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The Effect of Biofertilizer on Growth and Yield of Lowland Rice at Alluvial Soil

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ABSTRACT

The objective of this study was to investigate the impact of combining different doses and application methods of biofertilizers on the growth and yield of lowland rice (*Oryza sativa* L.) in West Java. The experiment was designed as a completely randomized factorial with two factors and three replications. The first factor included three different biofertilizer application methods, and the second factor consisted of five different biofertilizer doses. The use of high-fertility alluvial soil was favorable for rice growth when treated with biofertilizers. The interaction between the applied method and biofertilizer dosage had a significant impact on various growth parameters, such as plant height, tiller number, stem fresh weight (g), stem dry weight (g), leaf dry weight (g), panicle number per plant, filled grain number per plant, unfilled grain number per plant, and total grain weight (g). The application of 300 g per pot biofertilizer dose at planting time resulted in the highest filled grain weight per plant (58.6 g) and total grain weight per plant (65.1 g). However, while biofertilizers significantly enhanced rice plant growth, none of the four biofertilizer dose treatments were significant when compared to the control in any of the three application methods. Optimally dosed biofertilizers, when applied at proper planting time, can serve as an alternative approach to enhance rice growth and yield in alluvial soil. This eco-friendly technology has the potential to be integrated into field management practices.

Keywords: Alluvial soil; Applied Method; Biofertilizer; High productivty

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INTRODUCTION

Rice is a vital source of sustenance for over half of the world's population, particularly in Asia (Sakariyawo et al. 2013). Indonesia is among the top rice-producing countries in Southeast Asia, with an estimated potential production of 31.63 million tons for food consumption in 2020. To increase fertility and crop production, organic farming and biofertilizers can be utilized to intensify rice cultivation (Yu et al. 2018). Biological N_2-fixation technology, which uses fertilizer application, can reduce environmental risks and produce approximately 10 million tons of nitrogen required for rice annually worldwide (Wezel et al. 2014; Suhag 2016). Bacteria can promote plant growth through processes such as N_2-fixation, phosphate solubilization, and phytohormone production. Additionally, they indirectly stimulate plant growth by generating siderophores, producing HCN, and suppressing pathogen growth.

Rice cultivation requires a significant amount of nitrogen, typically 250-300 kg per hectare to produce 6 tons per hectare (Permentan 2007). In fact, soil has limitation of N nutrient which only can be solved by applying commercially available N fertilizers. However, soil often lacks sufficient nitrogen, which can be addressed through the application of commercially available nitrogen fertilizers. Unfortunately, these fertilizers can result in substantial losses of urea-N or NO3-N due to volatilization, leaching, and other environmental factors, leading to pollution problems (Meena et al. 2020).

Fortunately, certain species of bacteria, including *Azospirillum, Bacillus, Enterobacter, Herbaspirillum, Klebsiella, Pseudomonas, Rhizobium, Methylobacterium sp., and Bradyrhizobium,* are capable of fixing nitrogen and are suitable for use as biofertilizers (Nath Bhowmik and Das 2018; Rana et al. 2020; Swarnalakshmi et al. 2020; Saeed et al. 2021; Gamit and Amaresan 2022). These biofertilizers contain beneficial living microorganisms that improve soil conditions by fixing atmospheric nitrogen, solubilizing soil phosphorus, and facilitating nutrient availability for plants (Mahanty et al. 2017; Sharma and Rather 2023). Their use can increase crop yields by up to 25% and reduce inorganic fertilizer application by up to 25-50% for nitrogen and 25% for phosphorus nutrient (Aggani 2013; Al Abboud et al. 2014). Biofertilizers can also improve soil health, protect against drought and soilborne diseases, and increase rice yield potential (Marlina et al. 2014; Naher et al. 2016; Simarmata et al. 2016; Walkiewicz et al. 2020; Sun et al. 2021; Ravshanov et al. 2022; Sharma and Rather 2023). However, their effect on crop growth and yield may not always be significant, especially in the first test (Patel 2011; Sun et al. 2021).

Alluvial soil, which is formed from various materials deposited at flat to nearly flat slopes by fluvial and/or colluvial processes, can have varying physical, chemical, and mineralogical properties and nutrient accumulation (Al-Jabri 2016). Generally, alluvial soil has high to very high contents of P2O5 and K2O, but is low in organic matter, soil CEC, and exchangeable K. Soil pH is slightly acidic to alkaline, with medium to high contents of Ca and Mg, and high base saturation (Al-Jabri 2016). Cultivation with a balanced use of mineral fertilizers and organic manures can sustain microbial activity and improve soil health (Saxena et al. 2016). Lowland rice varieties can grow well in alluvial soil, which is typically rich in minerals and diverse beneficial microbes, though this may depend on the soil properties in the area.

