Pertanika J. Trop. Agric. Sci. 47 (4): 1391 - 1403 (2024)

TROPICAL AGRICULTURAL SCIENCE

Journal homepage: http://www.pertanika.upm.edu.my/

The Effect of Biofertilizer Dose on Growth and Yield of Four Maize Varieties in Indonesia

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ABSTRACT

Maize is one of the most demanding food crops, but its current production is not sufficient yet. However, demand needs are met through imports. Furthermore, maize is mostly cultivated on marginal land, affecting productivity. Biofertilizer application is an effort to increase maize yield by improving soil quality. This study determines the effect of biofertilizer application in liquid and granule form with several doses on the growth and yield of four local maize varieties of Indonesia. The study was carried out using nested randomized complete block design with two factors, i.e., 7 biofertilizers (two formulas, i.e., liquid and granule with 3 levels of dosage) and 4 maize varieties. The field experiment was conducted in Tawangrenjeni, Turen, Malang, East Java. The results showed that the application of biofertilizers affects the growth and yield of several maize varieties. Granular biofertilizer at a dose of 150 g/plant showed the best growth and yield observed variables, and Bisi 99 showed the best performance compared with other maize varieties.

Keywords: Corn, plant growth-promoting rhizobacteria, productivity, rhizobacteria consortia

ARTICLE INFO

Article history:
Received: 22 November 2023
Accepted: 27 February 2024
Published: 29 November 2024

DOI: https://doi.org/10.47836/pjtas.47.4.20

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INTRODUCTION

Maize (*Zea mays* L.) is one of the food crops in great demand in Indonesia. However, its current production is insufficient to meet demand, so imports often meet it. Furthermore, maize is mostly cultivated on marginal land with less fertility, which affects its productivity. Therefore, maize productivity in dry land needs to be increased

ISSN: 1511-3701
e-ISSN: 2231-8542

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(Ikhwan, Iriany, et al., 2021). The application of biofertilizer is an effort to increase maize yield by improving soil quality. Microorganisms contained in biofertilizers have various capabilities ranging from the production of growth-enhancing substances to the release of substances that ameliorate the effects of various abiotic stress conditions such as drought, nutrient deficiencies, salinity, pH stress, and even pollutants (Odoh et al., 2020).

Previous research by Ikhwan, Septia, et al. (2021) has obtained and identified several rhizobacteria isolated from maize rhizosphere. The results of 16S rDNA sequencing compared with Genbank at National Center for Biotechnology Information (NCBI) showed that 10 isolates were phylogenetically close to several bacterial strains, such as *Raoultella terrigena*, *Serratia marcescens*, *Serratia nematodiphila*, *Enterobacter hormaechei*, *Enterobacter cancerogenous*, *Enterobacter cloacae*, *Enterobacter asburiae*, *Citrobacter murliniae*, and *Pseudomonas fluorescens*. These rhizobacteria genera are commonly used as inoculants for producing biofertilizers such as *Enterobacter*, *Pseudomonas*, and *Serratia* (Glick, 2021; Seenivasagan & Babalola, 2021).

In biofertilizer formulations, a combination of several rhizobacteria can be used because many bacteria can live together and establish mutualistic relationships (Olanrewaju & Babalola, 2019). Furthermore, not all rhizobacteria have the same mechanisms and roles in supporting plant growth and production so that more profits will be obtained (Malusà et al., 2016). Akhtar et al. (2018) reported that maize grows better on bacterial consortium application compared to single or double inoculation on *Fusarium*-infested soil. In addition, Irfan et al. (2019) also found similar benefits in saline environments. It may occur because the consortium changes many nutrients, increases microbial activity in the soil, and changes nutrients through the symbiotic association of bacteria and plant roots.

A combination of several rhizobacteria was applied to improve the growth and yield of maize. Efthimiadou et al. (2020) reported an increase in maize yield due to the application of *Azotobacter chroococcum*, *Bacillus subtilis*, *Bacillus megatherium*, and their mixes. Ikhwan, Iriany, et al. (2021) added that the bacteria consortium of four bacterial strains can improve maize yield. Moreover, Katsenios et al. (2022) also investigated the effectiveness of ten plant growth-promoting bacteria strains, applied separately, on sweet corn cultivation. However, they found that applying different bacteria strain treatments did not influence the yield and quality of sweet corn. Therefore, research on applying bacteria consortia with several capabilities and mechanisms to enhance the growth and yield of maize is needed. This research attempted to apply a biofertilizer composed of a combination of ten bacterial strains. This study investigated the effect of biofertilizer application in liquid and granular form on several doses on the growth and yield of four Indonesian maize varieties.

