RICE GROWTH AND YIELD RESPONSE ON BIOFERTILIZER APPLICATION ON LATOSOL PADDY FIELD OF INDONESIA

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Abstract. Rice is a main staple food in Indonesia. There is a major focus on how to increase production to meet the need of the 250 million Indonesian population without deteriorating environmental conditions. This study aimed to evaluate the biofertilizer dosing method on rice growth and yield trait of lowland rice in West Java latosol soil. The experiment was conducted at the greenhouse of the Indonesian Center for Agricultural Land Resources Research and Development (ICALRRD), Bogor, West Java, Indonesia from March to June 2018. Rice variety Inpari 32 as a new plant type, was used in this study. The treatments were arranged in a factorial randomized block design with two factors and three replications. The first factor was the method of biofertilizer application (seed treatment, root dipping prior to transplanting and sown at planting). The second factor the dosage of biofertilizer consisted of 1) 0 g/pot, 2) 100 g/pot, 3) 200 g/pot, 4) 300 g/pot, and 5) 400 g/pot. Latosol soil samples were obtained from Muara experimental station, Bogor, West Java. The results showed that root dipping method prior to transplanting with the biofertilizer as much as 300 g and 400 g/ha showed the best results in terms of filled grain number, filled grain weight, total grain number and total grain weight as compared to other combination treatments. The dosage of biofertilizer and its integrated application can become alternative recommendation to increase yield on lowland rice at latosol soil. The highest correlation value (r = 0.983) was observed between total grain weight and percent of filled grain number while the lowest correlation value (r = 0.008) was observed between 1000 grain weight and percent of filled grain number.
Keywords: *Latosol soil, root dipping, filled grain number, grain weight, seed treatment*

Introduction

Rice is the main staple food for most people in the world, especially in Asia where 90% of the global rice consumption and production is focused (Arnold, 1999). As an Asian country, rice has become the most popular and the most important cereal crop consumed by the almost 250 million of Indonesian population while conserving environmental condition without destroying the forest for rice land extension (Nikmatul et al., 2020; Rahmah et al., 2017). The need of this commodity is going to increase year by year due to the population growth (Somchit et al., 2017). The increase of rice demand cannot be supplied if there is no improvement in rice production.

There are several strategies to improve rice production. High yielding varieties have given significant rice production increase (Long-ping, 2014). Rice breeding programs to obtain a new variety with a high grain yield have been reported by previous studies (Hasan et al., 2013; Akhtar et al., 2011; Khamwichit et al., 2006). Other strategy tended to use the combination of organic and chemical fertilizers to obtain not only a high yield but also to overcome environmental problems at the same time (Zaki et al., 2018). Organic matter combined with NPK chemical fertilizer positively affected soil and plant characteristics (Himmelstein, 2014). Organic matters are various i.e., animal, and green manure (Tejada et al., 2009; Nguyen, 2013), biochar (Jones et al., 2012; Bastida et al.,

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2015) and composts (Noble and Converty, 2005). Another improvement can be made through application of biofertilizer (Vessey, 2003). The high productivity of agriculture is mostly achieved by using chemical fertilizers (Yang et al., 2019). Another strategy is the use of the combination of organic and chemical fertilizers. The manure could be used to increase rice productivity in order to reduce chemical fertilizers damage on the environment (Tahovska et al., 2013).

Different organic fertilizers, biofertilizers contain active or latent microorganism (bacteria and fungi) in order to increase nutrient availability for supporting plant growth and production (Wijebandara et al., 2009). Additionally, the application of biofertilizers also proved to maintain long term soil fertility (Punjee et al., 2020). Biofertilizers could be composed of single beneficial microorganisms like Trichoderma enriched biofertilizers or even the mix of several beneficial fertilizers such as Bio-N with active microorganisms. The success of a biofertilizer to boost plant growth is determined by the dosage and application method. The addition of biofertilizer Agrimeth + 50% of recommendation of NPK inorganic fertilizer increased soybean yield by 1.26 t/ha (100%) compared to the solely 100% NPK inorganic fertilizer (Purba, 2016). In the soil treated with organic fertilizers, the total C-organic increased by 26, 18, and 6% in the soil added with farm yard manure, paddy straw, and green manure, respectively (Ghosh et al., 2012).