MATERIALS AND METHOD

Plant and Biofertilizer Materials

The plant material used in this study was the Inpari 32 variety, obtained from the Indonesian Center for Rice Research, which is well-suited for lowland or wetland environments. This variety is known for its high yield potential, resistance to pests and diseases, delicious taste, and popularity among farmers in irrigated lowland agro-ecosystems. The effective commercial biofertilizer used in the study was sourced from the Center for Research and Development of Agricultural Land Resources in Bogor, West Java. This biofertilizer contains a consortium of beneficial microbes, including *Methylobacterium* sp., *Azotobacter* sp., *Bacillus* sp., *Rhizobium* sp., and *Bradyrhizobium* sp., which are known to promote plant growth, fix atmospheric nitrogen, solubilize phosphorus, and exhibit anti-pathogenic activities (Bahadur et al. 2016; Ribeiro et al. 2020; Bargaz et al. 2021)

Green House Assay

The experiment was carried out in the greenhouse of the Indonesian Soil Research Institute, which is part of the Indonesian Agency for Agricultural Research and Development located in Bogor, Indonesia (6°34'47.6"S,106°45'15.7"E, 214.3 m above sea level) during the wet season from March to June 2018. The average annual minimum and maximum temperatures in the morning were 22.3°C and 38.8°C, respectively, while in the afternoon, they were 23.1°C and 40.4°C, respectively.

The alluvial soil used in the experiment was obtained from the Pusakanagara Experimental Station, which belongs to the Indonesian Center for Rice Research and is located in Subang, Indonesia (6°25'42'4 S, 107°89'69,9 E, 23.1 m above sea level). The topsoil, which was used in the pots, was 0-20 cm in depth. Each polythene pot, with a diameter of 30 cm and depth of 5 cm, was filled with 1 kg of soil. The pots were irrigated and maintained before germinated seedlings were planted.

The Inpari 32 seeds were soaked for 24 hours, brooded for about 12-24 hours until the coleoptile appears on the seeds, then sown in nursery box. The seedlings were planted 17 days after sowing with 2 seedlings per pot.

The pre treatment soil for growing rice were analyzed in Biology Soil Laboratory, Center for Research and Development of Agricultural Land Resources under Indonesian Agency for Agricultural Research and Development Bogor, Indonesia. The soil analysis consists of soil texture, pH, organic content, total N, available P, CEC, ex. K, ex. Ca, ex. Mg, ex. Na, Al^+, H, reduced Fe, and P fraction (Al, Ca and Fe). This preliminary analysis of soil properties before applied in the pots was purposed to know the original condition prior biofertilizer treatment.The experimental design was arranged in Completely Randomized Design (CRD) factorial with two factor and three replications. The first factor were three different biofertilizer application method consisting of 1) seed treatment with biofertilizer by mixing the seed with biofertilizer according to dose, 2) root dipping prior planting with biofertilizer for 15 minutes, and 3) biofertilizer application at planting time. The second factors consisted of five level biofertilizer doses, i.e. i) 0 g per pot (control), ii) 100 g per pot, iii) 200 g per pot, iv) 300 g per pot, and v) 400 g per pot.

A number of morpho-agronomical characters were observed, including plant height, root fresh weight stem fresh weight, leaf fresh weight, root dry weight, stem dry weight, leaf dry weight at vegetative stage and tiller number at generative stage, panicle number per plant, panicle length, filled grain number per plant, unfilled grain number per plant, weight of 1000 grain, filled grain weight, and total grain weight at harvest. Root, stem, and leaf materials were dried at 60°C until constant weight and weighted. The characterization of these traits followed the descriptor of some researcher also reported that the application of bacteria enhanced shoot biomass and root biomass (Patel 2011).

Statistical Analysis. The collected data were subjected to analysis of variance (ANOVA) according to experimental design. If there was a significant difference, Duncan's Multiple Range Test testwas performed at the level of 5% significance to compare the difference among treatments with SAS sofware program v 9.1.3. (Gupta et al. 2016).

