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IMPROVEMENT OF RICE GROWTH AND PRODUCTIVITY THROUGH BALANCE APPLICATION OF INORGANIC FERTILIZER AND BIOFERTILIZER IN INCEPTISOL SOIL OF LOWLAND SWAMP AREA

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ABSTRACT

The objective of this study was to obtain a proper balance dose between biofertilizer and inorganic fertilizer in order to increase the growth and yield of rice in Inceptisol soil of lowland swamp origin. Biofertilizer was made by enriching straw compost with N_2 interceptor bacteria, phosphate solvent bacteria and growth stimulator bacteria isolated from swamp lowland in South Sumatra. This study was conducted from November 2012 to March 2013 in a greenhouse. The design used was completely randomized design (CRD) factorial, with two treatment factors consisting of inorganic fertilizer (0,25, 50, 75 and 100% recommended dosage) and biofertilizer (0, 100, 200, 300, 400 and 500 kg.ha^{-1}). The results showed that the best treatment in term of plant height at 8 weeks after planting (WAP), the maximum number of tillers, number of productive tillers, number of grains per panicle and weight of milled dry rice were obtained in combination of 75% inorganic fertilizer and 300-400 kg.ha^{-1} biofertilizer.

Keywords: biofertilizer, inorganic fertilizer, lowland rice

INTRODUCTION

In the long run, the intensive utilization of paddy fields will decrease soil productivity and environmental quality. The use of high input of agrochemical substances will precisely decrease soil nutrients and produce the negative impact for environment in the form of increasing agrochemical substance residue within soil and crop. On the other hand, the decrease of relatively fertile paddy field area due to land conversion into non-agricultural usage produces threat in maintaining food sufficiency (Wihardjaka and Abdurachman, 2007).

Lowland swamp is one of suboptimal land which can be used as substitute for some functional conversion of paddy field area. Lowland swamp is flat topography area found along the right and left sides of main river which usually floods especially during wet periods, and relatively unaffected by sea water tidal fluctuation (Najiyati *et al*., 2005). Lowland swamp in South Sumatra is relatively extensive comprising about 368,685 hectares, and it is unique ecosystem due to differences of water flooding as well as availability of flooding and dry periods. Availability of continuous flooding and dry periods create different utilization of lowland swamp such as for crops cultivation which in turn will affect soil microbial diversity. The knowledge of community and biotechnology potential related to soil microbes in lowland swamp area is not widely investigated. However, population and types of bacteria and fungi available in lowland swamp are higher than those found in secondary forest. Cultivation of perennial crop such lowland swamp rice may increase population and types of bacteria and fungi due to intensive land management such as soil tillage before planting and manure application which may stimulate soil microorganisms activity (Gofar *et al.,* 2007).

Gofar *et al*. (2009) has found endophytic bacteria from healthy rice crop grown in lowland swamp ecosystem and these bacteria can be used as growth stimulator as well as nitrogen

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interceptor for low fertility soil condition so that it may optimize the early growth of rice crop and reduce inorganic N fertilizer dependency which in turn is capable to increase productivity of lowland swamp and tidal lowland. The isolates of endophytic bacteria as a growth stimulator has been developed as economical biofertilizer.

According to Isroi (2008), biofertilizer is inoculant which contains active organisms functioning to catch specific nutrients or to facilitate nutrients availability within soil for crop. Marlina *et al*. (2013) found the isolates of *Azotobacter* sp. and *Azospirillum* sp. which is isolated from crop's rhizosphere grown in lowland swamp area. These isolates had been proved capable to catch N_2, to stimulate rice crop growth and to increase NPK nutrients absorption so that they can be developed as biofertilizer for rice crop cultivation in lowland swamp area.

The study results by Hindersah and Gofar (2008) showed the potential of indigenous microbes from soils in South Sumatra either in dry land or wetland. *Azotobacter* sp. from lowland swamp which is cultivated with rice crop had a potential to be developed as biofertlizer because it was capable to catch N_2. Moreover, Gofar (2008) has proven the existence of endophytic bacteria from lowland swamp crops that can stimulate rice crop growth. Gofar *et al*. (2009) showed that inoculation with endophytic bacteria for lowland swamp rice crop resulted in rice yield increase compared to rice crop without inoculation. In addition, the study by Gofar and Marsi (2013) pointed out that milled dry rice yield of 17.20 g from dry land of Ultisol soil was obtained by applying biofertilizer dose of 10 ton.ha^{-1} and 75% of inorganic fertilizer.

