Research Article

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Fermented compost and N-fertilizer for enhancing the growth and productivity of purple eggplant on vertisols

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Abstract: The soil fertility and nutrient availability are limiting factors for growth and plant development. Fermented compost and nitrogen (N)-fertilizer are useful as sources of nutrients to support the growth of plant and microorganisms in soils. The combination of biological fertilizer and chemical fertilizer can support the concept of sustainable and integrated agriculture and minimize the adverse effects of chemical fertilizers. The research was conducted to get the recommended dose of fermented compost and N-fertilizer to increase the plant height and productivity of purple eggplant. The experiment was arranged as factorialized randomized block design and consisted of two factors and two replications, namely fermented compost dose (0, 5, 10, and 15 t ha⁻¹) and N-fertilizer dose (0, 75, 150, and 225 kg ha⁻¹). The observed responses were increase in plant height and productivity of purple eggplant. Compared to the control, the application of 15 t ha⁻¹ fermented compost and 225 kg ha⁻¹ N-fertilizer increased the plant height by 40.76% at 30 days after planting and 57.59% at 37 days after planting and increased the purple eggplant yield by 43.15%. BC ratio of the fermented compost (15 t ha⁻¹) is 1.16 and BC ratio of the N-fertilizer (225 kg ha⁻¹) is 1.09. Recommended dose to increase the plant height and productivity of purple eggplant in vertisol is 15 t ha⁻¹ of fermented compost and 225 kg ha⁻¹ of N-fertilizer.

Keywords: Solanum melongena, organic fertilizer, urea-fertilizer, vertisols

1 Introduction

The consumption of vegetables in the past 5 years has significantly decreased, and consumption level reduced to less than half of the recommended consumption level (Central Bureau of Statistics of the Republic of Indonesia 2015; Ministry of Agriculture 2015; BMKG 2017). Purple eggplant (Solanum melongena L.) is one of the important vegetable commodities needed in Indonesia. Although in Indonesia the productivity of the purple eggplant is about 32.64–34.11 ku ha⁻¹, for an area of one hectare 30 tons of purple eggplants can be produced (Rukmana 2006). National eggplant production tends to increase every year, but the eggplant production in Indonesia is still low and only accounts for about 1% of the world needs (Simatupang 2014).

Fertilization is one of the keys to success in improving eggplant production. Farmers generally use inorganic fertilizers to increase the growth and crop yield. However, lately there is an opinion that the increasing use of inorganic fertilizers has caused controversy, and even has created social, economic, and environmental problems, such as tensions between farmers, increased production costs, decreased quality of agricultural products, and decreased environmental quality because of water, soil, and air pollution. Dependence on excessive inorganic fertilizers leads to increase in expense and scarcity of inorganic fertilizers in the market. This condition results in farmers not using appropriate fertilizers or choosing to fertilize eggplant with just one type of fertilizer according to the available funds and the fertilizer available in the market. It was reported that unbalanced fertilizer, only nitrogen, tended to reduce crop yields and soil fertility.

According to Agbo et al. (2012), Maghfoer et al. (2013), Thingujam et al. (2016), Juhaeti and Lestari (2016), Okeowo et al. (2016), and Mostafa et al. (2017), eggplant is a plant that has a good response to fertilization. In general, plants that are applied with fertilizer, whether chemical, organic, or a combination of both, show better productivity than plants that are not applied with fertilizer.
Organic fertilizers are produced from weathering the remains of plants, animals, and humans. These organic fertilizers can improve soil structure, can increase soil absorption of water, can increase soil biological fertility, and are used as a source of nutrients for plants (Lingga and Marsono 2002; Kumar 2016; Kumar and Chopra 2016; Lasmini et al. 2018; Suwoyo et al. 2019). Bakashi is the result of weathering manure and other agricultural wastes whose processes are accelerated using microorganisms.