The low biofertilizer adoption rate by farmers was due to relatively high biofertilizer price beside the low land area owned by farmers, rice planting pattern, farmer’s educational level, biofertilizer quality, and response from the field officers (extension services). Therefore, it is necessary to improve field facilities, field extension service quality, decrease product price, and appreciate the farmers applying the bio fertilizer (Gama et al., 2016).

There is still limited study on applying biofertilizers on rice in Indonesia, therefore, this study aimed to evaluate the method of application and dosage of biofertilizers on rice growth and yield trait of lowland rice in West Java latosol soil of Indonesia.

Materials and methods

Place and time of study

The experiment was conducted at the green house of Indonesian Center for Agricultural Land Resources Research and Development (ICALRRD), Bogor Regency, West Java Province, Indonesia) during wet season from March to June 2018. It was located at 214.3 m above sea level (-6°34’47”S, 106°45’15.7”E. The mean minimum and maximum temperature inside the greenhouse in the morning were 22.3 °C and 38.8 °C, respectively. Meanwhile, the mean minimum and maximum temperature in the afternoon were 23.1 °C and 40.4 °C, respectively.

Research design

The experimental design used pots as rice plant containers that were arranged inside the greenhouse. The synthetic pots with a 50 cm diameter and 60 cm depth were filled with 10 kg of Latosol soil from Muara Garden, of Indonesian Center for Rice Research. All pots were irrigated with tap water and left for 20 days for organic material decomposition.

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Pots were arranged in factorial randomized block design with two factors and three replications. The first factor was three biofertilizer application methods i.e. seed treatment , root dipping prior to transplanting, and sown at transplanting. The second factor was consisted of five levels of biofertilizer dosage: 0 g/pot as a control, 100 g/pot, 200 g/pot, 300 g/pot, and 400 g/pot. Total of 45 pots were observed in the present experiment.

Planting material was Inpari 32 that was categorized as new plant type rice variety from the Indonesian Center for Rice Research (ICRR) in Subang, West Java, Indonesia. The seed was continuously grown into seedling, and it was transplanted to the pot at 17 days after seedling (DAS). For dipping treatment, the seedling was removed from the soil and the root was dipped in biofertilizer prior to transplanting to the pot. For the sown treatment, the biofertilizer was sowed into the growing medium after the transplanting. The biofertilizer used in present experiment was obtained from the ICALRRD that composed of *Bradyrhizobium japonicum* and *Rhizobium japonicum, Azotobacter* sp, *Bacillus* sp and *Methylobacterium* sp in powder-shaped carrier material.

The Latosol soil that was collected from Muara experimental garden located at 287 m asl (S:6°36’54 S:106°47’29E”). Soil samplings were collected at the soil depth up to 20 cm below soil surface, in five spots for every location. The observed soil characteristics prior to the experiment were texture, pH, organic C, N total, available P, cation exchange capacity (CEC), K-dd, Ca-dd, Mg-dd, Na-dd, Al-dd, reduced Fe and fractionated P (Al, Ca and Fe). Soil sample was mixed to be a composite sample, and all mentioned analysis was carried out in the Soil Biology Laboratory, ICALRRD, following previous study methods (Kesaulya et al., 2015).

Data collection and analysis

The plants sampled for biomass and its partition to the root and crown part (both in fresh and dry forms) were observed from one plant in each treatment and three replications.

The observed variables were plant height, tiller number, panicle length, panicle number per hill, grains per panicle, percentage of filled grains and the weight of 1000 filled grains. The plant height and tiller number per hill were observed weekly starting from the 1st day after transplanting. The plant biomass and its partition to the root and crown part were observed both in fresh and dried form. The drying process was done in an oven at 60 °C for 2 days.

Data analysis

Data of various root and shoot growth, as well as yield parameters were subjected to analysis of variance (ANOVA). The mean comparison followed Duncan’s Multiple Range Test with the Statistical Analysis System (SAS) 9.1.3 software version to delineate mean difference (Steel and Torrie, 1980).

Results and discussion

The analysis results of soil chemical properties conducted before experiment are shown in *Table 1*.