MATERIALS AND METHODS

Preparation of Biofertilizer

Biofertilizer composed of 10 bacterial candidates, i.e., *Raoultella terrigena*, *Serratia marcescens*, *Serratia nematodiphila*, *Enterobacter hormaechei*, *Enterobacter hormaeghel*, *Enterobacter cancerogenous*, *Enterobacter cloaceae*, *Citrobacter murliane*, and *Psedomonas fluorences*. Ikhwan, Septia, et al. (2021) isolated and purified these bacterial candidates. Before use, all isolates were mixed, grown in a medium of 2 g/L GrowMore 32-10-10 (USA), 2 g/L GrowMore 10-55-10 (USA), and 20% (v/v) molasses, and harvested in the fermenter (capacity of 2 L) as described by Ikhwan, Septia, et al. (2021).

Biofertilizer was produced using a method described by Ikhwan, Septia, et al. (2021) with some modifications. Production of liquid biofertilizer was carried out using a production fermenter (capacity of 500 L), with a media composition of 200 L of sterile distilled water by adding 2 g/L of red Grow More 32-10-10 (USA), 2 g/L of Grow More 10-55-10 (USA), and 10% (v/v) molasses. Granular biofertilizer was produced using a granulator (diameter of 2.5 m) with a composition of 20 kg of rice husk charcoal. The granulation process involves incorporating bacteria with a density of 1 x 10^9, which is sprayed into the granulation machine using a sprayer. Rice husk charcoal was poured into the granulation machine, and then the bacterial starter was sprayed slowly until the raw material turned into granules. It took around 10 min, and then the granules were air-dried. The characteristics of the granules are perfectly round with quite hard density and a diameter of about 0.5-1.0 cm.

Experimental Design and Data Analysis

The field experiment was conducted in Tawangrenjeni Village, Turen District, Malang Regency, East Java, Indonesia. This research was carried out using a nested randomized complete block design (RCBD) using two factors, where the main factor was the maize variety (V), and the nested factor was the dose of granule and liquid biofertilizer (P). The main factors were maize varieties consisting of 4 varieties, namely Bisi 18 (V1), Bisi 99 (V2), Pertiwi 6 (V3), and Pertiwi 3 (V4). The nesting factor was the dose of granule and liquid fertilizer (P), consisting of 7 levels, i.e., without treatment or control (P0), 50 g/plant of granular biofertilizer (P1), 100 g/plant of granular biofertilizer (P2), 150 g/plant of granular biofertilizer (P3), 50 ml/plant of liquid biofertilizer (P4), 100 ml/plant of liquid biofertilizer (P5), and 150 ml/plant of liquid biofertilizer (P6). A population of 18 plants for each treatment combination and 10 observation samples were taken randomly. Variables were observed and measured as described by Ikhwan, Iriany, et al. (2021), including plant height (cm), number of leaves, stem diameter (mm), ear weight (g), cobs weight (g), cobs dry weight (g), cobs diameter (mm), tip filling (%), and 100-grain weight (g). The data were analyzed using analysis of variance (ANOVA) to understand the effect of the treatments and then using Tukey's honestly significant difference (HSD) α 5% to find the best treatment.

RESULTS AND DISCUSSION

Different biofertilizer doses influenced the growth and yield of several maize varieties. The treatments significantly affected plant height, number of leaves, stem diameter, ear weight, and 100-grain weight. The influence of the treatments on maize plant height and number of leaves started to appear 21 days after planting (DAP) (Tables 1 and 2). At the end of observation, the highest average plant height and leave number were shown by Bisi 99 with an application of 100 g/plant granular biofertilizer, and the lowest average value was in the treatment of Bisi 18 without biofertilizer application. The effect of biofertilizer application on several maize varieties did not appear on stem diameter at first and at the end of observation. However, it significantly affected stem diameter from 21 to 35 DAP (Table 3).

