The effect of biological fertilizer formulation on the growth and harvest yield of several corn (*Zea mays* L.) on dry land

Ali Ikhwan[1], *Ahmad* Naufal Kamil[1], Muhidin[1], and, Faridatul[1]

[1]Department of Agrotechnology, Faculty of Agriculture and Animal Science. University of Muhammadiyah Malang, 65144 Malang, East Java, Indonesia.

Abstract. Dry land is land whose water source depends on rainfall. The research location is in Singosari, which is considered dry land because it lacks a water source for irrigation. The purpose of this study was to determine the effect of varieties and formulations of biofertilizers on the growth and yield of corn plants, as well as to identify the interaction between different varieties and biofertilizer formulations on the growth and yield of corn plants. This research was conducted in Pakel Hamlet, Baturetno Village, Singosari District, with a land area of 1000 m^2. The implementation time of this research started from March 2024 to July 2024. This study used a Split Plot Design with the main plot being corn varieties (V) and subplots being the doses of granular and liquid biofertilizers (D). The combination of various treatments with the type of biofertilizer formulation showed significant interactions with several variables. Overall, the granular biofertilizer formulation showed higher results compared to the liquid formulation. The Pertiwi 6 variety tends to produce higher average yield variables compared to other varieties.

1 Introduction

Corn (Zea mays L.) is a crucial food crop in Indonesia and plays a strategic role in the national economy as a source of food, feed, and industrial raw materials [1]. Based on data from the Ministry of Agriculture, corn production in Indonesia reached 30.1 million tons, with an 11% increase in harvested area and a 1.42% increase in productivity. Corn is highly adaptable, growing in various soil types and altitudes, making it suitable for dryland areas. Indonesia's land area covers 191.1 million hectares, of which 144.5 million hectares, or 75.6%, are categorized as dryland.

Drylands rely on rainfall for irrigation. Agricultural drylands account for 86.24% of Indonesia's agricultural land [2]. During the rainy season, these soils are prone to erosion, while during the dry season, water scarcity limits crop productivity. To optimize land use under these conditions, efforts have been made to develop corn commodities on drylands using superior varieties such as Bisi 18, Bisi 99, Pertiwi 6, and Pertiwi 3. Additionally, the

*Corresponding Author: aliikhwan64@gmail.com

use of biofertilizers containing rhizobacteria has been promoted to enhance soil fertility and plant resilience against drought stress.

Biofertilizers have the advantage of increasing crop production with high enzyme activity and maintaining soil fertility sustainably. Biofertilizers are administered with the aim of not causing negative impacts on the environment because they do not pollute the environment. Biofertilizers are fertilizers containing a group of living microorganisms that are beneficial to plants. To improve soil fertility and plant quality, these microorganisms provide nutrients through biological activities that interact with the physical and chemical properties of the soil. Based on previous research, the application of biofertilizers contains microorganisms including *Serratia marcescens, Serratia nematodiphila, Raoultella terrigena, Enterobacter hormaechei, Enterobacter cloaceae, Citrobacter murliane, Psedomonas fluorences, and Enterobacter cancerogenous*. These microorganisms contribute significantly to soil function because they contain several secondary metabolites that can maintain soil quality and improve plant growth and health. Characterization of secondary metabolism of rhizobacteria has three potential functional compounds consisting of osmoprotectants, phytohormones, and organopesticides [3].

However, previous research has generally focused on a single form of biofertilizer or specific crop varieties under irrigated conditions. There is limited information on how different biofertilizer formulations (granular vs. liquid) interact with various corn varieties in dryland environments, where soil moisture and nutrient availability are limiting factors. Therefore, this study aims to fill this research gap by evaluating the effect and interaction of corn varieties and biofertilizer formulations on growth and yield performance under dryland conditions in Singosari, Indonesia. This novelty lies in comparing two distinct biofertilizer formulations, granular and liquid, on multiple corn varieties specifically adapted to rainfed drylands.

The aim of this study was to determine the effect of varieties and biofertilizer formulations on the growth and yield of corn plants, as well as to identify the interaction between different varieties and biofertilizer formulations on the growth and yield of corn plants.

2 Materials and Methods

2.1 Place and time

This research was conducted in Pakel Hamlet, Baturetno Village, Singosari District, with a land area of 1000 m^2. The research was conducted from March 2024 to July 2024.

2.2 Tools and Materials

The tools used are a 3 L capacity fermentor, Bunsen burner, matches, sterile syringes, 500 L capacity fermentor, a water bath, a *stainless steel stirrer*, a drill, a pH meter, a sterile gallon, a beaker, an analytical balance, a soldering iron, a cable tie, a meter, a *Leaf Area Meter*, sacks, a pickaxe, a hoe, a laptop, stationery, and documentation tools.

The materials used were corn seeds of the Bisi 18 variety, the Bisi 99 variety, the Pertiwi 6 variety, the Pertiwi 3 variety, bacterial stock, *Enterobacter hormaechei, Raoultella terrigena, Serratia marcescens, Enterobacter cloaceae, Serratia nematodiphila, Citrobacter murliane, Enterobacter cancerogenous, Psedomonas fluorences*, NB liquid media, red growmore, green growmore, molasses, sterile water, NaOH, alvaboard, bamboo, Petro urea fertilizer, Bluezeb 80 WP fungicide, Dumil 40 SP insecticide, Sidamethrin 50 EC insecticide, and Pajero *stick adhesive*.

