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Utilization of Tasikmadu Starfruit Waste Compost for The Growth and Yield of Purple Eggplant (*Solanum melongena* L.) In Supporting Sustainable Agriculture

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Abstract

Based on the literature study, the demand for eggplant in East Java is increasing, encouraging farmers to increase productivity by using chemical fertilizer. In the long term, this practice could harm the environment. This study was conducted to obtain the right method and dosage of compost made from starfruit waste for the growth and yield of eggplant. The study was designed using a Factorial Randomized Block Design. The first factor was organic fertilizer with 5 levels, namely: Soil + goat manure 1:1, Soil + compost from composter 1:1; Soil + compost from *bio-pore*1:1; Soil + goat manure + compost from composter 1:1:1, and Soil + goat manure + compost from *bio-pore* 1:1:1. The second factor was NPK fertilizer with 4 levels, namely: 0 gram/liter, 1 gram/liter; 2 gram/ liter; dan 3 gram/liter. There were three replications for each treatment. The results showed that the best organic fertilizer was a combination of manure and compost, from composter and *bio-pore*, which had the highest result for plant height, number of leaves, biomass increase, and the number of eggplant fruits. The best concentration of NPK fertilizer for eggplant growth and physiology was 3 grams per liter.

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Keyword
Biopore;
Compost;
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Introduction

Starfruit (*Averrhoa carambola*) is a horticultural fruit plant with big-sized, orange fruit that can be harvested 4 times a year. In the cultivation process, leaves and unproductive branches are conducted every 40 days. The waste from one starfruit tree from one trimming is around 10 to 25 kg of leaves and 15-25 kg of fruit (Gunawan *et al.* 2019). Starfruit trees also produce other kinds of waste such as twigs, epiphytes that grow on the lower trunk, dried leaves, and fruits that are not selected. Waste from a plant contains organic matter that can be managed and utilized as a plant nutrient source, in the form of compost (Puspitawati and.Sumiasih 2021).

Compost is the result of organic waste such as leaves, other plant parts, animal bones, and others that naturally degrades through decomposition by decomposers. The practice of making compost is simple and easy and can be very helpful for farmers in waste management so the waste can be used properly. Therefore, further research on the technique of making compost from starfruit waste is needed.

In the Attaqie Farm area, there is a composting hut to process organic waste into compost. Every 1-2 days, organic waste from around Attaqie Farm is gathered to be turned into compost. However, the space for compost production become more and more limited, and other ways to process the organic waste are needed to accommodate compost production and for educational purposes for visitors.

According to Widyastuti 2012, organic waste such as trimmed fallen leaves is the main ingredient for *bio-pores to* function. This material needs to be added frequently because the waste that is put inside the *bio-pore* would shrink due to decomposition and consumption by soil organisms. Furthermore, according to Syafrizal and Fridarti 2017, composters can produce liquid organic fertilizer (LOC) and compost with relatively small amounts of capital and good profit. The advantages of making compost in a composter namely: the organic matter doesn't need to be chopped; it doesn't need to be mixed; and the yield can be obtained in the fifth month, so this method can be applied by the general public (Nurjazuli and Sari (2019).

Several plants are cultivated beside "Tasikmadu' starfruit at Attaqie Farm. Other plants include leafy vegetables, fruit vegetables, and ornamental plants. One of the fruit vegetables cultivated by the agroedutourism is eggplant. The purple eggplant (*Solanum melongena*) is a horticultural plant whose fruit is used as a vegetable in cooking. The fruit has high economic value.

According to the Central Bureau of Statistics 2020, the production of eggplant in East Java in 2018 was 67957 tons. It increased from 2012 to 2014 by 48.65% and then decreased in 2016 by 31.2%. and increase again to 2019 by 38.89%. Along with population growth and increasing public awareness of the importance of health, demand for eggplant will continue to increase (Ahmad et al. 2017). However, eggplant production sometimes decreases, one of the factors being caused by excessive use of chemical fertilizers. According to Haruna and Maruapey 2015, the cause of low eggplant yield is excessive use of chemical fertilizers which can damage the quality of the soil resulting in reduced nutrient intake by the plant. This research aimed to obtain an appropriate and effective composting method for Tasikmadu starfruit waste in starfruit plantations; to obtain the best combination of compost for the growth and production of eggplant; and the right dose of compost for the growth and production of eggplant.