Use of inorganic fertilizers or artificial fertilizers need to be reduced because of remembering requests consumers who want products that are free artificial pesticides and fertilizers. Reduction of fertilizer inorganic applied in agricultural systems organic. This is known as semi farming organic. In semi-organic agriculture usage less inorganic fertilizer compared to use of organic fertilizer. This study significantly contributes to provide recommendations about the best dose fermented compost and nitrogen (N)-fertilizer to support the growth and productivity of eggplant on vertisol.

In the research of Hafizah and Mukarramah (2017), the best dose of cow manure used for growth and productivity of cayenne pepper is about 20 t ha\(^{-1}\). A 200 g per plant dose of organic fertilizer biogas waste from cow manure influenced plant height, number of leaves, and age of harvest, whereas a dose of 250 g per plant affected fruit diameter, weight of plant fruits, and plant production. The results of the study of Mulyanti et al. (2015) showed that the administration of various types of bakashi affected the growth and the productivity of sweet corn. The results of the study of Kartina et al. (2019) showed that treatment using 35 t ha\(^{-1}\) chicken manure had the best effect on okra plant’s height, number of flowers and fruits per plant, and mass of fruit per plant. According to Tufaila et al. (2014), applying bakashi fertilizer with cow dung at a dose of 5–7.5 t ha\(^{-1}\) increased the growth and production of lowland rice. The treatment of cow feces bakashi fertilizer at a dose of 3 kg per plot on eggplant increased the plant height, fruit weight per plant, and weight of fruit per plot (Rianto et al. 2018). Furthermore, the results of the study of Zalna et al. (2018) showed that organic bakashi fertilizer manure influences the growth and yield of water spinach on almost all the parameters observed. The results of the research of Raksun and Mertha (2018) showed that bakashi can increase the purple eggplant production.

The combined application of organic fertilizers such as bakashi and inorganic N-fertilizer likely enhances eggplant growth and productivity. We assume that N is an ideal nutrient for eggplant’s vegetative growth including leaves, stems, and roots, which may further improve with adding organic fertilizers because of increase in soil microbial activity. Therefore, our study investigated the combined application of organic and inorganic fertilizers to increase eggplant production. This study significantly contributes to provide recommendations about the application dose of fermented compost and N-fertilizer to increase the plant height and productivity of purple eggplant.

2 Methods

The experiment was conducted in Ujungiaya District, Sumedang Regency, from May to September 2016. The materials used were purple eggplant seeds of Antaboga varieties, bakashi, urea, Curacron Insecticide, and Dithane M-45 Fungicide. The equipments were hoe, marker (sample), rapia rope, meter, handsprayer, bucket, fat sheet, label paper, thermometer, torch, calipers, scales, plastic bags, stationery, and camera.

Experimental design with factorial pattern consists of the following two factors: bakashi (B) consisting of four levels, such as \(b_0 =\) without bakashi, \(b_1 = 5 \, \text{t} \, \text{ha}^{-1}\), \(b_2 = 10 \, \text{t} \, \text{ha}^{-1}\), and \(b_3 = 15 \, \text{t} \, \text{ha}^{-1}\); and N-fertilizer consisting of four levels, such as \(n_0 =\) without N-fertilizer, \(n_1 = 75 \, \text{kg} \, \text{ha}^{-1}\), \(n_2 = 150 \, \text{kg} \, \text{ha}^{-1}\), and \(n_3 = 225 \, \text{kg} \, \text{ha}^{-1}\) which is repeated twice.