RESULT AND DISCUSSION

Chemical Properties of Alluvial Soil

The summary of soil chemical properties of alluvial soil prior to biofertilizer treatment is presented in Table 1. This soil was categorized as slightly acid with the texture dominated by fractions of clay (62%), dust (37%), and sand (1%), as called a silty clay textured soil with a low sand content. Total nutrient content of N (0.18%) and organic carbon (C) (1.40%) levels were medium. The soil cation exchange capacity (CEC) of 14.27 cmol (+) kg^{-1} seemed low. The Ca-dd and Mg-dd values were found to be medium, accounting of 9.95 cmol (+) kg^{-1} and 2.23 cmol (+) kg^{-1}, respectively.The available P_2O_5 (94 mg 100 g^{-1}) and K_2O (41 mg 100 g^{-1}) ranged medium to high. the soil was categorized as fertile because of a very low C/N ratio (<15), which value is a very sensitive indicator to determine soil fertility conditions. The higher the C/N ratio value, the slower the rate of soil organic matter decomposition by microorganisms. The microbiome plays an integral role in virtually all soil processes at the system level (Tao et al. 2020). The abundance of microbial, composition and activity will largely determine sustainable productivity of agricultural land (Wagg et al. 2019). According to the chemical, nutrient accumulation and microbes, productivity of alluvial soil is better than upland soils (Al-Jabri 2016). In relevant with this study that used rice variety for the assessment, alluvial plain is known to be the main land for food crops including wetland rice (Al-Jabri 2016).

Variance of Morpho-agronomical Characters

Analysis of variance showed that the diversity due to the biofertilizer application method was significant on the characters of root fresh weight, root dry weight, stem dry weight, leaf dry weight, number of filled grains per plant, number of unfilled grains per plant, filled grain weight, and total grain weight (Table 2). The difference in dose showed significantly for all observed characters except for the characters of root fresh weight, stem fresh weight, leaf fresh weight, root dry weight, and leaf dry weight. The interaction between the application method and the difference in dose did not differ significantlyfor all observed characters except for root fresh weight, leaf fresh weight, root dry weight, panicle length, and filled grain weight.

The significant interaction illustratesd that the application method has a different effect on the different dose. The characters of plant height, number of tillers, number of panicles per plant, panicle length, number of filled grains per panicle, filled grain weight, and total grain weight had the lowest coefficient of variability in various dosage and biofertilizer application methods.

The significant effect of biofertilizer dose, the application methods and their interaction to some morpho-agronomical characters of rice in this study demonstrated the effective this combined technologies on the basis of biofertilizer to enhance growth and yield of rice. Importantly, this environmental friendly biofertilizer is useful alternative of organic fertilizer to rice productivity. This study is in good agreement with previous studies that applied biofertilizer combined with seed priming, inorganic fertilizer, biofertilizer agent for applying or other treatments affected significantly to plant yield and the yield components (Atashbeigi et al. 2018). In general, the cell density of the inoculants when applied greatly influences their capacity for colonization and vitality in the natural soil environment.

Table 1. Alluvial soil chemical properties pre-treatment

Soil characteristics	Value	Soil characteristics	Value
Sand (%)	1	K2O HCl 25% (mg 100g^{-1})	41
Dust (%)	37	P2O5 (ppm) Olsen (ppm)	10
Clay (%)	62	K2O (ppm) Morgan (ppm)	205
pH H_2O	6.0	Ex. Ca (cmol(+) kg^{-1})	9.95
pH KCl	4.7	Ex. Mg (cmol(+) kg^{-1})	2.23
Ex. Al (cmol(+) kg^{-1})	0	Ex. K (cmol(+) kg^{-1})	0.34
Ex. H (cmol(+) kg^{-1})	0.11	Ex. Na (cmol(+) kg^{-1})	0.59
C-organik (%)	1.40	Total	13.11
N total (%)	0.18	CEC* (cmol(+) kg^{-1})	14.27
C/N ratio	8.0	Base saturation (%)	92
P2O5 HCl 25% (mg 100 g^{-1})	94		

*Cation Exchange Capacity

Table 2. Variance analysis of observed traits

Traits	Means square of			Coefficient of variation (%)
	Applied method (A)	**Biofertilizer dosage (D)**	**A x D Interaction**	
Plant height (cm)	5.21 ns	22.91**	25.29**	2.52
Tiller number	1.87 ns	41.87**	21.70**	14.45
Root fresh weight (g)	377.22 **	53.19 ns	63.47ns	30.17
Stem fresh weight (g)	81.30 ns	297.30 ns	259.77*	28.52
Leaf fresh weight (g)	468.7 ns	76.26 ns	73.17 ns	27.69
Root dry weight (g)	10.89 *	4.62 ns	4.73ns	40.03
Stem dry weight (g)	16.39 *	16.89*	11.97*	37.73
Leaf dry weight (g)	8.45 *	5.13 ns	6.42*	20.36
Panicle number per plant	0.822 ns	24.24**	12.71**	10.96
Panicle length (cm)	0.55 ns	1.16*	0.71 ns	2.89
Filled grain number per plant	546054.2 **	417691.8**	265329.3*	16.62
Unfilled grain number per plant	242492.08 **	243709.05**	132424.0**	25.20
1000 grain weight (g)	7.63 ns	2.19 ns	3.50 ns	10.18
Filled grain weight (g)	254.49 *	142.06*	98.34 ns	16.60
Total grain weight (g)	215.44 **	193.13**	125.94*	15.80