The application of biofertilizer, both in the form of liquid and granule, consistently produced better maize growth than the control. Based on observations of plant height, number of leaves, and stem diameter, the results tend to be better with granule and liquid biofertilizers compared to those without biofertilizers. The 100 g/plant granule biofertilizer treatment showed the highest plant height at the middle (21 DAP) and end (49 DAP) of observation. In contrast, Bisi 99 showed the highest plant height among other varieties at 21, 35, 42, and 49 DAP (Table 1). The difference in the growth between maize varieties is due to the specific characteristics of each variety and its response to the application of rhizobacteria formulation. However, the quantitative results of the HSD test in Tables 1 and 2 show that the application of biofertilizer significantly increased plant height and number of maize leaves compared to the control. These results follow the previous research reported by Onyia et al. (2020), which showed a significant improvement in the growth of maize due to biofertilizer application compared with the control.

Pseudomonas fluences affect maize growth and could increase plant height. They can also increase the agronomic variables of maize and plant root length (Bhattacharyya & Jha, 2012). *Pseudomonas aeruginosa* has a growth-promoting effect on *Zea mays* L, which grows in 1% benzene and 0.5% phenanthrene and can also increase agronomic variables. It could act as a biological fertilizer in soil contaminated with aromatic hydrocarbons (Wong-Villarreal et al., 2019).

The application of biofertilizer also affected the number of maize leaves variable. Based on the results obtained in Table 2, the treatment of liquid biofertilizer at a dose of 150 ml/plant showed the highest number of leaves at 21, 28, and 35 DAP. The increase in maize leaves could be affected by the presence of *Serrata marcescens*. Adoko (2021) reported that a combination of bacterial inoculum of S. *marcescens* and peat soil produces the best results of leaf area in maize (*Zea mays* L.). Halotolerant plant growth-promoting rhizobacteria (PGPR) can be able to reduce environmental or abiotic stress. *Enterobacter asburiane* can increase growth and yield under salinity conditions.

Table 1
Plant height of four maize varieties under several biofertilizer treatments at 14 to 49 days after planting

Treatments	Average plant height, cm (days after planting)											
	14		21		28		35		42		49	
V1P0	18.33	a	35.22	a	60.11	a	83.78	a	98.78	a	100.44	a
V1P1	22.56	a	39.56	abcd	66.56	abcd	88.89	abcd	107.33	abc	122.33	bcdefg
V1P2	23.33	a	38.00	abc	64.67	abc	86.00	a	102.89	ab	107.44	ab
V1P3	24.11	a	41.89	cdefghi	74.67	fgh	99.44	defg	109.33	bcd	123.89	cdefgh
V1P4	28.33	a	42.11	cdefghi	65.78	abc	85.33	a	108.78	abc	128.00	cdefghij
V1P5	25.33	a	38.22	abc	67.56	bcde	87.67	ab	102.11	ab	116.56	abcde
V1P6	24.56	a	46.78	ijkl	67.11	bcde	88.56	abc	110.44	bcde	114.22	abcd
V2P0	20.00	a	35.67	ab	61.56	ab	87.67	ab	102.22	ab	119.78	bcdef
V2P1	22.56	a	44.56	efghij	78.22	ghi	98.22	fgh	139.44	l	173.44	n
V2P2	21.67	a	44.22	defghij	73.56	efgh	93.33	cdef	135.89	kl	175.44	n
V2P3	24.22	a	49.78	kl	75.89	fgh	95.44	efg	133.11	jkl	169.11	n
V2P4	19.78	a	41.22	cdefg	76.33	fghi	91.67	bcde	119.33	defgh	151.11	lm
V2P5	22.78	a	46.11	ghijkl	67.56	bcde	105.44	ij	133.56	jkl	161.56	mn
V2P6	21.44	a	41.00	cdef	69.78	cdef	87.67	ab	109.33	bcd	127.00	cdefghi
V3P0	21.78	a	40.22	bcde	67.89	bcde	99.56	gh	107.67	abc	119.56	bcdef
V3P1	22.33	a	48.22	jkl	78.78	ghi	112.22	l	128.78	hijk	144.67	kl
V3P2	23.00	a	49.89	l	79.44	hi	112.00	l	126.44	hijk	144.22	jkl
V3P3	22.67	a	47.56	jkl	78.33	ghi	112.44	l	125.33	ghij	142.78	Ijkl
V3P4	22.89	a	46.22	hijkl	79.11	ghi	103.67	hi	115.78	cdefg	130.11	defghijk
V3P5	23.00	a	48.11	jkl	78.44	ghi	111.11	kl	122.67	fghi	135.78	fghijkl
V3P6	23.67	a	49.67	kl	77.44	ghi	110.00	jkl	120.44	efgh	131.22	efghijk
V4P0	21.78	a	35.22	a	63.33	abc	87.56	ab	104.89	ab	113.11	abc
V4P1	22.67	a	38.89	abc	67.00	bcde	95.33	efg	119.56	efgh	141.44	Ijkl
V4P2	25.22	a	41.67	cdefgh	72.56	defg	95.33	efg	116.00	cdefg	138.78	hijkl
V4P3	23.11	a	44.11	defghij	75.67	fgh	94.44	gh	115.11	cdef	137.78	ghijkl
V4P4	24.56	a	47.11	jkl	82.89	i	105.67	ijK	127.67	hijk	147.89	lm
V4P5	25.00	a	44.56	efghij	77.67	ghi	101.89	hi	131.67	ijkl	144.00	jkl
V4P6	23.33	a	45.22	fghijk	80.11	hi	102.11	hi	124.56	fghij	149.67	lm
CV (%)	9.66		9.29		7.91		4.99		7.39		10.32	