Materials and Methods

Date and Place

The research was carried out from August 2020 to February 2021. The research location was the Agroecotechnology Nutritious Garden & Agroecotechnology Integrated Laboratory, Trilogi University, Jakarta.

Materials and Tools

The materials used in this research were starfruit tree waste (twigs, stems, leaves, epiphytes pruning, unripe starfruit) originating from Attaqie Farm Agroedutourism located in Tuban, East Java, Effective Microorganisms (EM4), molasses, burnt husks, goat manure, Lembang soil, 'Cap Panah Merah' eggplant seeds of the Yuvita variety, water, NPK 16-16-16 fertilizer, 45 cm polybag, tray, wooden stake, and spoon/tagging.

The tools used in this research are a compost chopping machine, bio-pore drill, composter, 4-inch bio-pore lid, saw, machete, watering can, bucket, cart, hoe, 250 ml and 1-liter plastic cups, tarpaulin, thermometer, thermo-hygrometer, digital scales, trays, meters, and writing tools (notebooks + pens).

Six different chemical fungicides, listed in Table 1, were assessed at three varying concentrations (250 ppm, 500 ppm, and 1000 ppm) to study their compatibility with *Trichoderma* sp. using the food poisoned technique, following the method described by Nene and Thapliyal (1993). Pure culture of *Trichoderma* sp. was procured from Nepal Plant Disease and Agro Associates (NPDA).

Experimental Design

This research used a Factorial Randomized Block Design. The first factor was organic fertilizer with 5 levels, namely: Soil + goat manure 1:1 (GM), Soil + compost from composter 1:1 (CC); Soil + compost from *bio-pore* 1:1 (BC); Soil + goat manure + compost from composter 1:1:1 (GM+CC) and Soil + goat manure + compost from *bio-pore*1:1:1 (GM+BC). The second factor was NPK fertilizer with 4 levels, namely: 0 gram/liter (N0), 1 gram/liter (N1); 2 gram/ liter (N2); dan 3 gram/liter (N3). There were three replications for each treatment, with 3 sample plants per replications. In total, there were 180 sample plants.

Data Analysis

This research used a Factorial Randomized Block Design. The first factor was organic fertilizer with 5 levels, namely: Soil + goat manure 1:1 (GM), Soil + compost from composter 1:1 (CC); Soil + compost from *bio-pore* 1:1 (BC); Soil + goat manure + compost from composter 1:1:1 (GM+CC) and Soil + goat manure + compost from *bio-pore*1:1:1 (GM+BC). The second factor was NPK fertilizer with 4 levels, namely: 0 gram/liter (N0), 1 gram/liter (N1); 2 gram/ liter (N2); dan 3 gram/liter (N3). There were three replications for each treatment, with 3 sample plants per replications. In total, there were 180 sample plants.

Experimental Procedure

Compost Preparation

Making the compost: (1) 8 kg of organic waste was weighed and moved to a tarpaulin to be mixed with the microbe solution (2) 1 liter of microbe solution was put into the watering can (3) The microbe solution was poured to the chopped waste and mixed thoroughly.

Bio-pore Compost

Bio-pore holes are made by drilling a hole in the ground using a *bio-pore* drill to a depth of 1 meter. Next, a cover for the top of the *bio-pore* was made using a 4-inch diameter PVC pipe, that was cut to a size of ±20 cm with a saw, and installed the PVC pipe cover on one side of the PVC pipe. Then, the *bio-pore* hole was filled with chopped starfruit tree waste to a depth of ±70 cm from the bottom of the hole or about ±2.9 kg/hole. The top of the *bio-pore* hole was closed using the lid that had been made. The compost would be ready after 4 weeks. Then the compost was taken out using a biopore drill.

