APPLICATION OF ORGANIC FERTILIZER AND PGPR (*Plant growth-promoting rhizobacteria*) TO INCREASE RICE YIELD AND QUALITY

Oktavia S. Padmini, Sri Wuryani and Ruly Aryani

Faculty of Agriculture, University of Pembangunan Nasional "Veteran" Yogyakarta
Jl. SWK 104 Condongcatur, Yogyakarta, Indonesia
Responding Author Email: oktaviasarhesti@yahoo.com

ABSTRACT

Generally, the application of high doses of chemical fertilizer continuously causes leveling production and decreasing rice quality. The objective of this research was to examine the effect of organic fertilizer and PGPR on rice yield and quality. The experiment was conducted at Bener Village, Ngrampal sub-district, Sragen district, Indonesia. The experiment was arranged into Randomized Completely Block Design with three replicates. The main plot was application dose of organic fertilizer consisting of two treatments, ie., 1 ton/ hectare and 2 tons/ hectare. Sub plot was spraying frequency of PGPR (*Plant Growth-Promoting Rhizobacteria*), consisting of four treatments, ie., without PGPR, spraying PGPR three times, four times, and five times. The data were subjected to analysis of variance followed by Duncan's Multiple Range Test. Plants treated with organic fertilaizer 1 ton/ hectare and sprayed with PGPR four times resulted the highest production and the rice quality.

Keywords : *Organic fertilizer, PGPR, Rice yield and quality*

INTRODUCTION

The increasing of rice production has become one of Indonesian agricultural development priorities [1], [2]. Conventional agriculture that oriented only on increasing maximum yield using high doses of chemical fertilizers continuously resulted in environmental degradation. It shows that a decrease in soil fertility resulting in lower organic matter content and nutrient use efficiency. Farmers felt the most impact among other that plants do not respond to fertilization, though it doses is increased; and the increasing of plant productivity is not comparable with the addition of fertilizer intake [3],[4][5]. Reliance on chemical fertilizers as nutrients source, besides it tends to reduce land productivity causing lessening the productivity, it also decreases rice quality, e.g. rice structure becomes hard due to high amylose content and low amylopectine [6].

Beneficial soil microorganisms categorized as growth stimulant as well as natural fertilizers that roles on 1) suppressing the disease growth (bio protectant); 2) producing phytohormone (bio stimulant); 3) increasing nutrients availability for plants (bio fertilizer); 4) reducing organic matter; 5) stabilizing soil aggregate; 6) remodeling agrochemical compounds. The reduction of chemical fertilizers by applying organic fertilizers available on site and has not been used optimally is expected to optimize the balance between the components of biotic and abiotic soil,

give the nutrient availability in the soil, which in turn ensures the sustainability of land productivity and improve the quality of rice.

The basic principle of organic farming is the best maintenance of soil and how to give life in the soil [7]. Organic farming systems aim to improve the health of agro-ecosystems, biodiversity and biological activity [8]. Organic and semi-organic farming are able to increase the protein content of seeds and the quality of rice taste compared to conventional farming. Organic farming systems over the past three seasons tend to increase the content of amylopectine, but not significantly different in amylase content [6]. Organic fertilizers for three planting seasons produce amylopectine content significantly higher, whereas the amylase content lower than that of NPK fertilization[3]. The higher the amylopectine content, the rice getting more fluffy and sticky, whereas the higher the amylase content, the rice getting dry or hard [9].

Plant growth-promoting rhizobacteria (PGPR) are beneficial bacteria that are in the area of plant roots and enhance plant growth by various mechanisms. PGPR usage continues to increase in an effort to replace chemical fertilizers, pesticides, and supplements[10]. PGPR is a bacterium that can be found in rhizosphere, a thin layer of soil that surrounds the roots of plants, and provide a positive effect on the plant. PGPR contain bacteria such as Pseudomonas, Enterobacter, Azospirillum, Azotobacter, Burkholderia, Bacillus and Serratia [11] [10]. The bacteria must be able to defend themselves (survive) from the inoculation into seeds, multiplication in spermosphere (the area around the seed) in response to seed exudates, attacks on the root surface, and colonizes / inhabit in the root zone to strengthen the root system. Application of organic fertilizers combined with PGPR expected to substitute the use of NPK fertilizers as well as to improve the quality of rice. The objective of this research was to examine the effect of organic fertilizer and PGPR on rice yield and quality.

MATERIALS AND METHODS

The experiment was conducted at Bener Village, Ngrampal, Sragen Regency. The research method used was Split Plot with plot size was 6 mx 10 m.