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Table 1. *Latosol soil chemical properties, Bogor, 2018*

Soil characteristics	Value	Soil characteristics	Value
Sand (%)	13	K_2O HCl 25% (mg/100g)	20
Dust (%)	42	P_2O_5 Olsen (ppm)	45
Clay (%)	45	K_2O Morgan (ppm)	183
pH H_2O	6.0	Ca-dd (cmol(+)/kg)*	8.92
pH KCl	4.7	Mg-dd (cmol(+)/kg)*	1.90
Al-dd(cmol(+)/kg)*	0	K-dd (cmol(+)/kg)*	0.26
H-dd (cmol(+)/kg)*	0.11	Na-dd dd (cmol(+)/kg)*	0.82
C-organic (%)	2.35	Total	11.9
N total (%)	0.31	Cation exchange capacity (cmol (+)/kg)	12.74
C/N ratio	8.0	Base saturation (%)	93
P_2O_5HCl25% (mg/100g)	191		

Note: *:The Al-dd, H-dd, Ca-dd, Mg-dd, K-dd and Na-dd are exchangeable values of Al, H, Ca,Mg, K and Na, respectively.

The Soil texture was dominated by fractions of clay (45%), dust (42%), and sand (13%). Total nutrient content of N (0.31%) and organic C (2.35%) levels were medium. The soil cation exchange capacity (CEC) of 12.74 cmol (+)/kg was low. The Ca-dd and Mg-dd values of values of 8.92 cmol (+)/kg and 1.90 cmol (+)/kg was categorized as medium. The available P_2O_5 (191 mg/100 g) was very high and K_2O (20 mg/100g) was low-medium. The available C/N ratio value of 8.0 (<15), which value is an indicator the soil fertility determining conditions. The higher the C/N ratio value, the slower the rate of soil organic matter decomposition by microorganisms. The N total in latosol soil was 0.31%. The P was extracted with 2 solvents i.e., HCl 25% (total P) and Olsen (available P). The total and available P solvent were 191 mg/100 g and 45 ppm, respectively. The K was extracted with 2 solvents i.e., HCl 25% (total K) and Morgan (available K). The dissolved total and Available K were 20 mg/100 g and 183 ppm, respectively. Both results showed that latosol soil had lower available P and total K. Meanwhile, cation exchange capacity (CEC) showed 12.74 cmol (+) kg.

Analysis of variance plant trait showed that the interaction between the application method and the difference in dose showed significant results for all characters except stem dry weight, panicle number/plant, panicle length, filled grains number/plant, unfilled grains number/plant and 1000 grain weight (*Table 2*). The diversity due to the biofertilizer application method was significant for all characters except plant height, panicle length, unfilled grains per plant, and 1000 grain weight. The difference in dose showed significant for all characters except plant height, tiller number, leaf fresh weight, panicle length, unfilled grains per plant and 1000 grain weight. The significant interaction illustrates that the application method treatment has a different effect on the difference in treatment dose. The plant height, number of tillers, number of panicles per plant, panicle length, 1000 grain weight, number of filled grains per panicle, filled grain weight, and total grain weight had the lowest coefficient of variability in various dosage treatments and biofertilizer application methods. Response at four biofertilizer dose in different application methods on plant height and tiller number at vegetative and generative stage is shown in *Table 3*.

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Table 2. *Variance analysis of observed rice traits, Bogor, 2018*

Traits	Means square of			Coefficient of variation (%)
	Applied method (A)	Biofertilizer dosage (D)	A × D interaction	
Plant height (cm)	106.90*	13.89ns	59.93**	5.82
Tiller number	81.62**	81.62*	7.59**	15.07
Root fresh weight (g)	886.49**	126.33*	118.60*	24.30
Stem fresh weight (g)	2704.62**	300.70**	141.23*	19.42
Leaf fresh weight (g)	1141.42**	82133.30ns	142.87**	18.85
Root dry weight (g)	62.32**	18.65**	14.17*	35.24
Stem dry weight (g)	73.41**	26.82*	13.23ns	51.94
Leaf dry weight (g)	104.30**	9.27**	55.98*	15.42
Panicle number/plant	64.62**	6.28*	2.33ns	11.28
Panicle length (cm)	10.32ns	7.60ns	9.95ns	14.82
Filled grain number/plant	1858694.87**	439812.97*	212911.62ns	18.03
Unfilled grain number/plant	991766.69ns	1321759.48ns	989066.41ns	92.08
1000 grain weight (g)	7.63ns	2.19ns	3.50ns	10.78
Filled grain weight (g)	762.99**	184.55**	180.62**	13.09
Total grain weight (g)	775.80**	170.11**	153.64**	12.18

ns, * and **: non-significant, and significant at $P < 0.05$ and $P < 0.01$, respectively