As discussed previously, the importance of balance fertilizing between biofertilizer and inorganic fertilizer for rice crop in lowland swamp can affect nutrients absorption, growth and yield of a crop. Therefore, combination of biofertilizer and inorganic fertilizer (Urea, SP-36 and KCl) is very important input in order to improve land productivity in lowland swap.

The objective of this research was to determine the balance dose between biofertilizer and inorganic fertilizer which is capable to increase the growth and production of rice crop in Inceptisol soil in lowland swamp area.

MATERIALS AND METHODS

This experiment was conducted in a greenhouse by using Completely Randomized Design (CRD) Factorial which consisted of 2 treatment factors. The first factor was inorganic fertilizer dose with five levels consisting 0%, 25%, 50%, 75% and 100% of recommended dose. The second factor was biofertilizer dose with 6 levels consisting 0, 100, 200, 300, 400 and 500 kg.ha^{-1}. The recommended doses of NPK fertilizer for rice crop of Ciherang variety were 250 kg.ha^{-1} urea, 150 kg. ha^{-1} SP-36 and 100 kg.ha^{-1} KCl.

Compost was made from chopped rice straw having size of ± 5 cm and cow manure mixed within the ratio of 10:1 and was composted in four-week period, followed by sieving with screen in 2 mm in diameter. This compost was then sterilized by using autoclave at temperature of 121^{0}C and 1 atm pressure for 15 minutes.

Biofertilizer was made by mixing 100 kg sterile compost with bacterial biomass which is extracted from 100 ml isolate of *Azotobacter*, 100 ml isolate of *Azospirillum*, 100 ml isolate of endophytic bacteria and 100 ml isolate of phosphate solvent bacteria respectively having density of 10^8 CFU.mL^{-1}. Bacterial biomass was obtained by centrifuging the liquid propagation of these bacteria at velocity of 15000 rpm for 5 minutes.

Plant media preparation was started by soil sampling taken from the depth of 0-20 cm, followed by air drying and soil sieving. Soil having weight of 10 kg was put into flowerpot. Biofertilizer and fertilizers of N, P and K were applied one day before seed planting. The N fertilizer was given two times, i.e. half dose was given on day 1 before planting and the rest was given when plant was 1 month old. Five rice seeds were planted on each pot with the depth of 2 cm. After one week, 2 plants that showed uniform growth were chosen to be reared.

Crop maintenance consisted of: 1) Watering conducted one time per day. 2) Crop selection conducted at one week after planting, 3) Cultivating conducted manually by uprooting the existing weeds, 4) Pest and disease control conducted manually. Harvesting was done when the rice grains was more than 75% mature at each tiller, which was shown by yellow flag leaves.

The observed parameters were chemical soil properties before experiment, crop height in 8 weeks after planting, maximum number of tillers, number of productive tillers, analysis of soil N and P, NPK content of crop tissue at primordial phase, biofertilizer analysis, grain numbers per tiller and weight of milled dry rice. Data was statistically processed with analysis of variance for Completely Randomized Design (CRD) Factorial. When the variance analysis results showed significant difference, then it was followed by Least Significance Difference (LSD) test at 5% level.

RESULTS AND DISCUSSION

Soil Characteristics before Treatment

Based on analysis results of soil chemical properties conducted before experiment, soil used in this experiment was classified as acid soil (pH H_2O=5.50) with medium value of cation exchange capacity (17.52 $cmol_{(+)}$ kg^{-1}), low C-organic content (12.7 $g.kg^{-1}$), low value of N-total and available P (1.3 $g.kg^{-1}$ dan 4.50 $mg.kg^{-1}$), exchangeable bases such as medium value of Ca-exchangeable (Ca-exch.) with magnitude of 10.58 $cmol_{(+)}kg^{-1}$, high value of Mg-exch with magnitude of 3.45 $cmol_{(+)}$ kg^{-1}, high value of K-exch with magnitude of 0.77 $cmol_{(+)}kg^{-1}$, medium value of Na- exch with magnitude of 0.68 $cmol_{(+)}kg^{-1}$, high value of base saturation with magnitude of 88.36 %, Al- exch= 0.2 $cmol_{(+)}kg^{-1}$, H- exch= 0.19 $cmol_{(+)}kg^{-1}$, Fe = 174.38 $mg.kg^{-1}$, Cu = 5.02 $mg.kg^{-1}$, Zn = 8.80 mg $kg^{-1}$and Mn = 228.56 mg kg^{-1}, with soil texture of sandy clay loam consisting of 19.41 % sand, 44.86 % loamand 35.73 % clay. The soil used as growth media in this research generally having low soil fertility level with pH (H_2O) of soil is classified as acid having low values of C-organic content, N-total and available P. This is in line with the notion from Subagyo (2006) which confirmed that soil pH of lowland swamp area was in the range of 4.0 to 5.5 and had low value of macro nutrient content. In addition, soil in this research should be added with inorganic fertilizers or biofertilizers containing *Azospirillum* sp., *Azotobacter* sp., endophytic bacteria and phosphate solvent bacteria in order to increase N, P and K nutrients so that better growth and production of rice crop can be achieved.