Note. Means followed by the same letter in the same column are not significantly different based on the honestly significant difference test at the α 5% level; CV = Coefficient of variation; V1 = Bisi 18; V2 = Bisi 99; V3 = Pertiwi 6; V4 = Pertiwi 3; P0 = Control; P1 = 50 g/plant of granular biofertilizer; P2 = 100 g/plant of granular biofertilizer; P3 = 150 g/plant of granular biofertilizer; P4 = 50 ml/plant of liquid biofertilizer; P5 = 100 ml/plant of liquid biofertilizer; P6 = 150 ml/plant of liquid biofertilizer

Table 2
Number of maize leaves under several biofertilizer treatments on four maize varieties at 14 until 49 days after planting

Treatments	Average number of maize leaves (days after planting)											
	14		21		28		35		42		49	
V1P0	5.33	a	5.11	a	5.33	a	5.44	a	5.44	a	6.89	ab
V1P1	5.11	a	6.11	ef	6.11	bcd	6.55	cde	7.22	cdefgH	7.56	cd
V1P2	5.11	a	5.89	cdef	6.11	bcd	6.22	bcd	6.78	bcd	7.33	bc
V1P3	5.00	a	6.11	ef	6.22	bcde	7.11	fg	7.22	cdefgh	6.89	ab
V1P4	5.00	a	5.89	cdef	6.56	efg	6.78	ef	7.00	cdef	8.00	defg
V1P5	5.00	a	5.67	bcd	6.11	bcd	6.56	cde	7.11	cdefg	7.89	cdef
V1P6	5.00	a	5.89	cdef	6.33	cde	6.78	h	7.89	hijk	7.78	cde
V2P0	5.00	a	5.44	ab	5.89	b	6.45	bcde	6.56	bc	7.56	cd
V2P1	4.89	a	6.00	def	6.44	defg	7.56	gh	8.89	l	8.56	ghi
V2P2	4.89	a	5.89	cdef	6.67	fg	7.78	ef	8.44	kl	8.89	i
V2P3	4.89	a	5.89	cdef	6.67	fg	7.56	gh	8.33	jkl	8.56	ghi
V2P4	4.89	a	5.78	bcde	6.44	defg	7.44	gh	7.44	defgh	8.22	efgh
V2P5	4.89	a	5.78	bcde	6.22	bcde	7.44	gh	8.22	ijkl	8.89	i
V2P6	4.89	a	5.67	bcd	6.22	bcde	6.67	def	6.89	cde	7.89	cdef
V3P0	4.89	a	5.67	bcd	5.89	b	6.11	bc	7.00	cdef	7.44	bcd
V3P1	4.89	a	6.22	fg	6.44	defg	6.56	cde	7.78	ghijk	8.67	hi
V3P2	4.78	a	5.89	cdef	6.00	bc	6.11	bc	7.67	fghij	8.56	ghi
V3P3	4.78	a	6.22	fg	6.33	def	6.56	cde	7.78	ghijk	8.89	i
V3P4	4.78	a	6.00	def	6.11	bcd	6.11	bc	7.56	efghi	8.44	fghi
V3P5	4.78	a	6.11	ef	6.22	bcde	6.44	bcde	7.56	efghi	8.44	fghi
V3P6	4.67	a	6.56	g	6.78	g	6.78	ef	7.33	defgh	8.67	hi
V4P0	4.67	a	5.11	a	5.33	a	6.00	b	6.11	ab	6.33	a
V4P1	4.56	a	5.11	a	6.33	def	7.33	gh	7.44	defgh	8.22	efgh
V4P2	4.56	a	5.56	bc	6.00	bc	6.22	bcd	7.33	defgh	7.89	cdef
V4P3	4.44	a	5.56	bc	6.22	bcde	6.33	bcde	7.33	defgh	8.33	efghi
V4P4	4.33	a	5.89	cdef	6.67	fg	7.11	fg	7.78	hijk	8.33	efghi
V4P5	4.33	a	6.11	ef	6.78	g	7.44	gh	7.44	defgh	8.44	fghi
V4P6	4.00	a	6.00	def	6.67	fg	7.33	gh	7.89	hijk	8.44	fghi
CV (%)	6.20		5.13		5.18		6.90		8.83		7.00	