Composter compost

The composter was a big sack. Eight kg of organic waste was put inside the composter and left alone for 4 weeks. After 4 weeks, the compost was ready to use.

Harvest

Eggplant plants were harvested at 8 (Weeks After Planting) WAP. Harvesting activities were carried out in the morning or evening. The criteria for ripe fruit were that the fruit looks purple with a stalk that still looks fresh. Next, the observation for determined parameters was carried out.

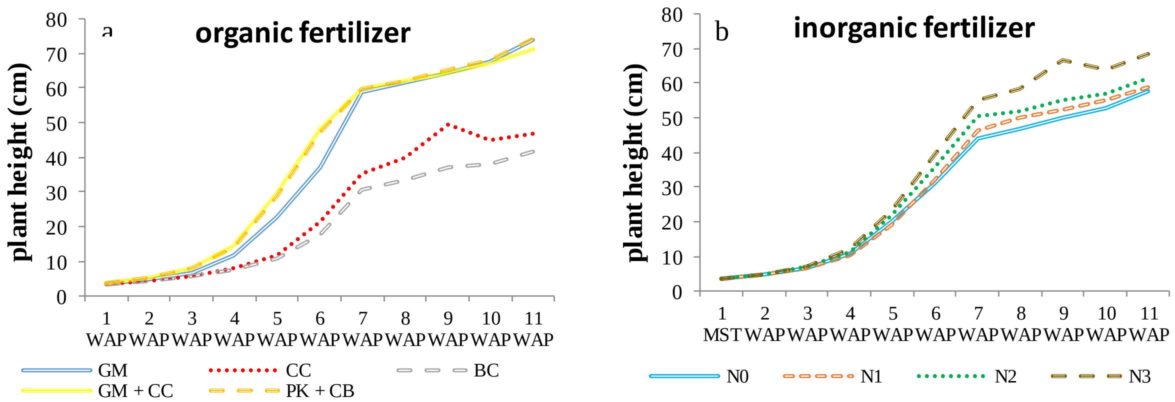
Observation Parameters

1. *Plant Height*
   The observation for plant height was conducted by measuring from the ground level to the tip of growing point from 1 WAP to 11 WAP.
2. *Number of leaves*
   The number of leaves was calculated by counting leaves from the lower stem to the tip of growing point of the plant from 1 WAP to 11 WAP. The leaves criteria to be counted was the stem and leaf still attached to the plant.
3. *Biomass*
   Biomass was measured by weighing the total fresh weight and dried weight from root, shoot, and fruit of the plant. The dried weight was measured by drying all of the plant in 80 °C oven for 48 hours and reach a constant weight (Zulkifli *et al*. 2020). The data was obtained at 24 Days After Planting (DAP), 48 DAP, and 78 DAP.
4. *Number of Fruits*
   The number of fruits was calculated by counting all the fruits. The fruits then harvested according to the harvesting criteria and conducted twice at 8 WAP and 11 WAP.
5. Fruit Weight
   Observation of fruit weight was conducted by weighing the fruit in each replication using a scale. The fruits weighed were based on each specified treatment. Fruits were weighed according to harvest criteria and harvested twice, namely at 8 MST and 11 MST.

Results and Discussion

The average growth of plant height on different treatments is shown in Figure 1. Treatments of manure (GM), mixture of manure + composter (GM+CC), and mixture of manure + *bio-pore* compost (GM+BC) showed higher plant growth compared to the composter compost (CC) and *bio-pore* compost (BC) treatments.

The average plant height treated with NPK fertilizer with a concentration of 3 g/l (N3) showed the highest value compared to the other level of inorganic fertilizer concentration. The 1 g/l (N1) concentration treatment was 1.92% higher and the 2 g/l concentration (N2) was 6.07% higher compared to the 0 g/l (N0) treatment. The concentration of 2 g/l tends to be 4.23% greater than a concentration of 1 g/l (N1) on average plant height.