Bakashi is made as follows: EM\(_4\), molasses/sugar, and water in a ratio of 55 mL:55 mL:5.5 L is added to cow manure 82.5 kg + rice husk 41.25 kg + bran 41.25 kg to form a mixture. The mound was covered with tarpaulin or thick plastic for 7 days. During the process, the temperature of the material is maintained between 40 and 60°C. If the temperature of the material exceeds 60°C, then the closing sack is opened, the dough material is flipped back, and the mound is closed again. After 7 days, tarpaulin or thick plastic can be opened. Making bakashi is said to be successful if the bakashi material is well fermented. The characteristics of bakashi are it will be overgrown by white mushrooms and a pleasant aroma. However, if bakashi produced smells bad, then the bakashi made is a failure. The bakashi that is ready should be used immediately. If the bakashi has to be stored, the bakashi must be dried first by aerating it on the floor. After drying, bakashi can be packed in plastic bags. Bakashi was made 8 days before the second tillage.

Furthermore, observations were made on the plant height (measured from the base of the stem to the highest leaf tip), length (measured from the base of the fruit to the tip of the fruit), diameter (three parts are measured...
such as 1/4, 2/4, and 3/4 parts of the base of the fruit using a caliper and averaged), number of fruits (calculated at the time of harvest), weight of fruit per plant (observations were made at harvest time using a scale), and weight of fruit per plot (observations were made on five samples per plot).

3 Results and discussions

The results of the eggplant height data at 16, 23, and 44 days after planting (DAP) are presented in Table 1.

Bokashi cow manure dose of 15 t ha⁻¹ provided the highest number of plant significantly different from other treatments. This result is in agreement with the studies of Zalna et al. (2018), Rakusun and Mertha (2018), Harjadi (1991), Huruna and Maruapey (2015), and Sriyanto et al. (2015).

Variations in N-fertilizer treatment showed no significant effect on the plant height at 16 and 44 DAP. However, at the age of 23 DAP, the application of 75 and 225 kg ha⁻¹ N-fertilizer showed a higher effect than other treatments. According to Syarief (1989), if the N content in plants is high, then the leaves of the formed plants will be maximal with the wider leaf sizes. With a higher number of leaves, photosynthesis can also be increased, as the leaves are organs where the process of plant photosynthesis takes place. The resulting photosynthate can be used as a raw material for further plant growth and development. According to Maghfoer et al. (2014), as the age of the eggplant plants increases, nutrient requirements, especially nitrogen (N), cannot be completely provided by the soil in which it grows. Providing bokashi cow manure can increase the availability and uptake of N elements needed for the vegetative growth of plants. As stated by Syarief (1989), the element nitrogen (N) is needed by plants to stimulate the vegetative growth of plants such as stems, roots, leaves, and branches. The bokashi and N-fertilizer interact with the height of the purple eggplant plants at 30 and 37 DAP (Tables 2 and 3).

From Tables 2 and 3, it can be seen that the treatment of 15 t ha⁻¹ cow manure accompanied by 225 kg ha⁻¹ N-fertilizer gives a highest plant height than the other treatments. In line with the results of the research of Safei et al. (2014), the type of organic fertilizer affects the height of the eggplant plants at the age of 45 DAP. This situation is caused by the addition of organic fertilizer that can affect the physical and biological properties of the soil; it can also improve the availability of nutrients for plants. The organic fertilizer can improve soil structure, improve the ability to retain water, improve soil biological properties and source of nutrients for plants (Prihantoro 1999).

The provision of organic material in the form of bokashi cow manure influences the improvement of physical, chemical, and biological soil properties. The availability of nutrients in the soil greatly affects the growth and development of roots and the ability of roots to absorb the nutrients. The development of a good root system determines the vegetative growth of plants, which ultimately determines the reproductive phase and yield of plants. In line with the opinion of Souza et al. (2017), bokashi cow manure contains macro- and micronutrients. The usefulness of bokashi cow manure for the soil