Addition of biofertilizer in the form of rice straw compost which is enriched by nutrients producing bacteria with chemical characteristics such as neutral pH value (pH=7.04), high cation exchange capacity (34.80 $cmol_{(+)}$ kg^{-1}), low value of C/N ratio (13.45), very high values in term of N-total, available P and K-exch (10.8 g kg^{-1}, 87.30 mg kg $^{-1}$ and 11.18 $cmol_{(+)}$ kg^{-1}) may improve the chemical properties of lowland soil which is currently in suboptimal condition for rice crop growth.

Vegetative Growth of Rice Crop

Results of variance analysis showed that inorganic fertilizer and biofertilizer treatments produced significant to highly significant effects on most observed parameters. Summary of variance analysis results for the observed parameters is presented in Table 1.

Table 1. Calculated value of F for the observed parameters

Source of variance	**Plant height at 8 weeks after planting (cm)**	**Maximum numberof tillers (tillers)**	**Number of productive tillers (panicles)**	**N uptake (g plant^{-1})**	**P uptake (g plant^{-1})**	**K uptake (g plant $^{-1}$)**
Inorganicfertilizer	**	**	**	**	ns	*
Biofertilizer	ns	**	**	**	**	**
Interaction	ns	ns	ns	ns	ns	ns

Remarks: ** = highy significant ; * = significant ; ns = not significant

Table 2. The main effect of inorganic fertilizers on plant height at 8 weeks after planting, maximum number of tillers (tillers), number of productive tillers (panicles) and NPK uptake

Inorganic fertilizer (% of recommended dose)	**Plant height at 8 weeks after planting (cm)**	**Maximum number of tillers (tillers)**	**Number of productive tillers (panicles)**	**N uptake (g plant^{-1})**	**P uptake (g plant^{-1})**	**K uptake (g plant^{-1})**
0	95.42 a	35.67 a	22.22 a	1.048 a	0.192 a	2.271 a
25	100.42 b	38.89 ab	23.78 a	1.346 b	0.213 a	2.513 ab
50	103.42 b	43.10 bc	27.00 b	1.698 c	0.211 a	2.623 ab
75	107.25 c	45.00 c	31.67 c	1.903 c	0.265 a	2.795 b
100	107.67 c	44.67 c	27.00 b	1.829 c	0.253 a	2.542 ab
LSD 0.05	3.45	5.29	3.03	0.285	0.083	0.452

Remarks: Numbers followed by different letters in a column were significantly different ($P < 0.05$) using LSD test

Table 3. The main effect of biofertilizer on plant height at 8 weeks after planting, maximum number of tillers (tillers), number of productive tillers (panicles) and NPK uptake

Biofertilizer (kg.ha^{-1})	**Plant height at 8 weeks after planting (cm)**	**Maximum number of tillers (tillers)**	**Numbers of productive tillers (panicles)**	**N uptake (g.plant^{-1})**	**P uptake (g.plant^{-1})**	**K uptake (g.plant^{-1})**
0	102.10	35.07 a	23.20 a	1.189 a	0.149 a	1.899 a
100	101.33	38.27 ab	25.33 ab	1.427 ab	0.194 ab	2.225 ab
200	103.47	42.20 bc	25.80 ab	1.544 bc	0.211 ab	2.388 ab
300	105.30	47.07 c	29.20 c	1.834 c	0.311 c	3.294 d
400	102.70	44.27 c	27.93 bc	1.754 c	0.257 bc	2.947 cd
500	102.10	41.93 bc	26.33 bc	1.640 bc	0.240 bc	2.539 bc
BNT 0.05	ns	5.80	3.32	0.312	0.091	0.495

Remarks: Numbers followed by different letters in a column were significantly different ($P < 0.05$) using LSD test

Inorganic fertilizer application at 75% of recommended dose produced crop height at 8 weeks after planting, maximum tiller number, productive tiller number and NPK uptake which was better than and significantly different from that of inorganic fertilizer applications at 0, 25, 50, and 100 % (Table 2). This was due to the fact that inorganic fertilizer application at 75% of recommended dose was capable to fulfill nutrient requirement of rice crop for better growth and production. Initial soil characteristics less suitable to support the crop growth as previously discussed resulted in quick response of plant toward inorganic fertilizer application. Increasing inorganic fertilizer application to 100 % of recommended dose had no effect on growth increase or nutrients uptake by rice crop. This was estimated due to nutrient imbalance which in turn decreased the production of lowland swamp rice. This was supported by finding of Winarso (2005) indicating the existence of relationship between nutrient concentration and growth as well as yield of crops (minimum law of Liebig) or decrease of crop yield depending on nutrient balance.