Note. Means followed by the same letter in the same column are not significantly different based on the honestly significant difference test at the α 5% level; CV = Coefficient of variation; V1 = Bisi 18; V2 = Bisi 99; V3 = Pertiwi 6; V4 = Pertiwi 3; P0 = Control; P1 = 50 g/plant of granular biofertilizer; P2 = 100 g/plant of granular biofertilizer; P3 = 150 g/plant of granular biofertilizer; P4 = 50 ml/plant of liquid biofertilizer; P5 = 100 ml/plant of liquid biofertilizer; P6 = 150 ml/plant of liquid biofertilizer

Table 3
Stem diameter of four maize varieties under several biofertilizer treatments at 14 until 49 days after planting

Treatments	Average stem diameter, mm (days after planting)											
	14		21		28		35		42		49	
V1P0	4.06	a	6.37	a	11.49	a	13.54	a	13.72	a	14.84	a
V1P1	6.19	a	8.29	bc	13.43	bc	16.63	defgh	17.40	cdefg	17.99	a
V1P2	5.78	a	7.96	b	12.37	ab	14.94	ab	16.73	bcd	17.01	a
V1P3	6.09	a	9.09	bcde	14.19	cde	16.29	bcdef	17.76	defg	18.07	a
V1P4	5.33	a	9.04	bcde	13.67	bcd	16.01	bcde	16.88	bcd	17.49	a
V1P5	4.49	a	9.17	cde	13.49	bcd	16.41	cdefg	16.96	bcde	17.31	a
V1P6	5.11	a	9.68	defg	14.36	cde	16.23	bcdef	17.29	bcdef	17.11	a
V2P0	5.02	a	8.10	bc	13.79	bcd	15.52	bcd	16.00	bc	18.07	a
V2P1	5.92	a	8.93	bcd	14.66	cdef	18.40	ijkl	19.00	ghi	19.76	a
V2P2	5.44	a	9.68	defg	15.42	efg	19.14	klm	19.89	ijk	21.31	a
V2P3	6.58	a	10.34	fghi	13.67	bcd	17.72	hij	18.62	fghi	20.74	a
V2P4	5.03	a	9.01	bcde	17.26	hi	18.32	ijkl	19.52	hij	21.39	a
V2P5	5.79	a	9.74	defg	14.76	cdefg	18.99	jklm	21.09	jkl	21.19	a
V2P6	6.07	a	8.91	bcd	14.87	defg	16.62	defgh	17.74	defg	18.57	a
V3P0	5.42	a	8.92	bcd	15.57	efg	17.47	fghi	18.83	fghi	19.66	a
V3P1	6.56	a	10.76	ghi	18.92	j	20.80	no	21.16	kl	21.96	a
V3P2	6.88	a	11.97	j	18.84	j	20.89	no	21.22	kl	21.52	a
V3P3	6.82	a	10.94	hij	18.91	j	21.39	o	21.66	l	22.79	a
V3P4	6.22	a	10.71	ghi	18.78	j	20.62	no	20.97	jkl	21.37	a
V3P5	6.40	a	10.96	hij	18.67	ij	19.51	lmn	20.89	jkl	21.71	a
V3P6	6.34	a	11.42	ij	18.74	j	20.26	mno	21.90	l	22.66	a
V4P0	4.32	a	5.90	a	11.54	a	15.11	bc	15.68	ab	17.06	a
V4P1	5.02	a	9.21	cdef	14.66	cdef	17.83	hijk	18.27	defgh	18.56	a
V4P2	5.78	a	9.17	cde	14.82	cdefg	15.31	bcd	15.97	bc	17.62	a
V4P3	5.96	a	10.14	efgh	15.29	efg	15.69	bcd	17.29	bcdef	17.77	a
V4P4	6.19	a	10.38	ghi	12.54	ab	17.26	fghi	18.33	defghi	18.04	a
V4P5	5.78	a	10.47	ghi	16.06	fgh	17.16	fghi	18.51	efghi	18.87	a
V4P6	6.09	a	9.64	defg	16.17	gh	18.06	ijk	18.22	defgh	18.61	a
CV (%)	12.97		10.37		8.11		6.97		7.57		8.73	

