The role of vermicompost and PGPR on growth and formation of bulbils shallot (Allium cepa L. Aggregatum)

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Abstract. One of the effects of climate change is a decrease in land productivity and subsequently causes a decrease in crop production. The decrease in land quality will be higher with the use of inorganic fertilizers. Alternative solutions to these problems are the use of vermicompost fertilizers and PGPR. The aim of this research was to examine the role of Vermicompost fertilizers and PGPR on the growth and formation of bulb tubers. The research design used Randomized Complete Block Design (RCBD) with 2 factors, the first factor was Vermicompost (5 tons ha⁻¹, 10 tons ha⁻¹, 15 tons ha⁻¹, 20 tons ha⁻¹), the second factor was PGPR (with PGPR and without PGPR), repeated as many as 3 times. The results showed that the combination of Vermicompost and PGPR significantly affected the number of bulbils, the combination of vermicompost 5 tons ha⁻¹ + with PGPR produced the highest bulbils. Vermicompost and PGPR had no significant effect on plant height, net assimilation rate, fresh weight, bulb weight, number of bulbils, and number of bulbs. There was no significant interaction between the treatment of vermicompost and PGPR on plant height, net assimilation rate, fresh weight, bulb weight, a number of bulbs.

1. Introduction

Shallots (Allium ascalonicum L.) are vegetable commodities that have high economic value and have many benefits. This causes the consumption of shallots for the population of Indonesia in 2018 to be quite high, reaching an average of 2.56 kg per capita year⁻¹. However, shallot production is currently still concentrated in several provinces. Some of the main shallot-producing provinces include Central Java, East Java, West Nusa Tenggara, West Java, South Sulawesi and West Sumatra. The growth of shallot production in 2017 has decreased compared to 2016 [1]. Production reduction is due to climate change and land productivity. This is because land productivity is highly dependent on climate change. Excessive use of inorganic fertilizers can harden the soil and reduce soil fertility due to reduced soil microbial diversity [2].

The use of organic fertilizers can be an effort to maintain soil fertility and health. Organic fertilizers can improve physical properties, namely decreasing sodicity, decreasing density, water infiltration rate, increasing porosity and aeration, increasing brine washing and chemical properties, namely decreasing acidity, increasing carbon content, soil nitrogen, and biological properties that help the growth of macro and microorganisms. Apart from increasing soil fertility, organic fertilizers can increase plant productivity [3]. The application of organic fertilizers can increase the yield of shallot bulbs [4]. The application of organic fertilizers and biological fertilizers affects the root biomass and the number of shallot tubers, i.e. the root biomass has a positive correlation with the number of shallot bulbs. [5-6]. Compost and liquid organic fertilizer can support the growth and increase in yield of the valley variety palu shallot [7].
One of the efforts to support the growth and yield of shallots requires the use of vermicompost and PGPR (Plant Growth Promoting Rhizobacteria). This is because vermicompost can reduce the population of fungal pathogens and increase beneficial microorganisms, namely Trichoderma and Paecilomyces lilacinus so that it can increase the yield of shallot bulbs [8]. Vermicompost can increase the growth, development and production of various types of plants. In addition, vermicompost contains several hormones that plants need for growth, namely gibberellins, auxins, and cytokines [9]. PGPR (Plant Growth Promoting Rhizobacteria) is a group of beneficial bacteria that actively colonizes parts of the root system, namely Bacillus sp., Azobacter sp., and Pseudomonas sp. [10]. PGPR 15 g l⁻¹ application can increase the number of leaves and the number of tubers of shallots [11]. Meanwhile, the combination of PGPR and organic fertilizers produced the highest growth and yield of shallots. This is because the addition of organic matter can affect the nutrient supply needed by plants. The novelty of this research is combining vermicompost with PGPR in shallot cultivation. This study aims to examine the role of vermicompost and PGPR on the growth and formation of shallot bulbils.

2. Materials and methods
This research was conducted on the land of Dukuh Pancot, Ngringo Village, Jaten District, Karanganyar has an average elevation of 92 MASL. The materials used were Bima Brebes variety of shallot bulbs, vermicompost organic fertilizer, and PGPR. The study used a randomized complete block design (RCBD) with 2 factors. The first factor is the dose of vermicompost consisting of 4 levels, namely 5 tons ha⁻¹, 10 tons ha⁻¹, 15 tons ha⁻¹, 20 tons ha⁻¹. The second factor, namely PGPR consisting of 2 levels, namely the provision of PGPR and without the provision of PGPR. Each treatment was repeated 3 times. The spacing in this study was 20 x 20 cm. The size of the planting plot is 1 x 2 m.