Application of 300 kg.ha^{-1} biofertilizer had increased the maximum number of tillers and number of productive tillers and was significantly different from that of applications of 0, 100 and 200 kg.ha^{-1}, as shown in Table 3. The increase in maximum number of tillers and number of productive tillers on 300 kg.ha^{-1} biofertilizer treatment was due to capability of this compound to create better soil condition for crop growth and provision of crop nutrients. Biofertilizer application was reported to be able to stimulate the growth of microbes and add macro and micro nutrients which in turn would increase soil fertility. According to Faludin (2009), the use of biofertilizer was considered as proper strategy to refertilizer the soil. Bio-fertilizer added into soil will provide certain nutrients for crops. Biofertilizer may contain bacteria that are important to stimulate crop growth so that crop yield is still high and sustainable. According to Permentan (2009), biofertilizer is biological active product consisting of microbes which can improve the fertilizing efficiency, fertility and soil health. Moreover, Vessey (2003) stated that biofertilizer facilitated nutrient availability, organic matter decomposition and better environment of N rhizosphere which in turn might support the growth and increase in crop yield.

Treatment using biofertilizer at a dose of 400 kg and 500 kg.ha^{-1} resulted in the decrease of plant height at 8 weeks after planting, maximum number of tillers and number of productive tillers than treatment given at a dose of 300 kg.ha^{-1} although this difference was not significant. This was estimated due to higher population of microbes within soil on treatments at a dose of 400 kg and 500 kg.ha^{-1} so that the competition in obtaining nutrients occurred between microbes and crops which resulted in retarded nutrient availability for crops. Making nutrients available in soil takes a long process, while it is known that rice growing period is only 100 days. This was supported by NPK nutrients uptake, in which the uptake decreased on biofertilizer treatments at a dose of 400 kg and 500 kg.ha^{-1} than compared to treatment at a dose of 300 kg.ha^{-1}. Referred to the results of studies by Simanungkalit (2001) and Supriyanto *et al*. (2012), biofertilizer is living organism which is added into soil as inoculant that helps to provide certain nutrients for crop. Therefore, the higher the fertilizer dose, the higher was the added microbes in soil. Thus, competition for nutrients occurred among microorganisms.

For every dose of inorganic NPK fertilizer, there was optimal dose of biofertilizer in increasing the uptake of N, P and K (Figure 1-3). Figure 1 showed that maximum N uptake by rice crop was obtained by combining NPK fertilizer at 75 % of crop requirement and 416.67 kg.ha^{-1}dose of biofertilizer. Figure 2 shows that maximum P uptake by rice crop was obtained by combining NPK fertilizer at 75 % of crop requirement and 83.33 kg.ha^{-1} dose of biofertilizer. Figure 3 reveals that maximum K uptake by rice crop was obtained by combining NPK fertilizer at 75 % of crop requirement and 333.33 kg.ha^{-1}dose of biofertilizer. Therefore, optimum uptake of NPK fertilizer was obtained by combining NPK fertilizer at 75 % of crop requirement and 300 kg.ha^{-1} dose of biofertilizer. It was assumed that NPK uptake had a positive correlation with biofertilizer, which was shown by uptake levels of N, P and K (Table 3).