Table 3. *Mean performance of biofertilizer dose on plant height and tiller number at vegetative and generative stages in different application method, Bogor, 2018*

Biofertilizer application	Traits					
	Plant height (cm)			Tiller Number		
	45 DAS	66 DAS	87 DAS	45 DAS	66 DAS	87 DAS
Seed treatment:						
0 g/plot (Control)	74.6abcd	110.5abc	113.1ab	19.3ab	20.0a	19.0a
100 g/plot	71.5d	106.2bc	110.8ab	17.0 abc	20.7a	18.3a
200 g/plot	80.6a	112.4ab	113.6ab	18.7ab	20.7a	17.7ab
300 g/plot	80.9a	111.3abc	112.8ab	18.3 ab	20.7a	16.7ab
400 g/plot	78.2abc	116.5a	119.3a	17.3 abc	17.7ab	17.0ab
Root dipping prior to planting:						
0 g/plot (Control)	73.5bcd	108.9abc	112.2ab	20.7a	22.7a	21.0a
100 g/plot	76.1abcd	107.8abc	111.6ab	18.0ab	19.7a	18.3a
200 g/plot	76.6abcd	110.6abc	117.1ab	16.0bc	21.3a	19.3a
300 g/plot	78.6abc	112.9ab	115.0ab	16.3bc	18.7ab	17.7a
400 g/plot	80.4a	113.9ab	117.5ab	17.3 abc	18.7ab	17.7ab
Application at planting time:						
0 g/plot (Control)	79.2ab	107.3abc	110.0ab	16.0bc	18.3ab	17.0ab
100 g/plot	78.3abc	116.1a	118.5a	10.7c	13.7bc	13.0bc
200 g/plot	70.7d	102.1c	105.b	7.3d	11.3c	13.0bc
300 g/plot	72.5cd	105.5bc	108.ab	6.3d	10.3c	11.0c
400 g/plot	60.3d	102.4c	106.8b	5.3d	15.2ab	17.7ab

Values with different letters in a column are significantly different according to Duncan's Multiple Range Test ($P \leq 0.05$)

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The rice plant height was significantly affected by combination treatment of method and dosage of biofertilizer at all time observation series, except 87 days after sowing (DAS). The effect of biofertilizer dose of 200 g/pot, 300 g/pot at application at seed treatment and 400 g/pot at application at planting time had the highest plant height (at 80.6 cm, 80.9 cm and 80.4 cm) at the 45 DAS. The biofertilizer dose of 400 g/pot at application at seed treatment and 100 g/pot application at planting time showed the highest plant height of 116.5 cm and 116.1 cm, respectively at the 66 DAS. At the 87 DAS the biofertilizer dose of 400 g/pot at application at seed treatment and 100 g/pot at application at planting time showed the highest plant height of 119.3 cm and 118.5 cm, respectively. Treatment of biofertilizer dose on plant height was significant at 0.05 p-value in all three application methods at the 45, 66, and 87 DAS. Biofertilizer application effect was significant at 0.05 p-value on plant height response on vegetative and generative stages in all three application methods.

The tiller number correlated with grain yield and impacted rice growth development to total grain weight. The early development plant reached maximum of tiller number. In *Table 3,* the effect of biofertilizer on tiller number at vegetative and generative stage is presented. The treatment of biofertilizer dose of control had the largest tiller number and was significantly different with all dosages of biofertilizer and at all application methods at 45 days after sowing (DAS). The tiller number at 66 DAS was not significant at seed treatment and root dipping prior to planting but significantly different with application planting time method. At vegetative and generative stage all dose observation series of planting time application showed the lowest tiller number. The biofertilizer applied at planting time and at all dosages (100, 200, and 300 g/pot) gave lower tiller number compared to those applied at seed treatment as well as root dipping prior to planting application method. These results occured at all vegetative and generative stages (45, 66, and 87 DAS).