2.3 Experimental design

Split Plot Design was used in this research experimental design with the main plots being corn varieties (V): Bisi 18 (V1), Bisi 99 (V2), Pertiwi 6 (V3), and Pertiwi 3 (V4), and subplots being the doses of granular and liquid biofertilizers (D): no dose treatment (D0), 50 g/plant granular biofertilizer dose (D1), 100 g/plant granular biofertilizer dose (D2), 150 g/plant granular biofertilizer dose (D3), 50 ml/plant liquid biofertilizer dose (D4), 100 ml/plant liquid biofertilizer dose (D5), and 150 ml/plant liquid biofertilizer dose (D6). So there were 28 treatment plots. Data were analyzed using a three-way analysis of variance, and the 5% HSD test was used to determine whether there was a significant effect.

2.4 Bacterial multiplication

Bacterial propagation was carried out using a 3 L fermentor with NB medium. Bacterial propagation was carried out aseptically. The fermentor was left running for 72 hours, and the bacterial isolate was ready for use.

2.5 Liquid biofertilizer production

This was done by multiplying bacteria using a 500 L fermenter. The media composition used was 200 g/200 L red growmore, 200 g/200 L green growmore, 20 L/200 L molasses, and 2.5 L of the propagated bacteria. The fermenter was left running for 72 hours with the pump running for 2 hours and the pump off for 1 hour to rest.

2.6 Granular biofertilizer production

This is done using a 2.5 m diameter granulator. The composition used in the granulation process is 20 kg of material consisting of 20 kg of charcoal. The granulation process involves inserting bacteria with a density of $1x10^9$, which is sprayed into the granulation machine using a sprayer. Inserting solid material into the granulation machine, then spraying the bacteria slowly so that the raw material turns into granules.

2.7 Land preparation

Land preparation includes soil cultivation and bed construction. Plant corn seeds according to the treatment plots with a spacing of 70 x 20 cm.

2.8 Plant maintenance

Plant maintenance includes spraying insecticides and fungicides, and applying liquid biofertilizer at 14 and 48 days after planting according to the treatment dosage.

2.9 Observation

Observations were conducted during the vegetative to early generative phases and post-harvest. The variables observed in this study included the number of leaves, plant height, stem diameter, age of male and female flowers, weight of husked cobs, leaf area, number of rows on the cob, length of husked cobs, diameter of unhusked cobs, weight of unhusked cobs, length of unhusked cobs, weight of dry cobs, corn filling level, and weight of 100 corn kernels.

3 Results and Discussion

3.1 Result

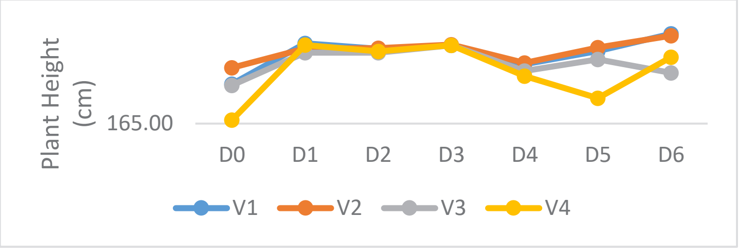


Fig. 1. Graph of interaction between varieties and biological fertilizers on plant height at observation age 49 DAP, **D0**: no treatment, **D1**: dose of granular organic fertilizer 50 g/plant, **D2**: dose of granular organic fertilizer 100 g/plant, **D3**: dose of granular organic fertilizer 150 g/plant, **D4**: dose of liquid organic fertilizer 50 ml/plant, **D5**: dose of liquid organic fertilizer 100 ml/plant, D6: dose of liquid organic fertilizer 150 ml/plant, **V1**: Bisi 18, **V2**: Bisi 99, **V3**: Pertiwi 6, **V4**: Pertiwi 3.

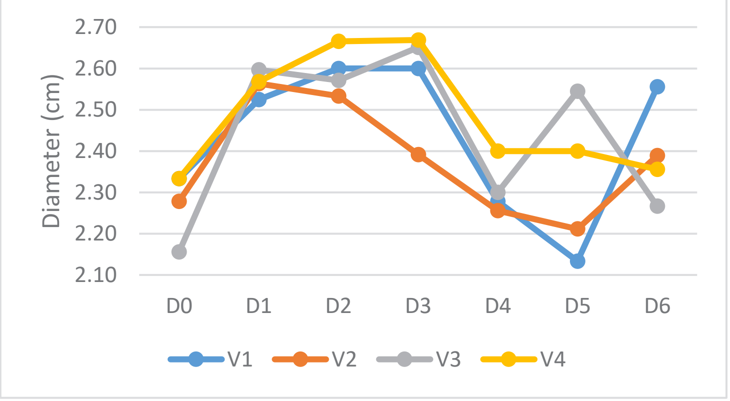


Fig. 2. Graph of interaction between varieties and biological fertilizers on plant diameter at observation age of 35 DAP, **D0**: no treatment, **D1**: dose of granular biological fertilizer 50 g/plant, **D2**: dose of granular biological fertilizer 100 g/plant, **D3**: dose of granular biological fertilizer 150 g/plant, **D4**: dose of liquid biological fertilizer 50 ml/plant, **D5**: dose of liquid biological fertilizer 100 ml/plant, **D6**: dose of liquid biological fertilizer 150 ml/plant, **V1**: Bisi 18, **V2**: Bisi 99, **V3**: Pertiwi 6, **V4**: Pertiwi 3.