Note: GM: goat manure, CC: composter compost, BC: *bio-pore* compost

Figure 1. The effect of organic fertilizer (a) and inorganic fertilizer (b) on eggplant plant height from 1 to 11 WAP

There was an interaction between treatments at 7 WAP which is presented in Table 1. Plant height with the organic fertilizer factor showed that the *bio-pore* compost mixture treatment (GM+BC) had a higher value and the composter mixture (GM+CC) had a lower value compared to manure (GM). This was a contrast with the treatment of composter compost (CK) and *bio-pore* compost (CB) without a mixture of manure. The composter compost treatment had a higher value in plant height growth compared to *bio-pore* compost (CB). According to Alwi *et al.* 2018, *bio-pore* can be utilized as an alternative for producing compost and can be more easily reached by farmers. *Bio-pore* is a small and deep hole in the ground that can increase absorption of water and can minimize flooding.

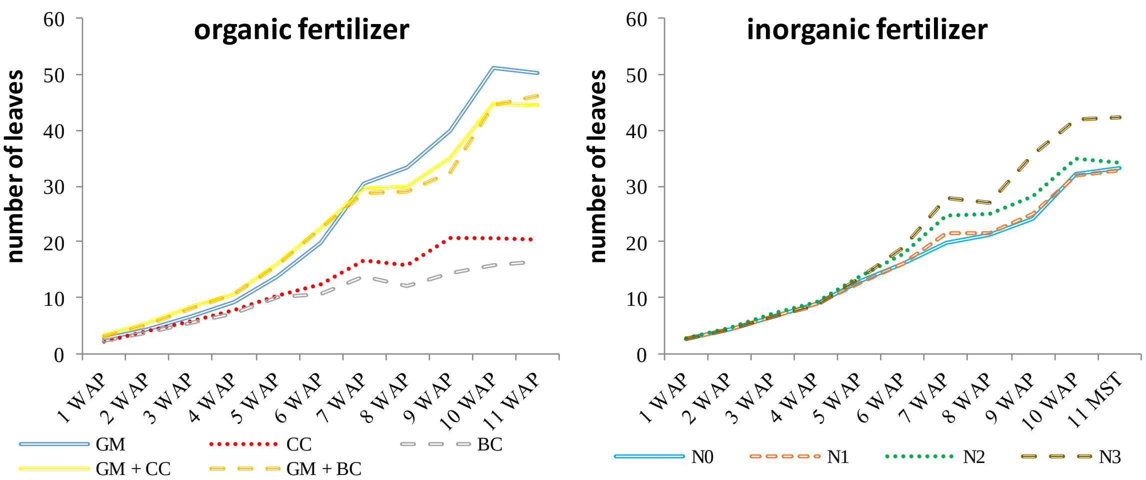
Table 1. Interaction between organic and inorganic fertilizers plant height at 7 weeks after transplant

Organic fertilizer	NPK 16 - 16 – 16 fertilizers			
	N0	N1	N2	N3
GM	55.67 a	59.00 a	59.67 a	61.67 a
CC	23.67 b	29.33 b	38.00 b	50.00 b
BC	22.33 b	28.67 b	33.33 b	38.33 c
GM + CC	57.33 a	57.67 a	60.67 a	64.00 a
GM + BC	60.00 a	57.00 a	60.00 a	62.00 a

Notes: numbers followed by the same letter showed no significant difference based on DMRT (α ≤ 5%); GM: goat manure, CC: composter compost, BC: bio-pore compost

Number of Leaves

The analysis results of the eggplant number of leaves showed that there was a significant interaction effect on the treatment of organic fertilizer and inorganic fertilizer. The data were further tested and presented separately and shown in Figure 2, while the interactions that occurred were shown in Table 2. The average number of leaves with NPK fertilizer treatment showed that the 3 g/l concentration (N3) treatment showed the highest results at leaf number parameters at 7 to 11 WAP. Meanwhile, inorganic fertilizer treatment with concentrations of 0 g/l (N0), 1 g/l (N1), or 2 g/l (N2) at 1 to 11 WAP showed results that were not significantly different.