The experiment tools and materials were Mekongga variety rice, fermented cow manure, decomposer, PGPR, analytical scales, and oven.

The Main Plot was used of manure that consists of two treatments:

Used of organic fertilizer 1 ton / hectare

Used of organic fertilizer 2 tons / hectare

Sub Plot was application of PGPR that consists of four treatments:

Without PGPR

Three times PGPR spraying

Four times PGPR spraying

Five times PGPR spraying

The data were analyzed to determine the variability and the influence of each factor of both the main plot and the subplot with DMRT (Duncan's Multiple Range Test) on the significant level of 5%.

RESULTS

Growth components

Table 1 showed that the number of leaves, plant dry weight were significantly higher in the treatment of 2 tons/ hectare organic fertilizer application with four times PGPR spraying compared to the application of 1 ton/hectare and 2 tons/ hectare of organic fertilizers with three times PGPR spraying and without PGPR spraying. Both were not significantly different with the application of 1 ton/ hectare organic fertilizer with four and five times PGPR spraying.

Table1.The effect of organic fertilizer and PGPR application on number of leaves plant, dry weight and number of tillers

Treatment		Number of leaves	Dry weight plant (g)	Number of tillers
Organic fertilizers 1ton/ hectare	Without PGPR	73.13 c	50.03 d	18.93 c
	three times PGPR spraying	75.67 b	90.03 b	21.00 bc
	four times PGPR spraying	77.87 ab	84.20 bcd	23.53 ab
	five times PGPR spraying	76.73 ab	73.67 cd	24.67 a
Organic fertilizers 2 tons/ hectare	Without PGPR	76.33 ab	57.57 d	20.20 bc
	three times PGPR spraying	74.67 bc	62.90 cd	22.80 abc
	four times PGPR spraying	79.43 a	89.20 abc	25.87 a
	five times PGPR spraying	78. 99 a	99.10 a	21.87 abc
	Interactions	+	+	+

Note : Numbers followed by similar alphabet in each column shows not significantly different in Duncan's multiple range test analysis at the 95% level of confidence. (+) positive interaction

The number of tillers were better in the treatment of 2 tons/ hectare organic fertilizer application with four times PGPR spraying and 1 ton/hectare organic fertilizers with five times PGPR spraying compared to the application of 1 ton/hectare and 2 tons/hectare organic fertilizer with three times PGPR spraying and without PGPR spraying, although not significantly different from the number of tillers with 2 tons/hectare organic fertilizer application withthree3 and five times PGPR spraying and 1 ton/ hectare organic fertilizer application with four times PGPR spraying.

Yield component

Table 2 showed that the rice yields components significantly higher in the treatment of 2 tons/hectare organic fertilizer application with four and five times PGPR spraying compared with the application of 1 ton/hectare and 2 tons/ hectare organic fertilizer with three times PGPR spraying and without PGPR spraying. Both were not significantly different with the application of 1 ton/hectare organic fertilizer with four and five times PGPR spraying.

Table 2. The effect of organic fertilizer and PGPR application on component of rice yield

Treatment		Number of panicle/ clump	Length of panicle (cm)	Weight of grains/ clump (g)	Weight of grain/plot (kg)
Organic fertilizers 1 ton/ hectare	Without PGPR	13.83 d	22.850 b	18.80 c	1.316 b
	three times PGPR spraying	18. 87 b	23.00 b	23.96 b	1.367 b
	four times PGPR spraying	20.16 ab	23.800 ab	24.70 ab	1.467 ab

	five times PGPR spraying	20.33 ab	23.53 ab	25.27 ab	1.456 ab
Organic fertilizers 2 tons/ hectare	Without PGPR	14.83 d	22.83 b	19.53 c	1.333 b
	three times PGPR spraying	17.87 c	22.83 b	20.33 bc	1.350 b
	four times PGPR spraying	21.17 a	24.58 a	28.33 a	1.533 a
	five times PGPR spraying	22.67 a	25.33 a	29.67 a	1.587 a
	Interactions	(+)	(+)	(+)	(+)

Note : Numbers followed by similar alphabet in each column shows not significantly different in Duncan's multiple range test analysis at the 95% level of confidence. (+) positive interaction

Table 3 shows that the increasing of protein content in the application of 1 ton/ hectare organic fertilizer with three times PGPR spraying was followed by a decrease in fat and carbohydrate content. Increasing of fat were occurred in the application of 2 tons/hectare organic fertilizers with three times PGPR spraying, but not different with application of 1 ton/ha organic fertilizer with three times PGPR spraying and without PGPR in 1 ton/ hectare and 2 tons/ hectare organic fertilizer. Increasing of fat and carbohydrates were occurred in the application of 2 tons/hectare organic fertilizers with five times PGPR spraying compared with application of 1 ton/hectare organic fertilizers with four times PGPR spraying, but not different significantly with others. The amount of energy was determined by the content of carbohydrates in rice as carbohydrate is the highest compound in rice.