| Table 1: Fermented compost and N-fertilizer on the plant height of the purple eggplant |
|---------------------------------|-------|-------|-------|
| Treatment                      | 16 DAP| 23 DAP| 44 DAP|
| Bokashi compost                |       |       |       |
| \( b_0 \) (0 t ha⁻¹)            | 13.37a | 20.14a | 47.60a |
| \( b_1 \) (5 t ha⁻¹)            | 14.72b | 22.95b | 56.12b |
| \( b_2 \) (10 t ha⁻¹)           | 14.49b | 22.35b | 54.10b |
| \( b_3 \) (15 t ha⁻¹)           | 15.89c | 25.70c | 63.08c |
| N-fertilizer                   |       |       |       |
| \( n_0 \) (0 kg ha⁻¹)           | 14.22a | 22.72a | 54.01a |
| \( n_1 \) (75 kg ha⁻¹)          | 14.68a | 23.47b | 57.99a |
| \( n_2 \) (150 kg ha⁻¹)         | 15.66a | 21.85a | 53.60a |
| \( n_3 \) (225 kg ha⁻¹)         | 15.01a | 23.10b | 55.28a |

Note: the average number of treatments in the same column followed by the same letter shows no significant difference according to Duncan’s multiple range test at a real level of 5%.

| Table 2: Fermented compost and N-fertilizer on the plant height of the purple eggplant |
|---------------------------------|-------|-------|-------|-------|
| B/N                             | Average plant height (cm) |
| \( n_0 \)                       | \( n_1 \) | \( n_2 \) | \( n_3 \) |
| \( b_0 \)                       | 30.25a  | 27.33a  | 26.49a  | 28.66a  |
| \( b_1 \)                       | 32.66a  | 35.99b  | 33.58ab | 30.91a  |
| \( b_2 \)                       | 32a     | 38.66b  | 29.91bc | 30.49a  |
| \( b_3 \)                       | 34.58a  | 39.5b   | 36.24c  | 42.58b  |

Note: the average number lowercase letters (vertical direction) and uppercase letters (horizontal direction) the same shows not significantly different according to Duncan’s multiple range test at a real level of 5%.
is physically increasing the soil porosity and biologically increasing the activity of microorganisms so that the process of overhauling organic material is faster in the soil. The bokashi cow manure provided to each treatment is different and the results also look different.

The result showed that there was no interaction between the bokashi treatment of the cow manure with N-fertilizer on the length and diameter of the fruit, and the number and weight of the fruit. Independently the influence of the bokashi dose of cow manure and nitrogen on the fruit length and diameter, the number and weight of the fruit plant (Table 4).

From Table 4, it was observed that providing bokashi cow manure can increase the fruit length per plant, which is higher and significantly different compared to the control. The 10 t ha\(^{-1}\) dose of bokashi increased the fruit diameter, number, and weight of the fruit per eggplant better than control (without giving bokashi). In line with the results of the research of Safei et al. (2014), the type of organic fertilizer affects the diameter and weight of the eggplants. Similar to the results of the research of Srijanto et al. (2015), in the eggplant, cow manure influences the number of fruits per plant, fruit length, fruit diameter, and fruit weight per plant. In contrast to the research results by Huruna and Maruapey (2015), the provision of the organic fertilizer biogas waste cow manure affects the fruit diameter and the weight of the fresh fruit of plants, but does not affect the length and number of fruit per eggplant. Good vegetative growth will support a good generative phase (Budiman 2010). The results of the research of El-Semellawy and El-Koumy (2015) showed that the use of bokashi doses of 1.2 kg per 10 kg soil media gives better wet egg productivity results than other treatments.

Various N-fertilizer treatments showed no significant effect on the length and number of the fruit plants. The 75 kg ha\(^{-1}\) nitrogen treatment increases the diameter and weight of the eggplant fruit plants. The research results by Fawzy et al. (2016) showed that the fruit length, fruit diameter, and the eggplant productivity were highest in the nitrogen treatment of 100 kg ha\(^{-1}\). Similarly, the results of El-Semellawy and El-Koumy (2015) in the eggplants showed that an increase in the rate of application of N to 150 kg ha\(^{-1}\) was in line with an increase in vegetative growth characteristics (plant height [cm] and number of leaves), plant fresh weight (g), fruit length, and diameter (cm). The results obtained by Sharmin and Rahman (2019) showed that the highest yield (18.0 t ha\(^{-1}\)) was obtained from the administration of 375 kg ha\(^{-1}\) urea, whereas the lowest yield (10.1 t ha\(^{-1}\)) was found in the control treatment (without urea administration).