Table 1. Results of the average stem diameter test of corn plants aged 28 DAP, 42 DAP and 49 DAP

Treatment	Average number of leaves (blades)		
Dose	**28 DAP**	**42 DAP**	**49 DAP**
D0 (control)	1.83 a	2.56 a	2.63 a
D1 (50 g granules/plant)	1.62 a	3.12 a	3.18 c
D2 (100 g granules/plant)	1.66 a	3.14 b	3.20 c
D3 (150 g granules/plant)	1.68 a	3.11 b	3.19 c
D4 (liquid 50 ml/plant)	1.77 a	2.56 a	2.76 a
D5 (liquid 100 ml/plant)	1.89 b	2.66 a	2.71 a
D6 (liquid 150 ml/plant)	1.93 b	2.58 b	2.82 b
HSD 5%	**0.03**	**0.02**	**0.03**

Notes: The average value followed by the same letter in the same column indicates that the treatment is not significantly different based on HSD at the 5% level.

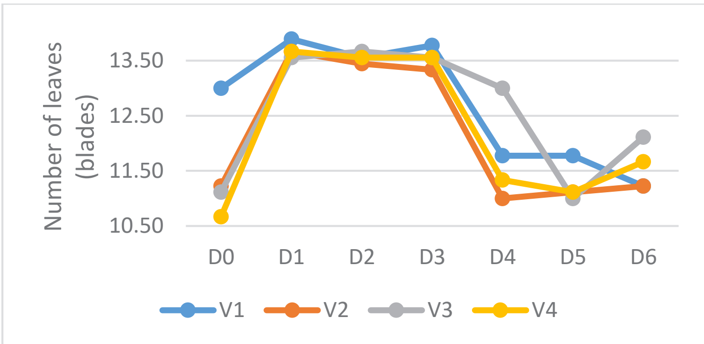


Fig. 3. Graph of interaction between varieties and biological fertilizers on the number of leaves at observation age of 49 DAP, **D0** : no treatment, **D1** : dose of biological fertilizer granules 50 g/plant, **D2** : dose of biological fertilizer granules 100 g/plant, **D3** : dose of biological fertilizer granules 150 g/plant, **D4** : dose of liquid biological fertilizer 50 ml/plant, **D5** : dose of liquid biological fertilizer 100 ml/plant, **D6** : dose of liquid biological fertilizer 150 ml/plant, **V1** : Bisi 18, **V2** : Bisi 99, **V3** : Pertiwi 6, **V4** : Pertiwi 3.

Table 2. Results of the average number of leaves of corn plants aged 21 DAP and 42 DAP

Treatment	**Average number of leaves (blades)**	
Dose	**21 DAP**	**42 DAP**
D0 (control)	6.86 b	11.08 a
D1 (50 g granules/plant)	6.64 b	12.36 b
D2 (100 g granules/plant)	6.75 b	12.64 b
D3 (150 g granules/plant)	6.11 a	12.89 c
D4 (liquid 50 ml/plant)	6.69 b	11.67 a
D5 (liquid 100 ml/plant)	6.64 a	12.06 a
D6 (liquid 150 ml/plant)	7.11 b	12.56 b
HSD 5%	**0.50**	**0.52**
Variety		
V1 (Bisi 18)	6.97 ns	12.29 ns
V2 (Bisi 99)	6.71 ns	12.19 ns
V3 (Pertiwi 6)	6.48 ns	12.08 ns
V4 (Pertiwi 3)	6.48 ns	12.16 ns

Notes: The average value followed by the same letter in the same column indicates that the treatment is not significantly different based on HSD at the 5% level.

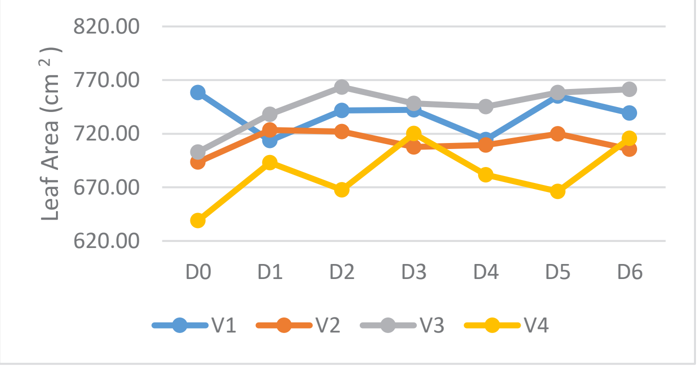


Fig. 4. Graph of interaction between varieties and biological fertilizers on leaf area at observation age of 49 DAP. **D0** : no treatment, **D1** : dose of granular biological fertilizer 50 g/plant, **D2** : dose of granular biological fertilizer 100 g/plant, **D3** : dose of granular biological fertilizer 150 g/plant, **D4** : dose of liquid biological fertilizer 50 ml/plant, **D5** : dose of liquid biological fertilizer 100 ml/plant, **D6** : dose of liquid biological fertilizer 150 ml/plant, **V1** : Bisi 18, **V2** : Bisi 99, **V3** : Pertiwi 6, **V4** : Pertiwi 3.

Table 3. Results of the average leaf area test for corn plants aged 21 DAP and 42 DAP

Treatment	**Average leaf area (cm ²)**	
Variety	**21 DAP**	**42 DAP**
V1 (Bisi 18)	96.12 b	705.84 b
V2 (Bisi 99)	97.80 b	713.09 b
V3 (Pertiwi 6)	84.77 a	685.07 a
V4 (Pertiwi 3)	94.54 b	636.08 a
HSD 5%	**1.66**	**9.75**
Dose		
D0 (control)	86.48 ns	690.78 ns
D1 (50 g granules/plant)	88.47 ns	682.08 ns
D2 (100 g granules/plant)	95.69 ns	695.58 ns
D3 (150 g granules/plant)	95.21 ns	678.72 ns
D4 (liquid 50 ml/plant)	88.16 ns	682.36 ns
D5 (liquid 100 ml/plant)	98.72 ns	688.83 ns
D6 (liquid 150 ml/plant)	100.45 ns	676.81 ns

Notes: The average value followed by the same letter in the same column indicates that the treatment is not significantly different based on HSD at the 5% level.