Table 3.The effect of organic fertilizer and PGPR application on content of fat, protein, carbohydrate and energy of rice

		Fat (%)	Protein (%)	Carbo-hydrate (%)	Energy
Organic fertilizers 1 ton/ hectare	Without PGPR	0.58 ab	8.99 d	74.71 ab	340.01 bc
	three times PGPR spraying	0.58 ab	9.27 bc	74.71 ab	341.12 ab
	four times PGPR spraying	0.52 bc	9.45 a	74.58 b	340.82 abc
	five times PGPR spraying	0.52 bc	9.18 c	74.68 ab	340.10 abc
Organic fertilizers 2 tons/ hectare	Without PGPR	0.58 ab	8.79 e	74.91 ab	340.03 abc
	three times PGPR spraying	0.61 a	8.84 e	74.61 ab	339.26 bc
	four times PGPR spraying	0.23 d	9.47 a	74.74 ab	338.91 c
	five times PGPR spraying	0.46 bc	9.41 ab	75.15 a	342.39 a
	Interactions		(+)	(+)	(+)

Note: Numbers followed by similar alphabet in each column shows not significantly different in Duncan's multiple range test analysis at the 95% level of confidence.(+)positive interaction

Table 4 showed that increasing in amylosa content in the application of 2 tons/hectare organic fertilizer with five times PGPR spraying. Increased amylopectin were occurred in the 1 tons/ hectare organic fertilizer application with four and five times PGPR spraying and 2 tons/hectare organic fertilizer application with five times PGPR spraying. Amylum digest is significantly higher in the treatment of 2 tons/ hectare organic fertilizer application with four and five times PGPR spraying compared with other treatment. Whiteness is significantly highest in the treatment of 2 tons/ hectare organic fertilizer application with five times PGPR spraying.

Table 4. The effect of organic fertilizer and PGPR application on amylosa and amylopectine content, amylum digest and whiteness of rice

Treatment		amylosa	Amylo pectin	Amylum digest	Whiteness
Organic fertilizers 1 ton/ hectare	Without PGPR	19.66 d	58.96 bc	35.46 d	56.61 g
	three times PGPR spraying	20.15 c	57.17 c	37.46 c	56.43 g
	four times PGPR spraying	19.61de	60.38 a	39.62 b	59.64 d
	five times PGPR spraying	19.57 e	60.11 a	40.33 b	62.63 b
Organic fertilizers 2 tons/ hectare	Without PGPR	20.38 b	58.05 bc	35.57 d	57.49 e
	three times PGPR spraying	17.58 g	59.66 b	39.55 b	58.97 d
	four times PGPR spraying	19.14 f	59.56 b	42.25 a	59.49 c
	five times PGPR spraying	22.28 a	61.00 a	42.38 a	62.91 a
Interactions		(+)	(+)	(+)	(+)

Note : Numbers followed by similar alphabet in each column shows not significantly different in Duncan's multiple range test analysis at the 95% level of confidence. (+) positive interaction

DISCUSSION

Application of 1 ton and 2 tons per hectare organic fertilizer into rice plants with 4 and 5 times PGPR spraying were not significantly affect, they provided growth and yield of rice rather than without and 3 times PGPR spraying. Based on the analysis results, soil was dominated by low to very low, so that the soil in the research area was considered as infertile. Analytical results on Vertisol, soil used in the experiments, had a pH (H_2O) of 6.64 and pH (KCl) of 5.99. Specific gravity and weight volume were in the amount of 2.65 g/cm3 and 1.82 g/cm3. Organic matter content was low (1.45%), cation exchange capacity was 23.75 me %, levels of N-total was 0.09%, and CN ratio was 9. Levels of P-available was 7.23 ppm and K-exchanged was 0.41 me% [12]. Improved results were obtained mostly due to PGPR spraying. However, PGPR spraying were able to provide nutrition to increase growth and yield of rice.