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

Effect on Growth and Yield

Response of four biofertilizer dose in difference application method on plant height and tillers number at vegetative and generative stage is shown in Table 3. Effect of biofertilizer dose of 400 g per pot had the highest plant height, while the biofertilizer dose of 100 g per pot had the lowest plant height at planting time application method at 45 day after sowing (DAS) (Table 3). Treatment of biofertilizer dose on plant height was not significant in all three application method at the 66 DAS. At 87 DAS, treatment of biofertilizer dose of 300 g per pot had the highest plant height (114.6 cm) at planting time application method, while the biofertilizer dose of 100 g per pot had the lowest plant height (107.2 cm)

(Table 3). According to Table 3, biofertilizer application was not significant in plant height response on vegetative and generative stage in all three application method.

Tillers number in rice growth development is important because it impact yield production. In early development, the plant will reach maximum tiller number. In Table 3, it was explained about the effect of biofertilizer in tiller number at vegetative and generative stage. Treatment of biofertilizer dose of 400 g per pot had the largest tiller number and not significantly different with control, while the biofertilizer dose of 100 g per pot had the lowest tiller number at planting time application method at 45 day after sowing (DAS) (Table 3). Treatment of biofertilizer dose of 300 g per pot and 400 g per pot was not significant in root dipping prior planting and application at planting time at the 66 DAS.

There was interesting finding showed that treatment of biofertilizer dose of 400 g per pot was significant with control at seed treatment method at 65 DAS (Table 3). At 87 DAS or generative stage, it mean optimum development in tiller number. It showed that biofertilizer dose treatment was significant only in seed treatment application method, while the biofertilizer dose treatment was not significant in root dipping prior planting and application at planting time method (Table 3)

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Table 1. Mean performance of biofertilizer dose on plant height and tillers number at vegetative and generative stage in different application method

Treatments	Traits					
	Plant height (cm)			Tiller Number		
	45 DAS	66 DAS	87 DAS	45 DAS	66 DAS	87 DAS
Seed treatment						
Control	68.6abc	107.0a	116.5a	7.3cde	16.3de	16.0bcde
100	71.5a	106.4a	114.9ab	8.0cde	17.7bcde	18.0bcd
200	70.6ab	100.1ab	107.4de	9.0bcd	17.3cde	16.7bcde
300	67.6abc	101.8ab	113.6abc	8.3cde	17.7bcde	16.3bcde
400	72.0a	100.0ab	109.3cde	10.0a	25.3a	23.0a
Root dipping prior planting						
Control	69.0abc	104.7 a	113.0abc	9.0bcd	21.7abc	20.3abc
100	70.0abc	105.3a	110.7bcde	10.0abc	18.3bcde	18.0bcd
200	71.9a	104.2a	112.2abcde	8.0cde	16.7cde	16.7bcde
300	64.7bc	99.5ab	111.0bcde	8.0cde	18.0bcde	15.3cde
400	69.4abc	104.0a	113.5abc	9.0bcd	18.7bcde	19.0abc
Application at planting time						
Control	70.4ab	105.0a	112.8abcd	9.0bcd	22.7ab	21.0ab
100	63.6c	95.4a	107.2e	6.0e	13.7e	12.3e
200	68.9abc	103.1ab	111.9abcde	7.0de	14.3e	13.7de
300	73.1a	105.4a	114.6abc	10.0abc	21.0abcd	19.3abc
400	73.9a	107.2a	109.6bcde	11.0ab	22.7ab	20.3abc

Note: values with different letters in a column are significantly different according to Duncan's Multiple Range Test (P ≤ 0.05).

The highest root fresh weight was showed in the dose of 300 g per pot at seed treatment application method, while the lowest root fresh weight was showed in the dose of 200 g per pot at planting time application method (Table 4). The effect of four treatment dose on root fresh weight response was not significantly different with control in three application method. Biofertilizer treatment at a dose of 300 g per pot had the highest stem fresh weight and was significantly different with the control at seed treatment application method. The highest leaf fresh weight was shown in biofertilizer treatment at a dose of 400 g per pot at planting time application method. All four biofertilizer treatments dose were not significant with control at three biofertilizer application method.