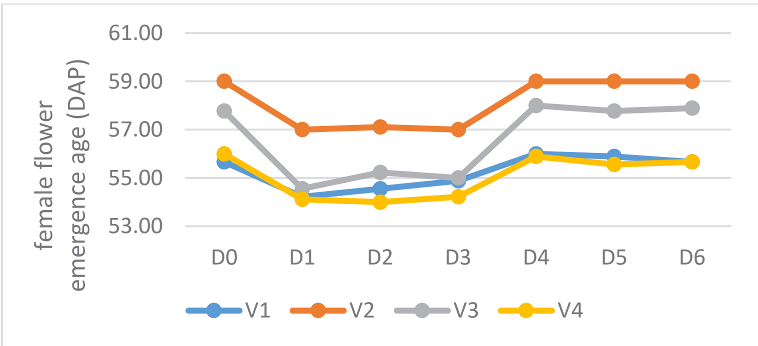
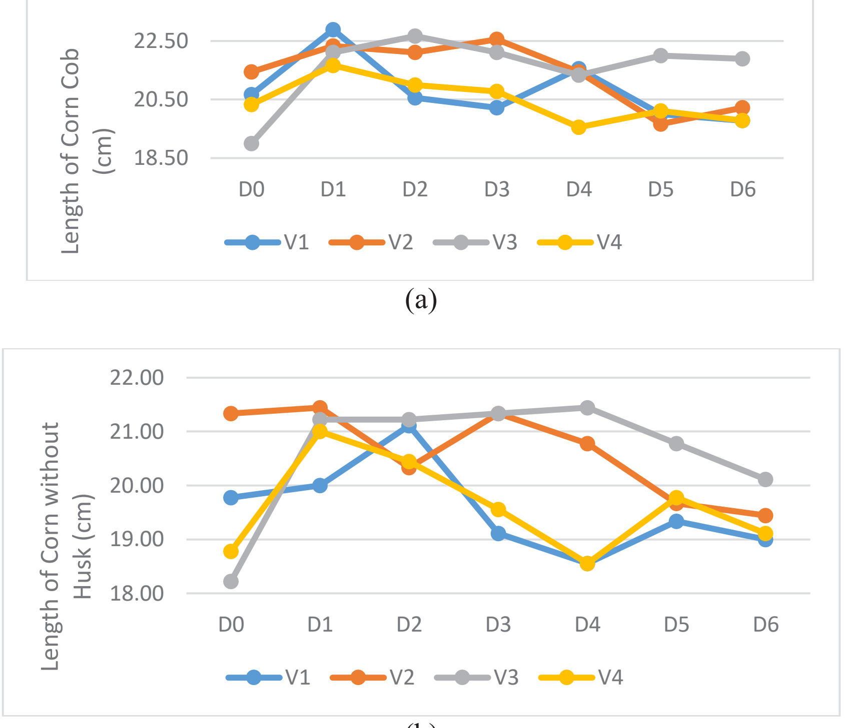


Fig. 5. Graph of the interaction between varieties and biological fertilizers on the age of female flower emergence. **D0** : no treatment, **D1** : dose of granular biological fertilizer 50 g/plant, **D2** : dose of granular biological fertilizer 100 g/plant, **D3** : dose of granular biological fertilizer 150 g/plant, **D4** : dose of liquid biological fertilizer 50 ml/plant, **D5** : dose of liquid biological fertilizer 100 ml/plant, **D6** : dose of liquid biological fertilizer 150 ml/plant, **V1** : Bisi 18, **V2** : Bisi 99, **V3** : Pertiwi 6, **V4** : Pertiwi 3.

Table 4. Average test results age of emergence of male flowers in corn plants (DAP)

Treatment	Average age of male flower emergence (DAP)
Variety	
V1 (Bisi 18)	53.00 a
V2 (Bisi 99)	55.57 b
V3 (Pertiwi 6)	52.46 a
V4 (Pertiwi 3)	53.06 a
HSD 5%	**0.40**
Dose	
D0 (control)	54.36 b
D1 (50 g granules/plant)	52.72 a
D2 (100 g granules/plant)	53.25 a
D3 (150 g granules/plant)	51.50 a
D4 (liquid 50 ml/plant)	54.22 b
D5 (liquid 100 ml/plant)	54.31 b
D6 (liquid 150 ml/plant)	54.31 b
HSD 5%	**0.48**

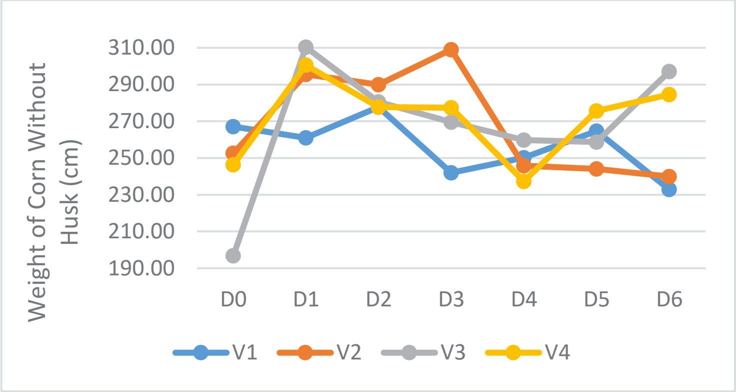
Notes: The average value followed by the same letter in the same column indicates that the treatment is not significantly different based on HSD at the 5% level.