Plant growth-promoting rhizobacteria (PGPR) are beneficial bacteria at the root zone of plants contain a variety microbes that provide nutrient and growth stimulant compound as well [11]. Soil microbes are utilized to maintain and improve soil fertility that is environmentally friendly. Good soil fertility will create good planting conditions, especially root growth, availability of macro and micro nutrients, and increasing of microorganism activity [10]. Padmini and Irawati [13] in their research reported that rice plants treated with Custom-Bio sprays into the soil and soaking rice seedlings with PGPR increased the total microbial population in the soil, resulting in a population of solvent P microbial and N_2 fixation microbial, as well as improved the content of total N and total P-total in the soil, compared with without Custom Bio and PGPR. Soaking rice seedling with PGPR also improves the growth and yield [14].

Microorganism found in PGPR were active in helping the plants growth by providing nutrients (N fixation, solvent P). The function of nitrogen increase plant growth and yield by increasing the number of seedlings and leaf area growth. Phosphate serves as constituting a source of energy for the metabolic processes in plants. Potassium serves as a transport medium that brings nutrient including available N and P from the roots to the leaves and uptake assimilates from the leaves to the whole plant tissues [15]. Phosphorus also serves in the generative growth, namely

the process of primordial initiation, rice grain filling and synchronized grain ripening. PGPR spraying repeatedly is necessary for the need of nutrient in every phase of plant growth. Phosphorus given at early growth stages have PPE (Partial Productive Efficiency) for higher grain, because P is required for the seedlings formation and total P requirement is less than N, if absorbed P at the beginning of the growth can be redistributed to growing organs easily [15].

The highest fat content wasobtained on the application1 ton/ha and 2 tons/ hectare organic fertilizer with three times PGPR spraying, but not significantly different from that without PGPR spraying. This implies that the fat content is affected only by organic fertilizer from manure. Fat is basically a decomposition of carbohydrate that stored as energy reserves [16]. However, because rice is not a source of fat so its content does not affect the quality of the rice. On the other hand the highest protein wasobtained from 1 ton/hectare and 2 tons/hectare organic fertilizer application with 4 times PGPR spraying. Manure is needed for microbial proliferation medium contained in PGPR include N fixation microbes that produce nitrogen for plant growth. Nitrogen is an essential element in protein synthesis.

The application of 1 ton/hectare organic fertilizer with four times PGPR spraying reached 9.7% brought optimum protein content. Based on research done by Wuryani *et al*., [17], this value is relatively higher than protein content in rice grown using chemical fertilizers that only 8.8%.Obviouslyusingorganic fertilizer is better to produce protein than using chemical fertilizers. Meanwhile, four times PGPR spraying also produce high carbohydrate content and not significantly different between applying 1 ton/hectare and 2tons/hectare of organic fertilizer. The implications of this treatment were evident also in the energy results that indicate not significantly different with the highest yield are treated with 1 ton/hectare of organic fertilizer application with four times PGPR spraying.

The application of 1 ton /hectare organic fertilizer with four times PGPR spraying produced the highest amylopectin. Amylopectin was correlated positively with the level of rice fluffy [9] and synergies with protein will give a nice flavor of rice. Instead amylase makes rice hard (*pera* and undesirable) because the bonds between the simple sugars are straight and strong so it is more difficult to disentangle to be the simple sugars' components.

Therefore the rice with high amylase content was more filling. It also deals with the nature of amylase which absorbs more water so that the rice becomes fluffy. Related to the digestibility, the starch that digested easily is the starches that hydrolyzed easily by the enzyme into smaller units (simple sugars). Amylopectin, as a type of starch carbohydrate polymer -1.4 - α glycoside bond that branched with -1.6 - glycoside bond, is an open bond so it's easier to unravel. Therefore, rice with high amylopectin content tends to have a high digestibility, as a result eating fluffier rice makes hungry easier. The data shown by the treatment of 1 ton/hectare of manure and four times PGPR spraying showed a high digestibility. These results support the proposed idea by Ikameilaty [18]. While the level of rice whiteness basically deals with the level of polishing, the higher the level of polishing the whiter rice will get [19]. Recently, the consumer prefers non white rice, so the results of this research that the treatment of producing white rice with a not optimal whiteness level does not significantly affect the quality of the rice.

CONCLUSION

Plants treated with organic fertilaizer 1 ton/ hectare and sprayed with PGPR four times resulted the highest production and the rice quality.

REFERENCES

[1].Sukristiyonubowo, R., Wiwik, H., Sofyan A, Benito, H.P., De Neve, S.2011. Change from conventional to organic rice farming system: biophysical and socio economic reasons .International Research Journal of Agricultural Science and soil Science1(5):172-182.