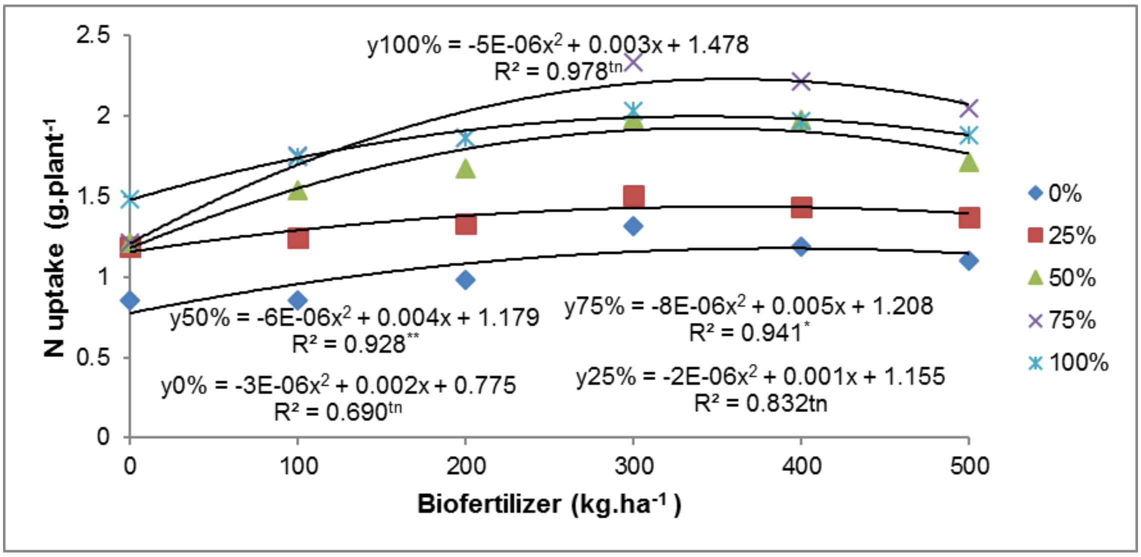

Figure 1. Interaction between biofertilizer with N uptake at a dose of inorganic NPK fertilizer

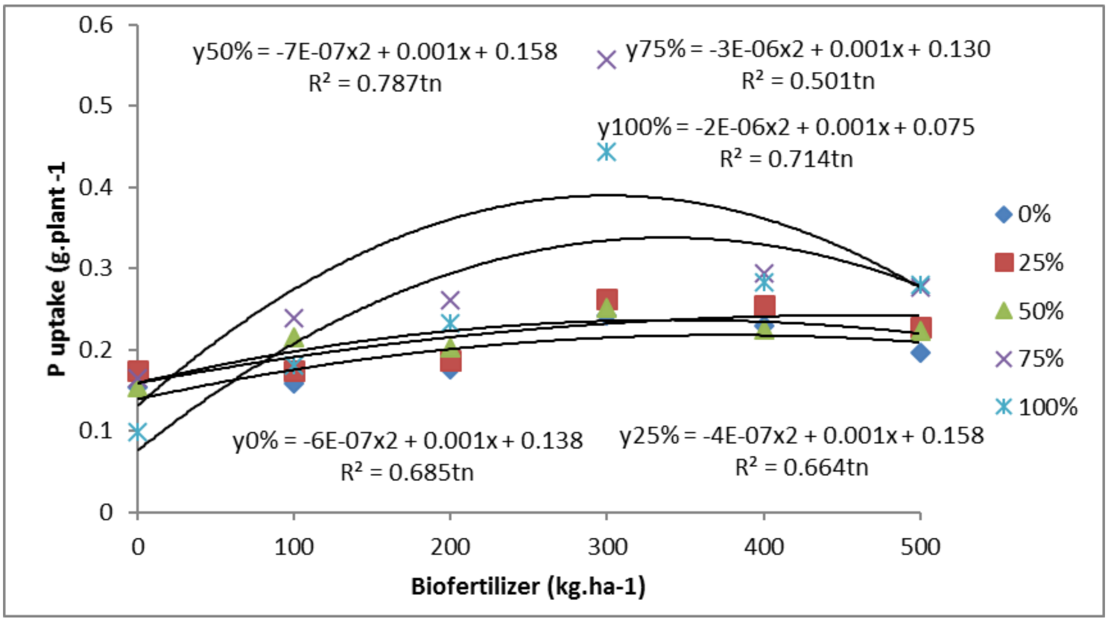

Figure 2. Interaction between biofertilizer with P uptake at a dose of inorganic NPK fertilizer