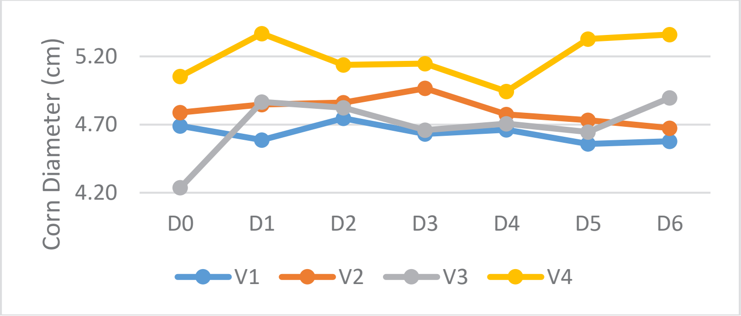
(a)

(b)

Fig. 6. Graph of interaction between varieties and biofertilizers on harvest yield, **(a)** length of cob with husk, **(b)** length of cob without husk. **D0** : no treatment, **D1** : dose of granular biofertilizer 50 g/plant, **D2** : dose of granular biofertilizer 100 g/plant, **D3** : dose of granular biofertilizer 150 g/plant, **D4** : dose of liquid biofertilizer 50 ml/plant, **D5** : dose of liquid biofertilizer 100 ml/plant, **D6** : dose of liquid biofertilizer 150 ml/plant, **V1** : Bisi 18, **V2** : Bisi 99, **V3** : Pertiwi 6, **V4** : Pertiwi 3.



(a)



(b)

Fig. 7. Graph of interaction between varieties and biofertilizers on harvest yield, **(a)** weight of cob without husk, **(b)** diameter of cob without husk. **D0** : no treatment, **D1** : dose of granular biofertilizer 50 g/plant, **D2** : dose of granular biofertilizer 100 g/plant, **D3** : dose of granular biofertilizer 150 g/plant, **D4** : dose of liquid biofertilizer 50 ml/plant, **D5** : dose of liquid biofertilizer 100 ml/plant, **D6** : dose of liquid biofertilizer 150 ml/plant, **V1** : Bisi 18, **V2** : Bisi 99, **V3** : Pertiwi 6, **V4** : Pertiwi 3.

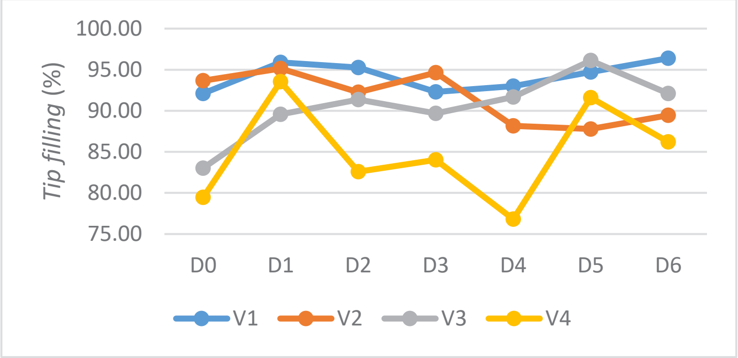


Fig. 8. Graph of interaction between varieties and biofertilizers on *Tip filling* harvest yields. **D0** : without treatment, **D1** : dose of granular organic fertilizer 50 g/plant, **D2** : dose of granular organic fertilizer 100 g/plant, **D3** : dose of granular organic fertilizer 150 g/plant, **D4** : dose of liquid organic fertilizer 50 ml/plant, **D5** : dose of liquid organic fertilizer 100 ml/plant, **D6** : dose of liquid organic fertilizer 150 ml/plant, **V1** : Bisi 18, **V2** : Bisi 99, **V3** : Pertiwi 6, **V4** : Pertiwi 3.

Table 5. Average test results for the weight of cob with husk and the weight of 100 grains

Treatment	Weight of corn cob with husk (g)	Weight of 100 grains (g)
Variety		
V1 (Bisi 18)	279.84 a	31.56 a
V2 (Bisi 99)	297.36 b	31.12 a
V3 (Pertiwi 6)	296.94 b	35.00 b
V4 (Pertiwi 3)	294.62 b	33.97 b
HSD 5%	**3.77**	**0.48**
Dose		
D0 (control)	278.52 a	27.62 a
D1 (50 g granules/plant)	320.24 c	36.39 c
D2 (100 g granules/plant)	312.20 b	35.78 b
D3 (150 g granules/plant)	295.81 b	33.56 b
D4 (liquid 50 ml/plant)	273.98 a	30.09 a
D5 (liquid 100 ml/plant)	275.51 a	32.40 b
D6 (liquid 150 ml/plant)	289.08 a	34.55 b
HSD 5%	**16.65**	**0.80**

Notes: The average value followed by the same letter in the same column indicates that the treatment is not significantly different based on HSD at the 5% level.

Table 6. Results of the average dry weight test without husk and the number of rows

Treatment	Dry weight without seams (g)	Number of rows
Variety		
V1 (Bisi 18)	176.29 ns	15.75 ns
V2 (Bisi 99)	179.90 ns	15.86 ns
V3 (Pertiwi 6)	174.42 ns	15.87 ns
V4 (Pertiwi 3)	179.74 ns	15.87 ns
Dose		
D0 (control)	184.80 b	15.36 a
D1 (50 g granules/plant)	162.25 a	15.69 a
D2 (100 g granules/plant)	164.19 a	16.08 b
D3 (150 g granules/plant)	161.09 a	16.67 c
D4 (liquid 50 ml/plant)	184.81 b	15.11 a
D5 (liquid 100 ml/plant)	191.59 b	15.81 b
D6 (liquid 150 ml/plant)	194.83 b	16.14 b
HSD 5%	**3.11**	**0.14**

Notes: The average value followed by the same letter in the same column indicates that the treatment is not significantly different based on HSD at the 5% level.