[2].Padmini, O.S. 2013. Productivity, Soil Fertility, And Economic Benefit In Changes From Conventional To Organic Rice Farming System At Sragen District. International Conference on Green Agro-Industry. Faperta UPNVY Yogyakarta 11-13 Nop 2013

[3].Padmini, O. S.2009. Peran Residu Legum - Padi Dan Campuran Pupuk Organik-Anorganik Terhadap Hasil Padi Dan Kandungan Amilosa–Amilopektin Beras. Jurnal Ilmu Pertanian Agrivita terakreditasi B.Vol.31(2):167-178

[4].Padmini, O. S., R.R.R. Brotodjoyo, Sri Wuryani, and Dwi Aulia, P. 2013. Increasing Rice Yield By Utilizing Sugarcane Waste And Liquid Organic Fertilizer. International Conference on Sustainable Agriculture and Invironment ICSAE. Univ Sebelas Maret UNS 27-29 Juni 2013

[5].Deore, G. B., Limaye A.S., Shinde B.M.,andS.L. Laware.2010. Effect of Novel Organic Liquid Fertilizer on Growth and Yield in Chilli (*Capsicum annum*,L.). Asian J. Exp. Biol. Sci.Spl.2010:15-19

[6].Jiann-Feng Lee, Yung-Wu Chen, Shih-Shiung chen, Yi-Fong Tsai. 2004. Effects of Long Term Application of Rape Seed Mealon The Grain Quality of Rice. Department of Agriculture National Chung HsinUniversity.

[7].Kosit,P.2011. Kyusei Nature Farming and the adaptation of farmers in the Isan Regionof Thailand. European Journal of Social Science 21(3):471-482.

[8].Dubey, Kand D.K. Dubey. 2010. Evaluation Of Cost Effective Organic Fertilizers. Research & Development Centre, Kilpest India Ltd., Govindpura, Bhopal, 462023,(M.P), India

[9].Houston, D. F. 1972. RICE, Chemistry and Technology. American Association of Cereal Chemists, Inc. Minnesota.

[10].Ashrafuzzaman,M. ,Farid Akhtar Hossen1, M.Razi Ismail, Md. Anamul Hoque, M. ZahurulIslam,S.M. Shahidullah, and Sariah Meon. Efficiency of plant growth-promoting

rhizobacteria (PGPR) for the enhancement of rice growth. African Journal of Biotechnology Vol.8(7),pp.1247-1252

[11].Khalimi H., Suprapta, D. N.,and Nitta. 2012. Effect of *pantoea agglomerans* on growth promotion and yield of rice. Agricultural Science Research Journals Vol.2 (5); pp.240-249

[12].Padmini, O. S. 2010. Peran Legum dan Pupuk Organik dalam Rotasi Tanaman Berbasis Padi di Vertisol Kabupaten Sragen

[13].Padmini, O. S. dan Endah B. Irawati. 2012. Aplikasi Custom-bio dan PGPR untuk Meningkatkan Populasi MikrobaTanah, Ketersediaan Unsur Hara dan Pertumbuhan Tanaman padi

[14].Padmini, O. S. 2011. Environmentally Friendly Rice Production Increased By Plant Growth Promoting Rhizo-bacteria (PGPR) To Develop Agrotourism. Proceeding Seminar International Sustainable Agriculture and Development Seminar, Yogyakarta, INDONESIA/UPN Veteran Yogyakarta

[15].Yoshida,S.1981. Fundamentals of Rice Crops Science. International RiceResearch Institute. Los Baños. Philippines.

[16].Conn,E.C.,P. K. Stumpf,,G. Bruening and Roy H. Doi.1987.Outlines of Biochemistry. John Wiley and Sons, Inc. Canada

[17].SriWuryani., O. S. Padmini and D.A. Puspitaningrum. 2012. Postharvest Quality Enchancement of Rice Var. Mekongga Respons of Liquid Organic Fertilizer Application. Paper presented on Asia Pacific Symposium,18–20 September 2012 at Yogyakarta-Indonesia

[18.Ikameilaty. 2011. Laporan Evaluasi Nilai Gizi: Daya Cerna Pati.http://ikameilaty. wordpress.com (diakses tanggal 15 Januari 2013)

[19].Sutrisno.2007. Penanganan Pascapanen Padi diIndonesia. Jurnal Keteknikan Pertanian. Vol.21(2):1-9