The research variables observed were plant height, net assimilation rate, fresh weight, the weight of bulbs per plot, number of bulbils per plant, number of bulbs per plant. The calculation of the net assimilation rate is carried out based on the dry weight of the plant leaf area per unit time using the formula:

\[
LAB = \frac{1}{A} x \frac{\Delta W}{\Delta t} x \frac{\log A_2 - \log A_1}{A_2 - A_1} x \frac{\log W_2 - \log W_1}{t_2 - t_1}
\]

Information:
LAB = net assimilation rate
A₂ = area of plant leaves in t₂ observation
A₁ = area of plant leaves in t₁ observation
The research data were analyzed using analysis of variance based on the F test with a test level of α 5% (95% confidence level). If the significant effect is carried out further analysis using Duncan's Multiple Range Test (DMRT).

3. Results and discussion

3.1. Observation of temperature
Microclimatic conditions, especially temperature, are very suitable for the cultivation of shallot plants. It can be seen in Table 1 that the average temperature is around 28°C to 30°C (Table 1). Air temperature is good for the growth of shallot plants between 25°C to 32°C with dry climates [12]. Based on rainfall data shows fluctuation. This is one of the influences of climate change. In June, August and September it should be dry season but there is high rainfall intensity, namely 42 mm, 82 mm, and 22 mm. Rainfall fluctuations interact with vegetation and hydrology [13].
Table 1. Observation of temperature and rainfall.

| Month   | Temperature (°C) | Rainfall (mm) |
|---------|------------------|---------------|
|         | Average | Min | Max |            |              |
| June    | 30.05   | 26  | 34  | 76        |
| July    | 28.5    | 22  | 35  | 48        |
| August  | 29.5    | 23  | 36  | 22        |
| September | 30     | 24  | 36  | 42        |

3.2. Plant height
The vermicompost treatment had a significant effect on plant height (Table 2). The highest average yield of plant height was in the vermicompost treatment of 20 tons ha⁻¹, namely 36.63 cm and the lowest was in the vermicompost treatment of 5 tons ha⁻¹, namely 33.66 cm. These results indicate that the higher the vermicompost dose, the higher the plant height. This is because vermicompost contains auxins, cytokinins, GA, and humic acid which act as growth regulators [14]. The hormones auxin and gibberellin are present in the embryo and apical meristem which have a function as cell elongation. GA3 regulates rod elongation and controls the IAA signaling pathway. GA3 and IAA induce cell wall expansion by activating the expression of genes encoding cell wall structural proteins such as Expansin (EXP) so that these two hormones have an effect on plant height [15].

Table 2. Effect of vermicompost + PGPR on plant height (cm) shallots.

| Vermicompost Fertilizer | PGPR With PGPR | PGPR Without PGPR | Average |
|-------------------------|----------------|-------------------|---------|
| 5 ton ha⁻¹              | 33.74          | 33.56             | 33.66a  |
| 10 ton ha⁻¹             | 33.54          | 36.45             | 35.00ab |
| 15 ton ha⁻¹             | 35.45          | 35.63             | 35.54ab |
| 20 ton ha⁻¹             | 35.93          | 37.33             | 36.63b  |
| Average                 | 34.66          | 35.74             |         |

Note: numbers followed by different letters in the column show the results are significantly different at the 5% level.

3.3. Net assimilation rate
Based on Table 3, vermicompost and PGPR treatment did not have a significant effect on the net assimilation rate. Factors that can affect the size of the net assimilation rate value are leaf area and plant stover dry weight. Plant growth can be said to be increased as seen from the increase in the number of leaf area which is in line with the increase in the net assimilation rate which is accumulated in the form of dry stover weight [16]. Leaf area can affect how much solar radiation a plant receives. The larger the leaf area of the shallot plant, the higher the photosynthate yield produced for the growth and development of shallot plants [17].

Table 3. The effect of vermicompost + PGPR on the net assimilation rate of shallots.

| Vermicompost | PGPR (gr.cm⁻².hari⁻¹) | Average (gr.cm⁻².hari⁻¹) |
|--------------|-----------------------|--------------------------|
|              | With PGPR | Without PGPR |               |               |
| 5 ton ha⁻¹   | 0.173     | 0.151       | 0.162         |               |
| 10 ton ha⁻¹  | 0.271     | 0.155       | 0.213         |               |
| 15 ton ha⁻¹  | 0.119     | 0.135       | 0.127         |               |
| 20 ton ha⁻¹  | 0.212     | 0.164       | 0.188         |               |
| Average      | 0.194     | 0.151       |               |               |
3.4. Fresh weight
The results showed that the interaction between vermicompost and PGPR was not significantly different. The fresh weight of shallot stover is influenced by the availability of nutrients and water by the plant roots [18]. This shows that the application of vermicompost and PGPR can supply nutrients to support the growth of shallots (Table 4).

