacity of Inpari I variety applied with bio-organic fertilizer and inorganic fertilizer at 50% recommended dose gave the best growth and production. It can increase rice production by 165% compared to yield capacity of Inpara 6 variety applied with inorganic fertilizer. That condition was supported by better NPK nutrients uptake, higher weight of 1,000 grains, higher number of fully unhulled rice and the lowest percentage of empty unhulled rice. This was in line with Widyayanti *et al* (2011) that showed that significant and positive correlation between yield and the number of fully unhulled rice numbers per panicle. As well as production of dry unhulled rice, i.e. higher value of fully unhulled rice numbers per panicle produce. Percentage of empty unhulled rice and higher weight of 1,000 unhulled rice grains which results in high production. Through the provision of biofertilizers, chicken manure enriched with Azospirillum and bacteriophosphate biofertilizers contributes to sustainability agriculture, especially in tidal wetland.

Table 5. The results of two different rice varieties were given different fertilizer

Fertilizer types	Varieties	
	Inpara 6	Inpari 1
Crop height (cm)		
Inorganic	105.50 b	106.50 c
Bio-organic	83,.0 a	83.67 a
HSD 0.05 = 0.72		
Maximum tiller numbers (tillers)		
Inorganic	20.67 a	25.33 b
Bio-organic	21.33 a	28.67 c
HSD 0.05 = 0.79		
Productive tiller number (panicles)		
Inorganic	10.50 a	12.00 c
Bio-organic	11.33 b	11.67 bc
HSD 0.05 = 0.66		
Production per plot (kg)		
Inorganic	0.60 a	0.98 ab
Bio-organic	0.98 ab	1.59 b
HSD 0.05 = 0.69		
Production increase (%)		
Inorganic	-	60
Bio-organic	60	165

Note: Numbers followed by the same letters in the same columns are not significantly different.

CONCLUSION

The yield capacity of Inpari I rice variety treated with bio-organic fertilizer + 50% recommended NPK fertilizer could increase the production of dry unhulled rice with magnitude of 165 % (1.59 kg/plot or equal to 3.98 ton/ha) compared to yield capacity of Inpara 6 rice variety treated with inorganic fertilizer (0.60 kg/plot or equal to 1.50 ton/ha) at tidal lowland of C flooding type.

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