The effect of biofertilizer dose of of 300 g per pot had highest root dry weight in the transplanting application method, while the lowest root dry weight was indicated by control in the dipping application method (Table 4). Biofertilizer treatment dose of 300 g per pot had the highest root dry weight and was not significantly different from control dose in three application method. Meanwhile, biofertilizer treatment dose of 100 g per pot had the highest stem dry weight in application at planting time. The effect of biofertilizer dose of 400 g per pot had the highest leaf dry weight in planting time application method and was not significant with control dose.

Table 4. Mean perfomance of biofertilizer dose on morphology traits in different application method

Treatment	Fresh Weight			Dry Weight		
	Root	Shoot	Leaf	Root	Shoot	Leaf
Seed treatment						
Control	30.7ab	29.0c	25.7a	5.5ab	6.2ab	4.4abc
100	29.7ab	34.7abc	29.7a	4.5abc	5.3ab	3.0abc
200	29.3ab	35.7abc	29.7a	4.9abc	3.2abc	2.7bc
300	38.0a	56.7a	38.3a	6.4a	4.4abc	1.6c
400	26.3ab	50.0abc	32.7a	4.8abc	4.4abc	6.0ab
Root dipping prior planting						
Control	36.7a	43.3abc	34.3a	3.4de	8.1abc	6.9abcde
100	33.3ab	54.3ab	37.3a	4.5abcde	9.0a	6.0abcde
200	26.3ab	38.3abc	30.7a	4.2bcde	4.8abcde	4.0cde
300	29.7ab	39.0abc	29.3a	8.6ab	5.6abcde	2.5e
400	31.3ab	51.7abc	36.0a	8.2abc	9.0a	7.1abcd
Application at planting time						
Control	23.3ab	51.3abc	33.3a	6.8abc	8.6ab	8.4ab
100	19.3b	36.7abc	26.0a	6.7abc	9.5a	6.9abc
200	17.3b	30.7bc	23.3a	7.4ab	7.4ab	5.9bc
300	21.7ab	37.7abc	28.3a	9.4a	7.6ab	4.3c
400	30.7ab	50.7abc	39.3a	7.9ab	9.2a	9.3a

Note: Values with different letters in column are significantly different according to Duncan's Multiple Range Test (P≤ 0.05).

Table 5. Mean perfomance of biofertilizer dose on yield component traits in different application method

Treatments	Traits			
	Panicle number	Panicle Length	Filled Grain Number	Unfilled Grain Number
Seed treatment				
Control	14.7cde	22.2abc	2019.7bcde	1103.7abc
100	16.0bcd	21.3abc	1757.7cde	1203.7ab
200	14.0de	21.6abc	1661.7de	975.3ab
300	15.0bcd	21.4abc	1775.7cde	1106.3abc
400	20.3a	21.1bc	2100.0abcde	1505.7a
Root dipping prior planting				
Control	16.3bcd	22.1abc	2226.0abcde	1032.3abcd
100	16.7bc	21.1c	2317.3abcd	786.7cd
200	15.0bcd	22.3abc	1975.0cde	994.0bcd
300	14.7cde	22.4ab	2376.3abc	968.7bcd
400	16.0bcd	21.7cabc	2221.0abcde	929.0bcd
Application at planting time				
Control	18.3ab	21.1bc	2649.7ab	1220.3ab
100	11.7e	21.1c	1560.7e	555.3d
200	13.0de	21.9abc	1912.0cde	648.0cd
300	16.3bcd	22.5a	2719.0a	1247.0ab
400	18.3ab	22.2abc	1919.3cde	1230.7ab

Note: values with different letters in a column are significantly different according to Duncan's Multiple Range Test (P ≤ 0.05).

The treatment of biofertilizer dose of 400 g per pot had the highest number of panicles per plant in seed treatment application method and significant with control dose, while biofertilizer dose of 100 g per pot had lowest number of panicles per plant in application method at planting time (Table 5). Number of panicle is one of important trait that relate with grain yield (Akbar et al. 2018; Akbar et al. 2019) so the increase of number per panicle because of biofertilizer application is desired. Treatment of biofertilizer dose in three application showed no significant difference on panicle length (Table 5). This illustrates that the treatment has no significant effect on Inpari 32 variety.