Aside of growth variables, morphology traits variables i.e., root fresh weight, stem fresh weight, leaf fresh weight, root dry weight, stem dry weight, and leaf dry weight were also observed. There was significant variance in response to applied method and dosage of biofertilizer on rice plant fresh weight partitioned into root, stem and leaves (*Table 4*).

Biofertilizers are live microbes from the soil that provide certain nutrients for plants. The soil used was a silty clay textured soil with a low sand content. The bacteria from plant roots could increase the solubility of P in the soil as a *Pseudomonas fluorescens* (Yulistiana et al., 2020) and *Bacillus cereus* 11UJ for antifungal activity on rice plants (Suryadi et al., 2015). Through this study, we tried to show the response of method and dosage on morphology and yield component and correlation between treatment and rice plant characters. Regarding morphological aspects measured at vegetative and generative stage, the biofertilizers significantly improved rice plants height and growth by increasing soil nutrients such as nitrogen and phosphorus which influence rice seedlings growth (Isahak et al., 2012).

The effect of four treatment dose on root fresh weight response was significant in the dose 300 and 400 g/pot at application at planting time and not significantly different from control and all dose in three application methods. The highest root fresh weight was measured when 300 g of biofertilizer was applied by using root dipping method (38.7 g), while the lowest result was observed in 400 g of biofertilizer sown at planting (10.7 g).

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The combination treatment of 400 g of biofertilizer sown at planting was determined as the lowest stem fresh weight (15.0 g), while the highest one was observed in no biofertilizer in seed treatment (63.0 g). The effect of the dose 300 and 400 g/pot application at planting time was significant in with control and all dose in three application methods. For the leaves part, the highest result was noticed at 300 g biofertilizer and no biofertilizer in seed treatment, while the lowest result was observed in 400 g of biofertilizer sown at planting (*Table 4*).

Table 4. *Mean performance of biofertilizer dose on morphology traits at vegetative stage in different application method, Bogor, 2018*

Biofertilizer application	Traits					
	RFW	**SFW**	**LFW**	**RDW**	**SDW**	**LDW**
Seed treatment:						
0 g/plot (Control)	34.3a	63.0a	42.3a	9.1a	10.6a	11.5a
100 g/plot	34.3a	54.0ab	40.3a	8.3a	10.5a	10.3ab
200 g/plot	29.7ab	50.7abc	36.3a	6.4ab	8.2ab	9.7ab
300 g/plot	35.0a	47.7bcd	42.3a	8.5a	7.3abc	9.9ab
400 g/plot	26.7ab	45.0bcd	41.7a	6.3ab	6.7abc	9.1bc
Root dipping prior planting:						
0 g/plot (Control)	34.3a	40.0bcd	34.0a	7.9a	5.2abc	8.3bcd
100 g/plot	32.0a	46.7bcd	36.0a	6.7ab	7.2abc	8.3bcd
200 g/plot	29.3ab	38.3cd	32.3ab	5.5abc	4.3abc	7.3cd
300 g/plot	38.7a	45.0bcd	40.0a	8.6a	6.5abc	8.8bc
400 g/plot	38.3a	45.7bcd	41.3a	9.6a	7.2abc	9.1bc
Application at planting time:						
0 g/plot (Control)	33.7a	41.3bcd	37.7a	9.1a	9.7a	8.3bcd
100 g/plot	26.0ab	33.7de	30.3ab	6.0ab	5.9abc	6.2de
200 g/plot	17.3bc	22.3ef	22.3bc	3.1bcd	2.6bc	4.5ef
300 g/plot	13.0c	16.0f	15.7c	1.5cd	1.8bc	3.2f
400 g/plot	10.7c	15.0f	13.7c	1.2d	1.2c	2.5f

Values with different letters in a column are significantly different according to Duncan’s Multiple Range Test ($P \leq 0.05$). RFW: root fresh weight (g), SFW: stem fresh weight (g), LFW: leaf fresh weight (g), RDW: root dry weight (g), SDW: stem dry weight (g), LDW: leaf dry weight (g)

Similarly to fresh weight, the rice plant dry weight was also significantly affected by the interaction of method and dosage of biofertilizer. Rice plant was partitioned into three parts, i.e. root, stem and leaves. For root part, the heaviest dry weight was recorded in 400 g of biofertilizer by using root dipping prior to transplanting (9.6 g), while the lowest result was noted in 400 g of biofertilizer sown at planting (1.2 g).