Note: GM: goat manure, CC: composter compost, BC: *bio-pore* compost

Figure 2. The effect of organic fertilizer (a) and inorganic fertilizer (b) on eggplant number of leaves from 1 to 11 WAP

The highest number of leaves was in the manure (GM) treatment compared to other treatments. The lowest number of leaves was in the *bio-pore* compost treatment. This is in line with Alwi *et al.* 2018 which states that the use of *bio-pore* organic fertilizer did not have a relevant effect on increasing the number of leaves compared to other organic fertilizer, but the use of *bio-pore* organic fertilizers has potential for the plant cultivation process.

Table 2. Interaction between organic and inorganic fertilizers on Number of leaves

Organic Fertilizer	NPK 16 - 16 - 16 Fertilizer			
	N0	N1	N2	N3
GM	20.15 b	23.51 a	23.67 a	27.69 a
CC	9.07 c	9.33 c	12.24 b	19.04 c
BC	8.13 c	10.31 c	10.30 b	13.97 d
GM + CC	23.79 a	18.92 b	24.56 a	23.59 b
GM + BC	21.75 ab	21.85 a	23.15 a	22.84 b

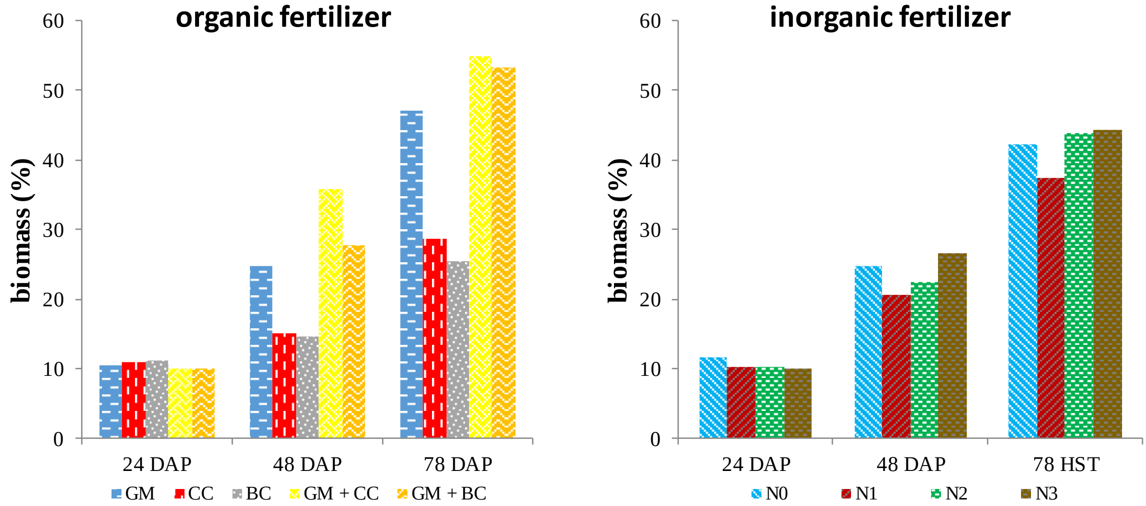
Notes: numbers followed by the same letter showed no significant difference based on DMRT ($\alpha \leq$ 5%); GM: goat manure, CC: composter compost, BC: bio-pore compost

The analysis results of the eggplant plants' biomass showed that there was no significant interaction effect between organic fertilizers and inorganic fertilizers. Data were further tested and presented separately and displayed in Figure 3. The percentage of biomass of both organic fertilizer and inorganic fertilizer factors was observed at 24 HST, 48 HST, and 78 HST. The average percentage of eggplant plant biomass with organic fertilizer factors at the age of 24 HST showed that all treatments had no significant effect. While at the age of 48 and 78 days showed that GM, GM + CC, and GM + BC treatments had a higher biomass compared to other treatments.