3.2 Discussion

3.2.1 Plant Height

The results of the analysis of plant height variance showed a significant interaction between plant varieties and biofertilizer formulas at the observation ages of 28 DAP, 42 DAP, and 49 DAP. The average plant height is shown in Figure 1. Based on Figure 1. At the age of 49 DAP, the V1D6 treatment (Bisi 18, Liquid biofertilizer dose 150 ml/plant) had the highest value with a value of 207.67 cm, while the lowest value was in the V4D0 treatment (Pertiwi 3, No treatment). The differences between formulations indicate that the granular biofertilizer provided a more stable nutrient supply compared to the liquid formulation. Granular formulations tend to release nutrients gradually, improving root zone microbial activity and nutrient absorption throughout the growth period. In contrast, the liquid formulation may provide faster but shorter nutrient availability, resulting in less consistent growth.

Regarding dosage, the 150 ml/plant (liquid) and 100 g/plant (granular) treatments produced the tallest plants, suggesting that higher microbial density in these doses enhanced nitrogen fixation and phytohormone production. However, excessive doses did not always improve growth, indicating that nutrient and microbial balance are critical for optimal plant height.

3.2.2 Stem diameter

The results of the stem diameter analysis showed a very real interaction between the variety and the formulation of biofertilizer at the observation ages of 21 DAP and 35 DAP; the dose treatment (D) provided a very real interaction on the stem diameter at the ages of 28 DAP, 42 DAP, and 49 DAP.

At 21 days after planting, the highest value was shown in the V1D1 treatment (Bisi 18, granular biofertilizer dose 50 g/plant) with an average value of 1.14, this was significantly different from V4D3 (Pertiwi 3, granular biofertilizer dose 150 g/plant) which had the lowest value, while at 35 days after planting, the highest average was in the V4D3 treatment (Pertiwi 3, granular biofertilizer dose 150 g/plant). The application of biological fertilizers will affect the nutrients in plants, especially in the rhizosphere. The quality of nutrients significantly affects the growth and development of plant roots, as well as the ability of roots to absorb nutrients. Vegetative plant growth is greatly influenced by a good root system, which in turn determines the reproductive phase and crop yield. The increase in stem size is caused by cell division assisted by good vegetative growth [4].

Based on Table 1 shows the highest average is in the D6 treatment (150 ml liquid/plant) At the age of 28 DAP this is not significantly different from the D5 treatment (100 ml liquid/plant), while the highest average is in D5 (100 ml liquid/plant) at the age of 42 DAP, and D2 (100 g granules/plant) at the age of 49 DAP. The greater the dose of biofertilizer, the greater the microbial population. One of the microbes contained in fertilizer is *Pseudomonas fluorescens.* The quality of plant growth can be improved by bacteria by producing growth hormones, nitrogen fixation ability to increase the amount of nitrogen available in the soil, osmolyte producers act as osmoprotectants during drought stress, and certain compounds that play a role in killing plant pathogens so that plants can produce optimal amounts [5].

The interaction between formulation and dosage significantly affected stem thickness. Granular formulations generally produce thicker stems due to their sustained nutrient release and higher microbial stability in the root zone. The liquid formulation, while effective in early growth, tended to decrease in performance at later stages as nutrients became less available.

The optimal dosage was observed at 100 g/ g/plant for the granular form and 100 ml/plant for the liquid form. These dosages provided adequate microbial density and nutrient concentration, improving cell division and lignification in stem tissues. Excessive doses, such as 150 g or 150 ml, did not increase the diameter further, indicating nutrient saturation effects.

3.2.3. Number of leaves

Analysis of the variety and formulation of biofertilizer showed that there was no significant interaction (ns) on the number of leaves at 14 DAP ; the combination of variety treatment and dosage of biofertilizer formulation showed a very significant interaction on the number of leaves at 28 DAP, 35 DAP, and 49 DAP ; and the formulation treatment of biofertilizer dosage (D) showed a significant interaction on the number of leaves at 21 DAP and 42 DAP. Based on **Figure 3** the highest average result was in the V3D5 treatment (Pertiwi 6, Liquid biofertilizer dosage 100 ml/plant) at the age of 28 DAP with a value of 10.11 strands. While the highest average was in the V2D5 treatment (Bisi 99, Liquid biofertilizer dosage 100 ml/plant) at the age of 35 DAP, with a value of 11.78. And at the age of 49 DAP, the highest value was in the V1D1 treatment (Bisi 18, Granular biofertilizer dosage 50 g/ g/plant) with an average of 13.89 strands.

Some of the bacteria used in this biofertilizer are *Pseudomonas fluorescens, Serratia marcescens,* and *Enterobacter.* This increase in leaf number is due to the ability of these bacteria to fix N from the air and fertilizer. These bacteria are able to supply the plant's need for N (Alfajri, 2022). If plants have available nutrients, their growth will increase. Increased photosynthesis with nutrients and the administration of PGPR improve overall plant growth. Optimal photosynthesis will result in an increase in leaf number in corn plants [6].