Table 4. Effects of vermicompost + PGPR on fresh weight (g) shallots.

| Vermicompost | PGPR          | Average |
|--------------|---------------|---------|
|              | With PGPR     | Without PGPR |
| 5 tons ha⁻¹  | 13.40         | 6.58    | 9.99   |
| 10 tons ha⁻¹ | 7.96          | 8.13    | 8.05   |
| 15 tons ha⁻¹ | 10.40         | 9.38    | 9.90   |
| 20 tons ha⁻¹ | 12.63         | 16.58   | 14.60  |
| Average      | 11.09         | 10.17   |        |

3.5. Bulbs weight per plot
The results showed that the combination of vermicompost and PGPR treatment had no significant effect on tuber weight per plot (Table 5). The combination of vermicompost 20 tons ha⁻¹ without PGPR showed the highest tuber weight, namely 2.38 g. This shows that the higher the vermicompost dose, the higher the tuber yield. This is because vermicompost can increase soil nitrogen and phosphorus so that plant nitrogen and phosphorus uptake increase. Bacterial and fungal strains increased P uptake by plants and were recorded as having higher available P [19].

Table 5. Effects of vermicompost + PGPR on bulbs weight per plot (kg) of shallots.

| Vermicompost | PGPR          | Average |
|--------------|---------------|---------|
|              | With PGPR     | Without PGPR |
| 5 tons ha⁻¹  | 2.16          | 1.84    | 2.00   |
| 10 tons ha⁻¹ | 1.93          | 2.11    | 2.02   |
| 15 tons ha⁻¹ | 2.00          | 2.23    | 2.11   |
| 20 tons ha⁻¹ | 2.07          | 2.38    | 2.23   |
| Average      | 2.04          | 2.14    |        |

3.6. Number of bulbils per plant
The results showed that the interaction between giving vermicompost + PGPR had a significant effect on the number of bulbils per plant. Vermicompost 5 tons ha⁻¹ with PGPR produced the highest number of bulbils per plant, namely 1 bulbil (Table 6). This is because vermicompost contains high amounts of salicylic acid, benzoic acid, and carboxylic acid aminocyclopropane which increases the accumulation of jasmonate and modifies cytokines, so that vermicompost can increase endogenous phytohormones [20]. In addition, PGPR can increase indole-3-acetic acid (IAA), salicylic acid (SA) and abscisic acid (ABA) in plants so that they can support plant growth and yield [21]. The combination of vermicompost with Bacillus has a significant increase in plant height, leaf area, chlorophyll, and total yield compared to the control treatment [22]. This is influenced by PGPR which is more effective when followed by the addition of organic fertilizers. The addition of organic fertilizers acts as a source of energy and food for PGPR microbes so that it can increase microbial activity in the supply of nutrients.
### Table 6. Effects of vermicompost + PGPR on the number of bulbils per plant.

| Vermicompost | PGPR          | Average |
|--------------|---------------|---------|
|              | With PGPR     | Without PGPR |
| 5 tons ha⁻¹  | 1.00 b        | 0.00 a  | 0.50   |
| 10 tons ha⁻¹ | 0.00 a        | 0.67 ab | 0.33   |
| 15 tons ha⁻¹ | 0.33 ab       | 0.67ab  | 0.50   |
| 20 tons ha⁻¹ | 0.33 ab       | 0.33 ab | 0.30   |
| Average      | 0.42          | 0.42    |

### 3.7. Number of bulbs per plant

A fertilizer dose of 20 tons ha⁻¹ + without PGPR gave the highest yield than the other treatments (Table 7). The number of bulbs is closely related to the number of tillers produced, one tuber is produced from one tiller. Macro elements P and K play a role in the formation and filling of tubers. The P element functions as tuber formation and accelerates carbohydrate metabolism, while the K element functions to increase bulbs' weight [23].

### Table 7. Effects of vermicompost + PGPR on the number of bulbs per shallot plant.

| Vermicompost | PGPR          | Average |
|--------------|---------------|---------|
|              | With PGPR     | Without PGPR |
| 5 tons ha⁻¹  | 12.40         | 10.40   | 11.40  |
| 10 tons ha⁻¹ | 10.47         | 12.33   | 11.40  |
| 15 tons ha⁻¹ | 11.07         | 11.80   | 11.43  |
| 20 tons ha⁻¹ | 10.80         | 12.60   | 11.70  |
| Average      | 11.18         | 11.78   |

### 4. Conclusion

Application of vermicompost with PGPR as an effort to mitigate climate change in supporting the growth and yield of shallots. The combination of vermicompost 5 tons ha⁻¹ with PGPR showed the highest formation of bulbils. The dose of vermicompost fertilizer of 5 tons ha⁻¹ is sufficient to support the growth and yield of shallot bulbs and does not require the application of PGPR.

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