Note. Means followed by the same letter in the same column are not significantly different based on the honestly significant difference test at the α 5% level; CV = Coefficient of variation; V1 = Bisi 18; V2 = Bisi 99; V3 = Pertiwi 6; V4 = Pertiwi 3; P0 = Control; P1 = 50 g/plant of granular biofertilizer; P2 = 100 g/plant of granular biofertilizer; P3 = 150 g/plant of granular biofertilizer; P4 = 50 ml/plant of liquid biofertilizer; P5 = 100 ml/plant of liquid biofertilizer; P6 = 150 ml/plant of liquid biofertilizer

The influence of biofertilizer application on several maize varieties was seen in cobs dry weight, cobs diameter, 100-grain weight, and tip filling (Table 4). Biofertilizer application also affected the ear weight and cob weight of several maize varieties (Figure 1). Bisi 99 showed the highest ear weight, cobs weight, and cobs dry weight, while Pertiwi 3 showed the highest 100-grain weight, cobs diameter, and tip filling, among other varieties. The dose between the two forms of biofertilizer similarly showed good performance on maize yield variables.

Maize (*Zea mays* L.) is a cereal crop that can be grown in various climatic conditions. Rhizobacteria isolated from holophytes were found to increase the vegetative growth parameters of maize under induced salinity (Aslam & Ali, 2018). Besides, rhizobacteria can increase plant growth in an area susceptible to nematodes. *Pseudomonas fluences* can significantly increase the growth of bitter melon plants that have been given the nematode *Renifom resinormis* (Humphries et al., 2021). Furthermore, Ali et al. (2022) reported that inoculation of *Enterobacter cloceae* could suppress the abiotic stress of maize and promote yield, fresh weight, dry weight, and leaf area of maize.

Apart from the ability to reduce the impact of biotic and abiotic stress, bacterial consortia in this study have also been proven to promote the growth and yield of maize. Kämpfer et al. (2016) stated that *Enterobacter* sp. can play an important role in improving plant growth. Some *Enterobacter* strains can play an important role in plant-microbial interactions in the biocontrol mechanism, wherein the results of the study showed that the treatment of granule biological fertilizers at a dose of 150 g/plant had the highest values in the parameters of dry weight and 100-grain weight. Mehta et al. (2015) also stated that the maize yield increases with the inoculation of *Pseudomonas fluences*. *Pseudomonas* sp. can also increase fruit length, root weight, and root length. *P. flurences* bacteria also have many roles in phosphate solubilization and the production of auxin and gibberellins. *Enterobacter* bacteria can act as a plant growth promoting (PGP) in rice and some maize strains (Toribio-Jiménez et al., 2017). Moreover, Devi et al. (2016) also reported that *S. marcescens* strain AL2-16 can produce indole acetic acid in a medium supplemented with l-tryptophan, solubilized inorganic phosphate, and gave positive results for ammonia production. Sutio et al. (2023) also highlighted the role of *S. marcescens* strain NPKC3_2_21 as P-solubilizing bacteria that enhance the availability of P by producing organic acids and entomopathogenic bacteria to insects, especially *Spodoptera litura*.