Based on table 2. At the age of 21 DAP, the D6 treatment (150 ml liquid/plant) had the highest average, which was significantly different from the D3 treatment (150 g granules/plant) and D5 (100 ml liquid/plant). The highest average number of leaves at the age of 42 DAP was in the D3 treatment (150 g granules/plant). The application of biofertilizer with a dose of 150 ml/plant had the highest value, this is comparable to the research [7] that the administration of higher PGPR concentrations is thought to increase the PGPR microbial population, thereby helping plants. The higher the concentration of PGPR administration, the greater the effect on the number of plant leaves.

The number of leaves was influenced by both formulation and dosage levels. The granular biofertilizer supported a higher leaf count, likely due to its prolonged nitrogen supply, which is essential for chlorophyll synthesis and vegetative development. Liquid biofertilizers showed faster but short-lived effects, increasing early leaf emergence but not maintaining consistent growth.

The 100 g and 150 ml dosages yielded the highest leaf counts, indicating that microbial populations at these levels were sufficient to enhance photosynthetic activity. Lower doses (50 g or 50 ml) produced fewer leaves due to limited microbial inoculum and nutrient support.

3.2.4. Leaf area

The results of the analysis of the variety treatment variance had an effect on leaf area at 21 DAP and 42 DAP, at 35 DAP, it gave an insignificant interaction (ns), while the variety treatment with the biofertilizer formulation gave a very significant interaction on leaf area at 49 DAP. Based on **Figure 4** at 49 DAP, the V3D2 treatment (Pertiwi 6, Granular biofertilizer dosage 100 g/plant) had the highest average yield with a value of 763.44 cm^2, while the V4D0 treatment (Pertiwi 3, Without dosage treatment) had the lowest average with a value of 639.00 cm^2. This shows that the administration of biofertilizer with this dosage has a significant effect on leaf area, where leaf area also affects plant growth. Akerina [8] stated. The rate of photosynthesis is influenced by leaf area; the more leaves that can help the photosynthesis process, the more plant production.

Based on **Table 3**, at the age of 21 DAP, the highest average value was shown in the V2 treatment (Bisi 99), which was not significantly different from the V1 treatment (Bisi 18) and V4 (Pertiwi 3). Meanwhile, at the age of 42 DAP, the highest value was also found in the V2 treatment (Bisi 99) and was not significantly different from the V1 treatment (Bisi

18). The results show that V1 and V2 have relatively the same leaf area in growth and have no significant effect on leaf area growth, this is due to the genetic factors of each variety which tend to be different.

The leaf area showed a similar trend, where the granular formulation promoted wider leaf expansion. The stable release of macro- and micronutrients from the granules encouraged prolonged photosynthetic activity and cell enlargement. Liquid biofertilizers, while beneficial in early stages, might have lost microbial effectiveness due to rapid nutrient washout in dryland conditions.

Among the dosages, 100 g/plant of granular and 100 ml/plant of liquid formulation resulted in the largest leaf areas, suggesting an optimal microbial balance for growth regulation. Extremely high dosages did not increase leaf area further, likely due to limited oxygen diffusion in the rhizosphere.

3.2.5. The age at which female and male flowers appear

The results of the analysis of the variety of varieties and biofertilizer formulations showed a very real interaction on the emergence of female flowers, while the variety (V) and dose (D) treatments had a very real effect on the age of male flower emergence. Based on **Figure 7**, it can be seen that the treatment that has the fastest average flower emergence is the V4D2 treatment (Pertiwi 3, Granular biofertilizer dose 100 g/plant), this is also not significantly different from the V4D1 treatment (Pertiwi 3, Granular biofertilizer dose 50 g/plant), V1D1 (Bisi 18, Granular biofertilizer dose 50 g/plant), V4D3 (Pertiwi 3, Granular biofertilizer dose 150 g/plant), V1D2 (Bisi 18, Granular biofertilizer dose 100 g/plant), V3D1 (Pertiwi 6, Granular biofertilizer dose 50 g/plant).

This is because the nutrients produced from granular biofertilizer respond to flower growth. This aligns with [9] opinion that environmental and genetic factors influence plant growth. This is because when a plant flowers, high temperatures and sufficient water are needed to aid pollination, which accelerates flower emergence.

According to the results of Table 4, the age variety treatment with the fastest flowering was V3 (Pertiwi 6), with an average of 52.46, not different from treatments V1 (Bisi 18) and V4 (Pertiwi 3). On the other hand, the dose treatment with the highest value was D0 (control), which was not different from the other treatments. The absence of interaction between variety and dose was caused by the transition of the growth phase from the vegetative stage to the generative stage, marked by the appearance of male flowers. In addition to being determined by environmental factors, it was also determined by the genetic factors of the plant itself [10].

The appearance of male and female flowers was affected by formulation and dosage. Granular formulations generally accelerate flowering because of their steady nutrient release and hormonal stimulation from rhizobacteria. Liquid formulations tended to delay flowering slightly, possibly due to inconsistent nutrient availability.

The 100 g/plant and 50 ml/plant treatments were found to promote earlier flower initiation, reflecting efficient nutrient utilization. Higher dosages did not shorten flowering age further, which suggests that hormonal equilibrium is more critical than nutrient concentration for this stage.

3.2.6. Corn harvest results

The results of the analysis of the variety variation and the formulation of the biofertilizer dosage showed a significant interaction on the parameters of the weight of the cob without the husk, the length of the cob without the husk, the length of the cob with the husk, *tip filling*, and the diameter of the cob. Meanwhile, the results of the analysis of the variety treatment variation (V) and the dosage of the biofertilizer (D) had a significant effect on the weight of the cob with the husk, the weight of 100 grains, the dry weight and the number of rows.