Provision of nitrogen nutrients for plants makes the plant parts become green because they contain chlorophyll that plays a role in photosynthesis. The N-fertilizer is a macronutrient needed by plants. At the right dose, the N-fertilizer will have a good influence on plant growth and productivity. According to Iritani (2012), the availability of macro- and micronutrients in plants is one of the supporters of external factors in determining the

### Table 3: Fermented compost and N-fertilizer on the plant height of the purple eggplant at 37 DAP

| B/N | Average plant height (cm) |
|-----|--------------------------|
|     | \(n_0\) | \(n_1\) | \(n_2\) | \(n_3\) |
| \(b_0\) | 37.33a | 39.33a | 34.83a | 37.745a |
| \(b_1\) | 44ab | 36.33a | 45.245b | 41.415a |
| \(b_2\) | 41.58ab | 52.83b | 42.33ab | 39a |
| \(b_3\) | 49.165b | 51.33b | 47.41b | 58.83b |

Note: the average number lowercase letters (vertical direction) and uppercase letters (horizontal direction) the same shows not significantly different according to Duncan’s multiple range test at a real level of 5%.

### Table 4: Fermented compost and N-fertilizer on length of fruit, diameter of fruit, number of fruit per plant, and weight of fruit per plant

| Treatment | Average observation |
|-----------|---------------------|
|           | Length of fruit (cm) | Diameter of fruit (cm) | Number of fruit per plant | Weight of fruit per plant (g) |
| Bokashi compost |                  |                      |                            |                          |
| \(b_0\) (0 t ha\(^{-1}\)) | 23.29a | 3.50a | 9.29a | 1501.66a |
| \(b_1\) (5 t ha\(^{-1}\)) | 25.13b | 3.75ab | 9.92b | 1592.49b |
| \(b_2\) (10 t ha\(^{-1}\)) | 26.21b | 3.90b | 10.25c | 1744.16b |
| \(b_3\) (15 t ha\(^{-1}\)) | 25.99b | 3.73ab | 10.21bc | 1737.91b |
| N-fertilizer |                  |                      |                            |                          |
| \(n_0\) (0 kg ha\(^{-1}\)) | 24.46a | 3.61a | 9.67a | 1567.91a |
| \(n_1\) (75 kg ha\(^{-1}\)) | 25.48a | 3.90b | 10.17a | 1702.49b |
| \(n_2\) (150 kg ha\(^{-1}\)) | 25.20a | 3.65ab | 9.92a | 1593.32a |
| \(n_3\) (225 kg ha\(^{-1}\)) | 25.49a | 3.72ab | 9.92a | 1712.49b |

Note: the average number of treatments in the same column followed by the same letter shows no significant difference according to Duncan’s multiple range test at a real level of 5%.
high rate of photosynthesis, so that it also determines the amount of assimilation obtained. Thus, it is suspected that the photosynthesis that runs perfectly with the help of light and the availability of adequate macro- and micro-nutrients have a good effect on plant height, number of fruits per plant, fruit length and diameter, and fruit weight of the plant (Rinsema 1983; Safei et al. 2014).

According to Sutejo (1994), the availability of nitrogen will stimulate the formation of chlorophyll in leaves and is part of the constituent of enzymes and chlorophyll molecules. Related to this, Iritani (2012) argued that the formation of leaves with chlorophyll in them results in more photosynthesis in plants. The results of the photosynthesis in the form of carbohydrates, proteins, fats, minerals, and vitamins will be higher. Good growth of the plant can be achieved if the nutrients affect growth in a balanced state. The application of 30% N-fertilizer along with compost is an effective nutritional management strategy to maintain N uptake and corn productivity, reduce N loss, and also increase soil fertility (Zhang et al. 2016).