The effect of biofertilizer dose of 300 g per pot had the highest number of filled grains per plant in application method at planting time and significantly different with dose of 100, 200 and 400 g per pot (Table 5). This finding showed that there is optimum dose of biofertilizer in soil. Higher population of microbes within soil on treatments caused the competition in obtaining nutrients occurred between microbes and crops which resulted in retarded nutrient availability for crops. The process to provide available in soil takes a long process, while it is known that rice growing period is around 120 days.

The lowest number of unfilled grain per plant was shown by biofertilizer dose of 100 g per pot in application method at planting, while the highest number of unfilled grain per plant was indicated by dose of 400 g per pot in seed treatment application method (Table 5). It was expected to obtain low unfilled grain per panicle and high number of total so that the productivity will increase. One of the factor that cause of high number of unfilled grain per panicle is soil nutrient especially nitrogen. The implementation of biofertilizer can increase the availability of N nutrient so it can decrease number of unfilled grain per plant.

The effect of four level biofertilizer dose was not significant with control in three different application method (Table 6). This finding showed that the quality of grain weight is consistent from control treatment until biofertilizer treatment (Figure 1). We guessed that biofertilizer application in rice impact not in the size of grain, however the number of filled grain as shown in Table 5 so in can increase yield potential.

The biofertilizer dose treatment of 300 g per pot had the largest filled grain weight per plant (58.6 g), while dose of 100 g per pot had the lowest weight of filled grain per plant (35.3 g) in the application at planting time method (Table 6). The effect of biofertilizer dose of 300 g per pot had the largest total grain weight per plant (65.1 g) in the application at planting time (Table 6). Biofertilizer treatment of 300 g per pot was not significant with control on filled grain weight and total grain weight, however these traits increased 17% and 18%, respectively. This finding told that biofertilizer treatment can increase yield potential. Researchers also found that biofertilizer application can increase grain yield (Marlina et al. 2014; Naher et al. 2016; Simarmata et al. 2016). According to Figure 1 also showed that biofertilizer application at planting time have the highest filled grain weight and total grain weight compared with other application method.

Table 6. Mean performance of biofertilizer dose on yield traits in different application method

Treatments	Traits	
	Filled grain weight (g)	Total grain weight (g)
Seed treatment		
Control	46.6 abcde	51.3 abcd
100	39.4 bcde	44.4 bcd
200	35.7 de	40.3 cd
300	36.0 cde	40.8 abcdef
400	45.7 abcde	53.07abcd
Root dipping prior planting		
Control	52.9 ab	58.0 ab
100	48.1 abcde	52.3 abcd
200	44.1 abcde	48.7 bcd
300	47.8 abcde	52.3 abcd
400	50.6 abc	55.8 abc
Application at planting time		
Control	50.2 abcd	55.2 abc
100	35.3 e	38.0 d
200	43.9 bcde	47.1 bcd
300	58.6 a	65.1 a
400	43.6 bcde	49.5 bcd

Note: values with different letters in a column are significantly different according to Duncan's Multiple Range Test (P ≤ 0.05)

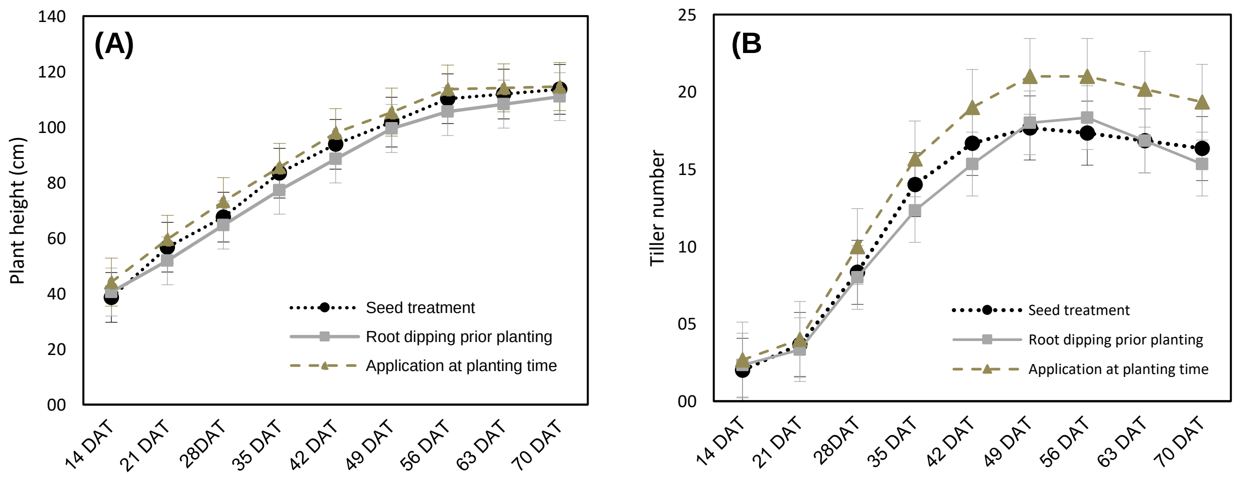

Figure 1. Effect of 300 g biofertilizer dose on plant height and tiller number in different application method. Vertical bars show standard error of means of three replicates DAT: Days after transplanting.