The highest value of cob length with husk was in the V3D1 treatment (Pertiwi 6, Dose of granular biofertilizer 50 g/plant) with an average of 22.89 cm, while the highest average length of cob without husk was in the V3D4 treatment (Pertiwi 6, Dose of liquid biofertilizer 50 ml/plant) with a value of 21.44 cm. One of the uses of bacteria contained in biofertilizer is to increase the nitrogen element. In this case, the N element combines nucleic acid, protein, chlorophyll, and other organic materials. Photosynthesis is influenced by chlorophyll, which can produce stored carbohydrates that affect the parameters of corn cobs [11].

Both cob length parameters were positively affected by granular formulations. Granular biofertilizer treatments produced longer cobs because the steady nutrient supply improved kernel development. Liquid formulations contributed to faster initial growth but did not maintain cob elongation at later stages.

The best results were obtained at 50–100 g/plant (granular) and 100 ml/plant (liquid). These doses provided balanced nutrient uptake and optimal microbial activity for reproductive growth. Doses above 150 g or 150 ml did not enhance cob length, suggesting diminishing returns from excess microbial inoculum.

The results of Figure 7 show that the highest average weight of cobs without husks was in the V3D1 treatment (Pertiwi 6, Granular biofertilizer dose 50 g/plant) with a value of 310.35 grams, while the highest average cob diameter was in the V4D1 treatment (Pertiwi 3, Granular biofertilizer dose 50 g/plant) with a value of 5.37 cm. The decomposition process will be assisted by biofertilizers in the soil. Various nutrients in the soil will be gradually released, especially nitrogen and phosphorus compounds. This process will also benefit the chemical and biological properties of the soil, one of which is providing nutrients to plants and helping to increase the soil's ability to retain water [12].

The results of Figure 8 show that the highest average was in the V1D6 treatment (Bisi 18, Liquid biofertilizer dosage 150 ml/plant) with a value of 96.39%. This proves that the application of liquid biofertilizer at a dosage of 150 ml/plant provides good results on the tip filling parameter. According to [13], with the right dosage of organic fertilizer, the function of the organic material provided can also be optimized. This includes maintaining water availability by increasing the stability of the soil to bind water, which indirectly impacts the filling of kernels in corn cobs.

Granular formulations significantly improved cob diameter and kernel filling compared to liquid treatments. The higher microbial stability in granular biofertilizers ensured consistent nutrient supply during the grain-filling phase. The liquid formulation was less effective in maintaining nutrient delivery, resulting in lower kernel density.

The 100 g/plant granular and 150 ml/plant liquid doses gave the best results for cob diameter and tip filling. These dosages supported optimal root–microbe interactions, leading to efficient nutrient translocation and starch accumulation in kernels.

The results of **Table 5 s**how that the highest average treatment of corn cob weight varieties is in treatment V2 (Bisi 99), this is significantly different from treatment V1 (Bisi 18), this is not significantly different from treatment V4 (Pertiwi 3). While the highest average weight of 100 grains is in treatment V3 (Pertiwi 6). In the dose factor treatment, the highest average value of corn cob weight is in treatment D1 (50 g granule/plant) as well as in the parameter of 100 grain weight, the highest average value is in treatment D1 (50 g granule/plant). Genetic factors of corn plant varieties determine the weight of 100 grains of corn. According to [14], The direct influence of genes, which determine the number of rows of corn plants, is one of two categories of factors that influence growth : external (environmental) and internal (genetic) factors.

Granular formulations produced heavier cobs and 100-grain weights than liquid formulations, indicating better nutrient assimilation throughout the growing season. The sustained microbial activity in the granular form promoted stronger root systems and enhanced carbohydrate translocation to grains.

The 50–100 g/plant (granular) and 100 ml/plant (liquid) doses gave the best yield results. Lower doses lacked sufficient microbial biomass, while higher ones may have caused nutrient competition and reduced efficiency.

The results of the study showed that the application of biofertilizer had a significant effect, comparable to the study, which found that the application of PGPR increased the weight of the cob. This is because PGPR bacteria can indirectly provide iron, potassium, phosphate, sulfur, and nitrogen ions to the plant. If the plant has these nutrients, its growth will increase.

Based on table 6. The highest average dry weight without husk was in the D6 treatment (150 ml liquid/plant), while for the number of rows in the D3 treatment (150 ml Granule/plant) had the highest value. This shows that the administration of biofertilizer with this dose has an effect on the dry weight of the cob and the number of rows. One of the nutrients produced from the administration of biofertilizer is the P nutrient, where this element is very influential in the formation of seeds, according to [15] Corn yields are able to be optimal because of the availability of the right nutrients, When the P nutrient is found in large quantities, it is given to the reproductive part, namely the seeds.

The dry cob weight and number of rows were influenced by formulation and dosage. Granular biofertilizers improved both parameters by maintaining microbial stability and nutrient availability until harvest. Liquid biofertilizers showed moderate improvements, mainly at higher doses.

The highest dry cob weight was observed at 150 ml (liquid) and 100 g (granular) doses, while the largest number of rows was achieved with 150 g granular fertilizer. These results emphasize that optimal formulation and dosage combinations can maximize reproductive potential in corn grown under dryland conditions.

4 Conclusion

Based on the research results, there was a significant interaction between plant varieties and biofertilizer formulations on the parameters of plant height, stem diameter, number of leaves, leaf area, age of female flower emergence, length of cob with husk, length of cob without husk, weight of cob without husk, diameter of cob without husk, and level of cob filling. Granular biofertilizer formulations showed higher yields compared to liquid formulations. Pertiwi 6 varieties tended to produce higher average yield variables compared to other varieties.

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