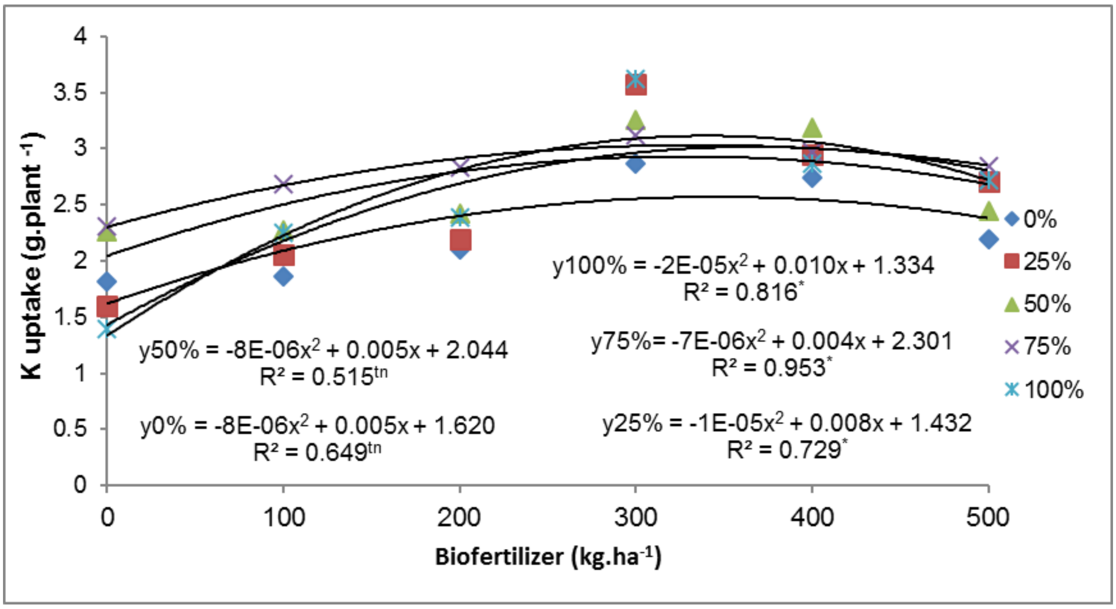

Figure 3. Interaction between biofertilizer with K uptake at a dose of inorganic NPK fertilizer

Rice Crop Yield

There was no significant interaction between inorganic fertilizer and biofertilizer on grain numbers per panicle and weight of milled dry rice. Therefore, fertilizer optimum dose was determined by using regression equation as shown in Figure 4 and 5.

Figure 4 shows the maximum number of grains per panicle for rice crop which was obtained by combining NPK fertilizer at 50 % of crop requirement and 500 kg.ha^{-1} dose of biofertilizer. Figure 5 shows the maximum weight of milled dry rice which was obtained by combining NPK fertilizer at 50 % of crop requirement and 460 kg.ha^{-1} biofertilizer. There-fore, the optimum value of grain numbers per panicle and weight of milled dry rice were obtained by combining NPK fertilizer at 75 % of crop requirement and 300 kg.ha^{-1} biofertilizer. It was estimated that grain number per panicle and weight of milled dry rice had a positive correlation with biofertilizer. This was linear with the study results by El-Ainy (2008) reporting that bio-fertilizer application had a positive corre-lation with rice crop production.

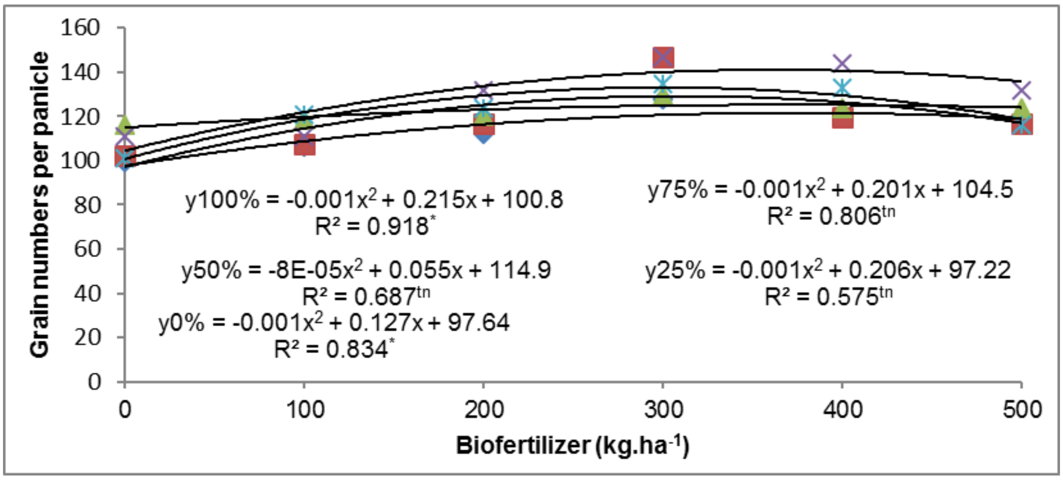

Figure 4. Interaction between biofertilizer with the number of grains per panicle at a dose of inorganic NPK fertilizer