The average percentage of biomass with the NPK 16-16-16 factor at 24 HST showed that the concentration of 0 g/l (N0) tends to result in greater biomass than the concentration of 1 g/l to 3 g/l. Entering 48 HST, the concentration of 1 g/l (N1) increased by 20.49%, then 2 g/l (N2) increased by 22.53% and 3 g/l increased by 26.49%, but the concentrations of 1 g/l and 2 g/l were still lower than the concentration of 0 g/l, while the concentration of 3 g/l (N3) had a greater value than 0 g/l (N0). At 78 HST, the concentration of 1 g/l (N1) increased by 37.76%, then 2 g/l (N2) increased by 43.78% and 3 g/l increased by 44.19%, the concentration of 1 g/l was 13.28% lower than that of 0 g/l (N0), while the concentration of 3 g/l (N3) had a greater value than that of 0 g/l (N0).

The eggplant plant biomass on organic fertilizer treatments showed that at 48 HST the treatment of manure + compost composter (GM + CC) resulted in the greatest increase compared to manure + *bio-pore* compost (GM + BC). However, entering 78 HST, the increase in biomass percentage in the treatment of manure + *bio-pore* compost (GM + BC) was greater compared to the manure + compost composter (GM + CC) treatment. This was in contrast with the treatment of composter compost (CC) and *bio-pore* compost (BC) without manure, in the composter compost treatment from 24 HST to 78 HST had a greater increase than *bio-pore* compost on the percentage of biomass.

Inorganic fertilizer with a concentration of 3 g/l tends to have higher biomass than the other concentrations. The concentration of 2 g/l at 24 to 48 HST had a lower value of biomass, but entering 78 HST had an increase in the percentage value of biomass. The concentration of 1 g/l from the beginning to the end had a lower biomass compared to other concentrations. According to Zulkifli *et al*. 2020, goat manure contains cations and anions that can be used by eggplant plants to increase the rate of photosynthesis and have an impact on increasing plant biomass. Aminifard *et al.* 2010 stated that the combination of N, P, and K can encourage growth and biomass production and NPK fertilizer is used to increase eggplant production.

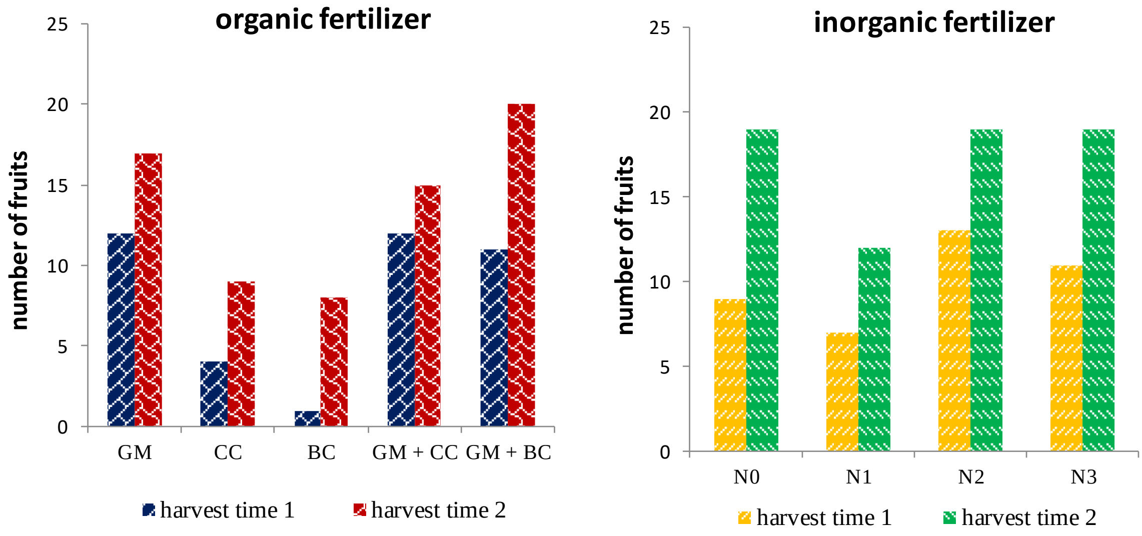


Note: GM: goat manure, CC: composter compost, BC: *bio-pore* compost

Figure 3. The effect of organic fertilizer (a) and inorganic fertilizer (b) on eggplant plant biomass