In term of stem and leaves part, the lowest dry weight was noted in 400 g of biofertilizer sown at planting (1.2 g and 2.5 g), while the heaviest dry weight was found in no biofertilizer in seed treatment. The effect of biofertilizer dose of 300 g/pot had the highest root dry weight in the transplanting application method, while the lowest root dry weight was indicated by control in the dipping application method. Biofertilizer treatment dose of 300 g/pot had the highest root dry weight and was not significantly different from control dose in three application methods. Meanwhile, biofertilizer

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treatment dose of 100 g/pot had the highest stem dry weight in application at planting time. The effect of biofertilizer dose of 400 g/pot had the highest leaf dry weight in planting time application method and was not significant from control dose.

There was significant result regarding the effect of interaction between method and dosage of biofertilizer on the yield variables, as indicated by the panicle number per hill, panicle length, filled grain number per hill, empty grain number per hill, filled grain weight and total grain weight (*Table 5*).

Table 5. *Mean performance of yield component traits in response to different method and dosage of biofertilizer, Bogor, 2018*

Biofertilizer application method	Dosage	Panicle number per hill	Panicle length (cm)	Filled grain number per hill	Empty grain number per hill	Filled grain weight	Total grain weight (g)
Seed treatment	Control	16.7a	21.8a	2198.7ab	1133.7b	48.8ab	54.1ab
	100 g	17.0a	21.3a	1811.7bcd	1000.3b	45.6ab	50.3ab
	200 g	15.7abc	21.5a	1890.7abcd	934.7b	41.8bc	46.1bc
	300 g	16.0ab	21.5a	1268.0d	1546.7ab	29.5d	36.8c
	400 g	15.3abc	22.7a	1827.7bcd	1112.7b	46.0ab	50.6ab
Root dipping prior to transplanting	Control	17.3a	21.4a	2286.3ab	972.3b	49.7ab	54.4ab
	100 g	16.3a	26.1a	2191.7ab	820.7b	49.7ab	54.0ab
	200 g	16.0ab	22.0a	2522.3ab	994.7b	52.3ab	57.7a
	300 g	16.3a	21.9a	2214.7a	3130.3a	55.7a	60.9a
	400 g	16.3a	22.5a	2471.0a	853.7b	54.2a	58.6a
Sown at planting	Control	15.3abc	27.3a	2195.3a	836.7b	54.1a	58.2a
	100 g	12.7cd	23.2a	1993.7ab	819.3b	45.1ab	49.3ab
	200 g	12.0d	21.7a	1394.3cd	659.0b	33.3cd	36.4c
	300 g	10.7d	21.6a	1346.3cd	676.0b	32.2cd	35.2c
	400 g	13.0bcd	23.4a	1444.7d	1223.7b	27.8d	36.0c

Means in the same column followed by the same letter were not significantly different at P = 0.05 using Duncan multiple range test (DMRT)

The highest number of panicles per hill was found in the combination treatment of root dipping prior to transplanting without any biofertilizer i.e., 17.3 panicle per hill that was significantly different to combination treatment of sown at planting with various biofertilizer dosage such as 100 g (12.7 panicle per hill), 200 g (12.0 panicle per hill), 300 g (10.7 panicle per hill) and 400 g (13 panicle per hill). In term of panicle length, all the combination treatments did not significantly differ from one to another. The highest number of filled grain per hill was observed in 400 g of biofertilizer that applied by using root dipping method prior to transplanting i.e., 2471 grain, while the lowest result was found in the 300 g biofertilizer applied in seed treatment i.e., 1268 grain. The biofertilizer application can increase grain yield (Simarmata et al., 2016; Marlina et al., 2014; Naher et al., 2016).