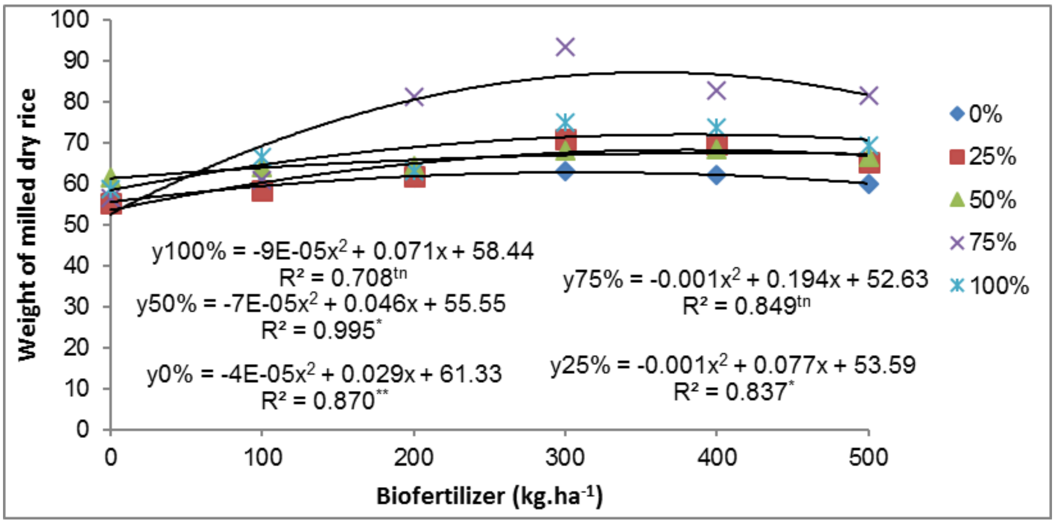

Figure 5. Interaction between biofertilizer with weight of milled dry rice (g.plant^{-1}) at a dose of inorganic NPK fertilizer

Moreover, there was a positive relationship between NPK nutrients uptake and production level (grain numbers per panicle and weight of milled dry rice) for each biofertilizer. The higher the NPK nutrients uptake, the higher was the rice crop production. Value of R^2 showed that rice crop had higher correlation between NPK nutrient uptake and crop production.

Biofertilizer used in this study contained bacteria of *Azospirillum* sp., *Azotobacter* sp., endophytic bacteria and phosphate solvent bacteria with specific roles. As reported in Saxena and Tilak (1998), Yasari and Patwardhan (2007), Shaukat *et al*. (2006) and Karthikeyan and Sakthivel (2011), bacteria of *Azospirillum* and *Azotobacter* could increase crop biomass, crop productivity, which contributed N nutrient through N_2 fixation at crop rhizosphere environment as well as phytohormone in direct manner. Moreover, studies from Yasari and Patwardhan (2007), Mehry *et al*. (2008) and Arzanesh *et al.* (2009) confirmed that application of *Azospirillum* was very effective in stimulating crop growth.

Hindersah and Simarmata (2004) emphasize that *Azotobacter* bacteria have capability in producing phytohormone of auxin and cytochinine as well as supporting the soil function as growth media. Furthermore, Gofar (2007) points out that some endophytic bacteria from plant tissue may stimulate the growth of chilly crop, although others may suppress the growth of chilly crop.

Study from Simanungkalit (2001) implies that application of biofertilizer and inorganic fertilizer was integrated approach in improving the growth and the production of crop.

CONCLUSIONS

Application of biofertilizer at 300-400 kg.ha^{-1} dose combined with inorganic fertilizer at 75 % of crop requirement dose was the best combination in increasing NPK nutrient uptake for rice crop and weight of milled dry rice.

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REFERENCES

Arzanesh, M.H., H.A. Alikhani, K. Khavazi, H.A. Rahimian and M. Miransari. 2009. In vitro growth of wheat (*Triticum aestivum* L.) seedling, inoculated with *Azospirillum sp.* under drought stress. Int. J. Botany.5: 244-249.

El-Ainy, IT. 2008. Combination of biofertilizer and nutrient source to stimulate nutrient uptake, growth and productivity of corn (*Zea mays L*.) and rice (*Oryza sativa L*.). (in Indonesian). Postgraduate Program, IPB, Bogor. pp.67.

Faludin, M. 2009. Formula effectiveness of biofertilizer in stimulating nutrient uptake, production and quality of corn yield and upland rice (In Indonesian). A Thesis in Plant Biology. Postgraduate Program. IPB, Bogor. pp.69.

Gofar, N. 2007. Exploring endophytic bacteria as a growth stimulator in cayenne pepper (In Indonesian). Agrista J. 11(1): 1-7

Gofar, N., M.A., Diha dan A. Napoleon. 2007. Soil microbial diversity on cutlivated lands in Lebak (In Indonesian). Akta Agrosia Journal (accredited) Special Edition 1: 5-10

Gofar, N. 2008. Cultivated soil mesofauna diversity in Lebak and its role in maintaining soil ecosystem balance (in Indonesian). National Seminar of Entomology Association, Palembang, Indonesia on October 18, 2008. p 1-11.