In summary, the application of biofertilizer significantly increased maize growth and yield compared to the control. The results confirmed that biofertilizers could contribute as a new cultivation practice for sustainable growth and productivity of grain crops. The rhizobacteria consortium had a positive impact on growth and yield variables; no antagonistic reactions were seen. The difference in the growth

Table 4
Yield observation of four maize varieties under several biofertilizer treatments

	Treatments	Cobs dry weight (g)		100-grain weight (g)		Cobs diameter (mm)		Tip filling (%)
Bisi 18	Control (P0)	116.78	a	32.83	a	42.93	a	95.00 c
	Granule 50 g (P1)	170.00	cdef	41.54	fg	48.76	efghi	96.89 cde
	Granule 100 g (P2)	163.67	cde	39.02	def	46.18	bcde	97.11 cde
	Granule 150 g (P3)	168.44	cdef	41.71	fg	46.07	bcde	97.22 cde
	Liquid 50 ml (P4)	156.44	bcd	38.26	def	45.59	abcd	97.56 de
	Liquid 100 ml (P5)	166.44	cdef	37.28	bcde	46.51	cdef	97.56 de
	Liquid 150 ml (P6)	135.56	ab	37.77	cdef	44.48	abc	95.78 cd
Bisi 99	Control (P0)	134.67	ab	33.50	ab	43.61	ab	92.11 b
	Granule 50 g (P1)	232.56	jkl	39.88	def	49.34	ghij	96.00 cd
	Granule 100 g (P2)	240.00	kl	35.93	abcd	49.37	ghij	97.22 cde
	Granule 150 g (P3)	227.56	jkl	36.16	abcde	49.03	fghi	97.22 cde
	Liquid 50 ml (P4)	248.45	l	37.12	bcde	50.06	hij	97.78 de
	Liquid 100 ml (P5)	206.89	ghij	33.85	abc	48.03	defghi	97.00 cde
	Liquid 150 ml (P6)	210.44	hij	33.41	ab	47.34	defgh	96.89 cde
Pertiwi 6	Control (P0)	129.67	ab	40.32	efg	44.29	abc	87.22 a
	Granule 50 g (P1)	187.56	efghi	49.91	ij	49.44	ghij	97.89 de
	Granule 100 g (P2)	182.00	cdefg	46.69	hi	48.73	efghi	97.56 de
	Granule 150 g (P3)	193.22	fghi	48.35	hij	48.53	efghi	97.33 cde
	Liquid 50 ml (P4)	155.22	bc	44.44	gh	46.76	cdefg	97.78 de
	Liquid 100 ml (P5)	155.78	bc	44.48	gh	47.06	cdefg	98.00 de
	Liquid 150 ml (P6)	163.11	cde	49.19	ij	47.48	defgh	97.89 de
Pertiwi 3	Control (P0)	171.33	cdef	39.85	def	46.90	cdefg	92.33 b
	Granule 50 g (P1)	213.56	ijk	54.74	l	54.30	l	97.89 de
	Granule 100 g (P2)	191.56	fghi	54.52	kl	53.11	kl	97.89 de
	Granule 150 g (P3)	167.56	cdef	48.55	hij	50.57	ijk	98.22 e
	Liquid 50 ml (P4)	171.56	cdef	50.56	ijkl	53.32	kl	98.44 e
	Liquid 100 ml (P5)	182.11	cdefg	50.75	ijkl	51.93	jkl	98.11 e
	Liquid 150 ml (P6)	183.44	defgh	51.38	jkl	52.03	jkl	97.89 de
CV (%)		13.13		8.51		5.05		2.18

Note. Means followed by the same letter in the same column are not significantly different based on the honestly significant difference test at the α 5% level; CV = Coefficient of variation; P0 = Control; P1 = 50 g/plant of granular biofertilizer; P2 = 100 g/plant of granular biofertilizer; P3 = 150 g/plant of granular biofertilizer; P4 = 50 ml/plant of liquid biofertilizer; P5 = 100 ml/plant of liquid biofertilizer; P6 = 150 ml/plant of liquid biofertilizer between maize varieties is due to the specific characteristics of each variety and its response to the application of rhizobacteria formulation. Generally, granular biofertilizers showed better performance in improving plant growth and yield compared to liquid biofertilizers. The 100-grain weight increased up to 37% compared to the control. The use of granular biological fertilizers provides practical implications and advantages for fertilization and distribution. Furthermore, the urge for more sustainable cultivation practices has led researchers worldwide to investigate the ability of rhizobacteria to enhance plant growth and yield. Different parameters should be examined, and the application procedure should be optimized to understand the activity of rhizobacteria on crop productivity and provide practical recommendations for supporting the agricultural field.