The analysis results showed an interaction between the bokashi of cow manure treatment with nitrogen on the weights of the fruit plot (Table 5). From Table 5, it can be observed that the bokashi of cow manure treatment of 15 t ha$^{-1}$ accompanied by 75 kg ha$^{-1}$ N-fertilization has an effective and efficient effect in increasing the fruit weight of the purple eggplant per plot.

In the treatment with bokashi of cow manure, a dose of about 15 t ha$^{-1}$ with N-fertilizer 75 kg ha$^{-1}$ gives a better effect in increasing the fruit weight of the purple eggplant per plot. In contrast to the research results of Waskito et al. (2017), the composition of soil planting media + sand + cow manure with a dose of 150 kg N-fertilizer increases the plant height, number of leaves, weight of fruit crop per harvest, weight per fruit, and length and diameter of the eggplant fruit. In relation to the research of Maghfoer et al. (2014), treatment using the combination of 75% urea + 25% goat manure increased the plant growth and gave the highest fruit yield (49.2 t ha$^{-1}$) in comparison with combination using other fertilizer and 100% urea. This is because the plant needs for each nutrient differ depending on the availability of nutrients present in the soil. Generally this maximum productivity relates to all plant conditions and nutrient availability in the soil. It is said to be optimal if the elements are available in the right amount. Deficiency or excess of one nutrient will be able to reduce the efficiency of other nutrients (Lasmini et al. 2018; Raheem et al. 2019).

Based on the results of soil analysis on the experimental field (Appendix 1), the nitrogen element content included very low criteria, so that the addition of a dose of 75 kg ha$^{-1}$ N-fertilizer was sufficient in increasing the chlorophyll content in the leaves. The better growth due to combined fertilizer application assuming enhanced leaves chlorophyll content. Therefore, plants increase their rate of photosynthesis that likely produced sugar assimilates. As a result, we expected that this combination of fertilizer application increased the growth and productivity of eggplant.

This is presumably because providing the bokashi of cow manure and N-fertilizer at the right dose to the purple eggplant can increase the growth and productivity. Therefore, the physical, chemical, and biological conditions of the soil are better, besides that the increase in plant height in the treatment of the bokashi of cow manure and N-fertilizer is associated with an increase in N content in plants.

### Table 5: Fermented compost and N-fertilizer on weight of fruits per plot

| B/N | Average weight of fruits per plot (kg) |
|-----|---------------------------------------|
|     | $n_0$ | $n_1$ | $n_2$ | $n_3$ |
| $b_0$ | 19.05a | 17.60a | 17.58a | 17.84a |
| A     | A      | A      | A      | A      |
| $b_1$ | 20.87a | 20.57ab| 18.18a | 23.34b |
| AB    | AB     | A      | B      | B      |
| $b_2$ | 18.96a | 22.39b | 23.31b | 26.23b |
| A     | AB     | B      | B      | B      |
| $b_3$ | 19.54a | 26.64c | 25.94b | 27.27b |
| A     | B      | B      | B      | B      |

Note: the average number lowercase letters (vertical direction) and uppercase letters (horizontal direction) the same shows not significantly different according to Duncan’s multiple range test at a real level of 5%.

### 4 Conclusions

Treatment using the combination of 75% urea + 25% goat manure increased the plant growth and gave the highest fruit yield (49.2 t ha$^{-1}$) in comparison with combination using other fertilizer and 100% urea. Compared to the control, the application of 15 t ha$^{-1}$ fermented compost and 225 kg ha$^{-1}$ N-fertilizer increased the plant height by 40.76% at 30 days after planting and 57.59% at 37 days after planting and increased the purple eggplant productivity by 43.15%. This finding confirms that fermented compost and N-fertilizer can be applied to increase the productivity of purple eggplant.
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