Gofar, N., A. Napoleon and M.U., Harun. 2009. Exploring endophytic bacteria as a growth stimulator in rice grown on swamplands and tidal swamps of Lebak, South Sumatra (In Indonesian). A Report of Competitive Grant, DIKTI, Re-search Centre, Unsri, Indralaya. pp. 36.

Gofar, N. and Marsi. 2013. Growth and Upland Rice Yield on Ultisol with Compost Enriched with Biofertilizer. National Proceeding Seminar and Annual Meeting in Agricultural Science BKS-PTN (in

Indonesian), Western Areas, Pontianak March 19-20, 2013. Vol.1 p 169-180

Hindersah, R. and N. Gofar. 2008. Isolation of Azotobacter in Lebak Tengahan Swamplands, Ogan Ilir Regency, South Sumatra: A preliminary study in potential of biofertilizer in wetlands, presented in a National Seminar and Annual Scientific Gathering of HITI in Palembang from 17 to 18 December, 2008. p.92-97.

Hindersah, R. and T. Simarmata. 2004. Potential of *Azotobacter* in enhancing soil health. Indonesian J.of Nature. 5(2): 127-133

Isroi. 2008. Pupuk organik, pupuk hayati, pupuk kimia (online) (http://www.mpg.de/news01/news0103 htm, accessed 15th September 2010.

Karthikeyen, B.and K.M. Sakthivel. 2011. Efficiency of *Azotobacter chroococcum* in rooting and growth of *Eucolyptus camaldulensis* stem cuttings. Res.J. Microbiol. 6: 618-624

Marlina, N., Silviana and N. Gofar. 2013. Seleksi bakteri penambat nitrogen (Azospirillum dan Azotobacter) asal rhizosfer tanaman budidaya di lahan lebak untuk memacu pertumbuhan tanaman padi. Prosiding Seminar Nasional dan Rapat Tahunan Bidang Ilmu-ilmu Pertanian BKS-PTN Wilayah Barat Tahun 2013 vol 1: 739-750.

Mehry, A., M. Akbar and E. Giti. 2008. Colonization and nitogenase activity of *Triticum aestivum* (cv. Baccross and Mahdavi) to the dual inoculation with *Azospirillum brasilense* and *Rhizobium meliloti* plus 2,4-D. Pak. J. Biol., Sci., 11:1541-1550

Najiyati, S, L. Muslihat and I.N.N. Suryadiputra. 2005. Guideline for peat land manage-ment for sustainable agriculture. (In Indonesian). Project Climate Change, Forest and Pertlands in Indiana Wetland International Indonesia. Programme and Willite Habitat Canada Bogor Indonesia. pp.241.

Permentan. 2009. Peraturan Menteri Pertanian RI tentang pupuk organik, pupuk hayati dan pembenah tanah No. 28/Permentan/SR 130/5/2009.

Saxena, A.K. and K.V.B.R. Tilak. 1998. Microbes: For health, wealth and sustainable environment. Malhotra Publishing House, New Delhi. pp.25.

Shaukat, K., S. Alfasayab and S. Hasnain. 2006. Growth response of *Helianthus annuus* to plant growth promoting rizobacteria used as a biofertilizers. Int. j. Agric. Res. 1: 573-581

Simanungkalit, R.D.M. 2001. Application of biofertilizer and chemical fertilizer: An Integrated Approach (in Indonesian). Agrobio Bulletin 4(2): 56-61

Subagyo, A. 2006. Lebak Swamplands *in D*idi Ardis S *et al*. Characteristics and cultivation of swamplands. Research and Development Center of Agricultural Land Resource (in Indonesian). Bogor. p 99-116

Supriyanto, A, F.K. Umah and T. Surtiningsih. 2012. Effects of applying biofertilizer and different planting media on growth and productivity of cayenne pepper (*Capsicum frustescens L.*) in polybags (in Indonesian). Biology Department, Faculty of Science and Technology, Airlangga University, Surabaya

Vessey, J.K. 2003 Plant growth promoting rhizobacteria as biofertilizer. Plant Soil 255: 571-586.

Wihardjaka and Abdurrachman. 2007. Effects of long term fertilization on rainfed agriculture. (In Indonesian). Research in Staple Produce vol. 26 (3):199-205

Winarso, S. 2005. Soil fertility (In Indonesian). Gravia media. Yogyakarta. 267 p

Yasari, E. and A.M. Patwardhana. 2007. Effects of (Azotobacter and Azospirillum) inoculants and chemical fertilizers on growth and productivity of canola (*Brassica nopus* L.) Asian J. Pant Sci. 6: 77-82