CONCLUSIONS AND SUGGESTIONS

The interaction between the application method and biofertilizer dose had a significant impact on the growth and yield of rice in alluvial soil. Among the various biofertilizer doses tested, 300 g per pot applied at planting time resulted in the highest filled grain weight per plant and total grain weight per plant, demonstrating its effectiveness. This biofertilizer dose is a suitable alternative recommendation for lowland and/or wetland rice grown in alluvial soil, and its integrated application with planting time can significantly increase the yield of rice.

DAFTAR PUSTAKA

Aggani SL. 2013. Development of bio-fertilizers and its future perspective. Scholars Academic Journal of Pharmacy. 2 (4):327-332

Akbar M, Purwoko B, Dewi I, Suwarno W. 2018. Agronomic and drought tolerance evaluation of doubled haploid rice breeding lines derived from anther culture. SABRAO Journal of Breeding & Genetics. 50 (2)

Akbar MR, Purwoko BS, Dewi IS, Suwarno WB. 2019. Selection of doubled haploid lines of rainfed lowland rice in preliminary yield trial. Biodiversitas Journal of Biological Diversity. 20 (10)

Al Abboud M, Ghany TA, Alawlaqi M. 2014. Role of biofertilizers in agriculture: a brief review. Mycopath. 11 (2)

Al-Jabri M. 2016. Soil properties of the alluvial plain and its potential use for agriculture in Donggala Region, Central Sulawesi.

Atashbeigi S, Talat F, Fajri A. 2018. Investigating The Effect Of Seed Priming And Bio-Fertilizer On The Quantitative And Qualitative Characteristics Of The Calendula Officinalis Plant. Scinzer Scientific Publication. 4 (1):1-11

Bahadur I, Maurya BR, Kumar A, Meena VS, Raghuwanshi R. 2016. Towards the soil sustainability and potassium-solubilizing microorganisms. Potassium solubilizing microorganisms for sustainable agriculture.255-266

Bargaz A, Elhaissoufi W, Khourchi S, Benmrid B, Borden KA, Rchiad Z. 2021. Benefits of phosphate solubilizing bacteria on belowground crop performance for improved crop acquisition of phosphorus. Microbiological Research. 252:126842

Gamit H, Amaresan N. 2022. Role of methylotrophic bacteria in managing abiotic stress for enhancing agricultural production: A review. Pedosphere.

Gupta V, Parsad R, Bhar L, Mandal B. 2016. Statistical analysis of agricultural experiments. Part-I: Single Factor Experiments ICAR-Indian Agricultural Statistics Research Institute Library Avenue, Pusa, New Delhi.

Mahanty T, Bhattacharjee S, Goswami M, Bhattacharyya P, Das B, Ghosh A, Tribedi P. 2017. Biofertilizers: a potential approach for sustainable agriculture development. Environmental Science and Pollution Research. 24:3315-3335

Marlina N, Gofar N, Subakti AHPK, Rohim AM. 2014. Improvement of rice growth and productivity through balance application of inorganic fertilizer and biofertilizer in inceptisol soil of lowland swamp area. AGRIVITA, Journal of Agricultural Science. 36 (1):48-56

Meena M, Swapnil P, Divyanshu K, Kumar S, Tripathi YN, Zehra A, Marwal A, Upadhyay RS. 2020. PGPR-mediated induction of systemic resistance and physiochemical alterations in plants against the pathogens: Current perspectives. Journal of Basic Microbiology. 60 (10):828-861

Naher UA, Panhwar QA, Othman R, Ismail MR, Berahim Z. 2016. Biofertilizer as a supplement of chemical fertilizer for yield maximization of rice. Journal of Agriculture Food and Development. 2 (0):16-22

Nath Bhowmik S, Das A. 2018. Biofertilizers: a sustainable approach for pulse production. Legumes for soil health and sustainable management.445-485

Patel S. 2011. Harmful and beneficial aspects of Parthenium hysterophorus: an update. 3 Biotech. 1 (1):1-9

Permentan. 2007. Peraturan Menteri Pertanian RI tentang rekomendasi pemupukan N, P, dan K pada padi sawah spesifik lokasi No 40/Permentan/OT.140/4/2007.