The highest number of empty grains per hill was noticed in the 200 g of biofertilizer applied by sown at planting method i.e., 659 grain, while the highest result was found in 300 g of biofertilizer applied by root dipping method prior to transplanting i.e., 3130.3 grain. The highest filled grain weight was observed in 300 g of biofertilizer

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applied by root dipping technique while the lowest one was noted in the combination treatment of 400 g of biofertilizer sown at planting. In term of total grain weight, the highest result was found in 300 g of biofertilizer by using root dipping prior to transplanting while the lowest results were found in 400 g of biofertilizer sown at planting.

The rice growth and yields are significantly improved as the effect of bacterial inoculation of strain KKU2500-3 as biofertilizer (Banayo et al., 2012). Previous study reported that all tested biofertilizers have significant and positive effect for rice plant growth and yield (Simarmata et al., 2016). The biofertilizers addition that contained *Azospirillum sp, Rhizobium, Azotobacter sp.,* as active ingredients improved plant growth (Permanasari et al., 2014; Kartina et al., 2015; Kiuk et al., 2019).

Correlation coefficients between treat of rice plant characters are shown in *Table 6*.

Table 6. *Yield and yield component correlation coefficients of studied traits, Bogor, 2018*

	RFW	SFW	LFW	PH	TN	1000 GW	EGN	PN	PL	GNP	FGN	FGW	TGW
RFW	1	.814**	.818**	.324*	.225	-.086	.166	.470**	-.087	.505**	.286	.408**	.517**
SFW		1	.894**	.249	.327*	.093	.066	.556**	-.110	.464**	.217	.394**	.459**
LFW			1	.307*	.277	.153	.146	.572**	-.130	.537**	.263	.429**	.535**
PH				1	.060	.092	.041	.099	.137	.459**	.103	.473**	.432**
TN					1	.085	.127	.779**	-.038	.459**	-.244	.390**	.365*
1000 GW						1	.166	.079	-.209	.008	-.082	-.137	-.014
EGN							1	.252	.006	.200	-.112	.048	.148
PN								1	-.064	.584**	-.025	.484**	.518**
PL									1	.164	-.024	.080	.152
GNP										1	.450**	.849**	.983**
FGN											1	.401**	.596**
FGW												1	.845**
TGW													1

RFW: root fresh weight (g), SFW: stem fresh weight (g), LFW: leaf fresh weight (g), RDW: root dry weight (g), SDW: stem dry weight g), LDW: leaf dry weight (g), PH: plant height, TN: tiller number, GW: Grain weight, EGN: Empty grain number per hill, PN: Panicle number per hill, PL: Panicle length, GNP: percent of filled grain number, FGN: Filled grain number, FGW: Filled grain weight, TGW: Total grain weight (g)

At the vegetative stage, the agronomic characters that had positive and significant relationship with total grain weight were root fresh weight (r = 0.517), stem fresh weight (r = 0.459), leaf fresh weight (r = 0.535), plant height (r = 0.432) and tiller number (r = 0.365). At the generative stage, the yield component that had positive and significant relationship with total grain weight were panicle number per hill (r = 0.518), percent of filled grain number (r = 0.983), filled grain number (r = 0.596) and filled grain weight (r = 0.845). The other characters, number of 1000 grain weight was inversely correlated with total grain weight, (r = - 0.148) but not significantly. The number of empty grains per hill (r = 0.152), showed very weak correlation with grain yield. The results indicated positive correlations among traits tested in most of the cases. The highest correlation value (r = 0.983) was observed between total grain weight and percent of filled grain number while the lowest correlation value (r = 0.008) was observed between 1000 grain weight and percent of filled grain number.

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The number of panicles per plant and the number of filled grains per panicle showed high significant value which could be used as selection criteria for rice yield improvement (Somchit et al., 2017).

Conclusion

The present study concluded that the method and dosage of biofertilizer application affected growth and yield of rice plant at Latosol soil. The root dipping method prior to transplanting with the biofertilizer showed the best results in terms of weigh and filled grain of rice. The dosage of biofertilizer and its integrated application could become alternative recommendation to increase rice grain yield on lowland or wetland at latosol soil. The total grain weight had positive and significant relationship with root fresh weight, stem fresh weight, leaf fresh weight, plant height, tiller number, panicle number per hill, percent of filled grain number, filled grain number, and filled grain weight. The highest value was found between total grain weight and percent of filled grain number.

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