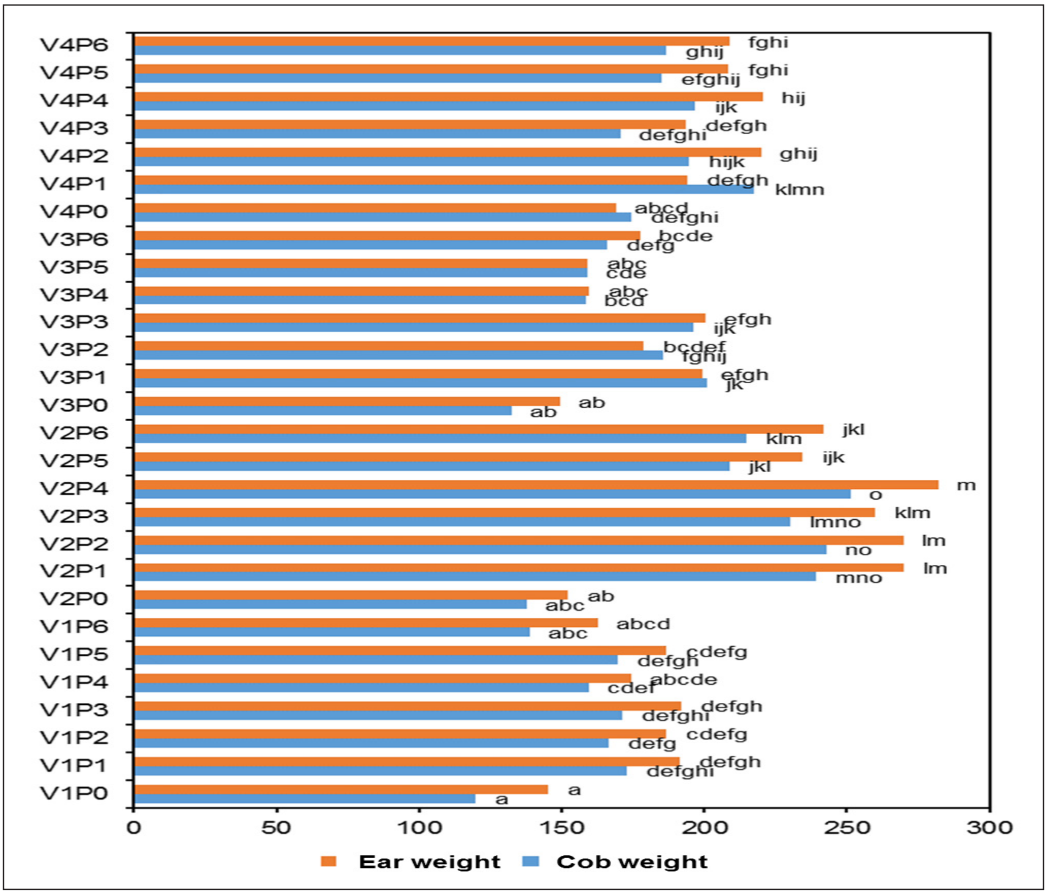

Figure 1. Ear weight and cob weight of four maize varieties under several biofertilizer treatments

Note. The bar charts followed by the same letter in the same color are not significantly different based on the honestly significant difference test at the α 5% level; V1 = Bisi 18; V2 = Bisi 99; V3 = Pertiwi 6; V4 = Pertiwi 3; P0 = Control; P1 = 50 g/plant of granular biofertilizer; P2 = 100 g/plant of granular biofertilizer; P3 = 150 g/plant of granular biofertilizer; P4 = 50 ml/plant of liquid biofertilizer; P5 = 100 ml/plant of liquid biofertilizer; P6 = 150 ml/plant of liquid biofertilizer

CONCLUSION

Maize varieties and biofertilizer doses significantly influenced the growth and yield of maize. The form and dose of fertilizer affected the growth and yield variables significantly, with the granule form at a dose of 150 g/plant showing the best growth (plant height, plant height, number of leaves, and stem diameter) and yield (ear weight and 100-grain weight) compared to control. Bisi 99 showed the best performance in growth and yield variables compared to other maize varieties. Further research is needed regarding phytohormone bioassays, changes in soil nutrient status, and efficacy against insects due to the application of biofertilizers. Moreover, the potential of rhizobacteria as a biofertilizer needs to be explored.

ACKNOWLEDGEMENTS

This research was funded by the National Research and Innovation Agency (BRIN), Deputy for National Research and Innovation Facilitation (Grant Number: 65/II.7/HK/2022). The authors also gratefully acknowledge the Research Team and Department of Agrotechnology, Faculty of Agriculture and Animal Science, University of Muhammadiyah Malang, for supporting this research.

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