Rabia AH, Neupane J, Lin Z, Lewis K, Cao G, Guo W. 2022. Principles and applications of topography in precision agriculture. Advances in Agronomy. 171:143-189

Rana KL, Kour D, Kaur T, Devi R, Yadav AN, Yadav N, Dhaliwal HS, Saxena AK. 2020. Endophytic microbes: biodiversity, plant growth-promoting mechanisms and potential applications for agricultural sustainability. Antonie Van Leeuwenhoek. 113:1075-1107

Ravshanov B, Namozov F, Kurbonov A, Abdalova G, Karimov A, Khaitov B, Park KW. 2022. Integrative effect of nitrogen fertilization and biotreatments on rice growth and yield potential under open-field agriculture. Journal of Plant Nutrition.1-11

Ribeiro IDA, Volpiano CG, Vargas LK, Granada CE, Lisboa BB, Passaglia LMP. 2020. Use of mineral weathering bacteria to enhance nutrient availability in crops: a review. Frontiers in plant science. 11:590774

Saeed Q, Xiukang W, Haider FU, Kučerik J, Mumtaz MZ, Holatko J, Naseem M, Kintl A, Ejaz M, Naveed M. 2021. Rhizosphere bacteria in plant growth promotion, biocontrol, and bioremediation of contaminated sites: A comprehensive review of effects and mechanisms. International Journal of Molecular Sciences. 22 (19):10529

Sakariyawo OS, Okeleye KA, Dare MO, Atayese MO, Oyekanmi AA, Aderibigbe SG, Okonji CJ, Ogundaini OG, Soremi PA. 2013. Agronomic evaluation of some drought tolerant NERICA rice varieties to arbuscular mycorrhizal fungi (AMF) inoculation in the rainforest transitory zone of Nigeria. Journal of Agricultural Science. 5 (11):118

Saxena A, Yadav AN, Rajawat M, Kaushik R, Kumar R, Kumar M, Prasanna R, Shukla L. 2016. Microbial diversity of extreme regions: an unseen heritage and wealth. Indian Journal of Plant Genetic Resources. 29 (3):246-248

Sharma K, Rather SA. 2023. Microalgae as Biofertilizer for Sustainable Agricultural Productivity. In: Bioremediation and Phytoremediation Technologies in Sustainable Soil Management. Apple Academic Press, pp 75-100

Simarmata T, Turmuktini T, Fitriatin BN, Setiawati MR. 2016. Application of bioameliorant and biofertilizers to increase the soil health and rice productivity. HAYATI Journal of Biosciences. 23 (4):181-184

Suhag M. 2016. Potential of biofertilizers to replace chemical fertilizers. Int Adv Res J Sci Eng Technol. 3 (5):163-167

Sun H, Zhang Y, Yang Y, Chen Y, Jeyakumar P, Shao Q, Zhou Y, Ma M, Zhu R, Qian Q. 2021. Effect of biofertilizer and wheat straw biochar application on nitrous oxide emission and ammonia volatilization from paddy soil. Environmental Pollution. 275:116640

Swarnalakshmi K, Yadav V, Tyagi D, Dhar DW, Kannepalli A, Kumar S. 2020. Significance of plant growth promoting rhizobacteria in grain legumes: Growth promotion and crop production. Plants. 9 (11):1596

Tao C, Li R, Xiong W, Shen Z, Liu S, Wang B, Ruan Y, Geisen S, Shen Q, Kowalchuk GA. 2020. Bio-organic fertilizers stimulate indigenous soil Pseudomonas populations to enhance plant disease suppression. Microbiome. 8:1-14

Wagg C, Schlaeppi K, Banerjee S, Kuramae EE, van der Heijden MG. 2019. Fungal-bacterial diversity and microbiome complexity predict ecosystem functioning. Nature communications. 10 (1):4841

Walkiewicz A, Brzezińska M, Bieganowski A, Sas-Paszt L, Frąc M. 2020. Early response of soil microbial biomass and activity to biofertilizer application in degraded brunic arenosol and abruptic luvisol of contrasting textures. Agronomy. 10 (9):1347

Wezel A, Casagrande M, Celette F, Vian J-F, Ferrer A, Peigné J. 2014. Agroecological practices for sustainable agriculture. A review. Agronomy for sustainable development. 34 (1):1-20

Yu X, Guo L, Jiang G, Song Y, Muminov MA. 2018. Advances of organic products over conventional productions with respect to nutritional quality and food security. Acta Ecologica Sinica. 38 (1):53-60.