The analysis results of the eggplant number of fruits showed no significant interaction effect between organic fertilizers and inorganic fertilizers. The average number of eggplant fruits on organic fertilizer in the first harvest time (Figure 4), showed that the treatment of manure (GM) and (GM+CC) was not significantly different from (GM+BC) and higher than the treatment of CC and BC.

The treatment of 1 g/l concentration (N1) tends to result in a lower number of fruits compared to the organic fertilizer treatment. The treatment of 3 g/l concentration resulted in a higher number of fruits than the concentration of 2 g/l (N2) and 0 g/l (N0). According to Hartoyo and Anwar 2018, the increase in the number of fruits per plant is influenced by the role of nutrients such as N, P, and K. Nitrogen acts as a stimulator of overall growth in plants, especially branches, stems, and leaves and functions as a form of chlorophyll, protein, and fat (Lingga and Marsono 2001). In plant growth, nitrogen acts as a constituent of enzymes contained in cells, thus affecting the formation of carbohydrates (Lingga 2000).



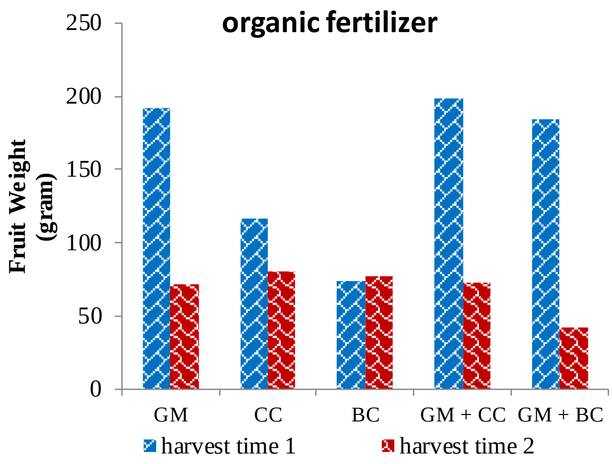
Note: GM: goat manure, CC: composter compost, BC: *bio-pore* compost

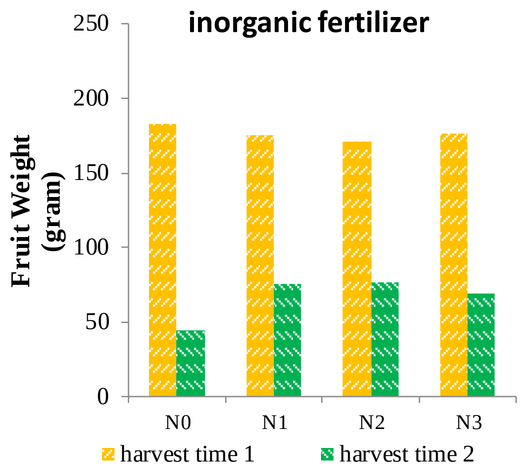
Figure 4. The effect of organic fertilizer (a) and inorganic fertilizer (b) on eggplant number of fruits in two harvest times

The average fruit weight of purple eggplant with respect to organic fertilizer factors depicted in Figure 5 shows that the manure fertilizer (GM) treatment tends to result in a larger total fruit weight compared to other treatments. The manure fertilizer (GM) treatment and the mixture of compost from composters (GM+CC)) at harvest 1 show no significant difference with the compost mixture from biopore compost (GM+BC). Moving into harvest 2, the manure fertilizer (GM) treatment tends to yield larger fruit weights compared to the manure fertilizer mixed with composter compost (GM+CC) and manure fertilizer mixed with biopore compost (GM+BC) (Figure 5).

The treatment with composter compost (CC) tends to result in a larger total fruit weight compared to biopore compost (BC). The composter compost treatment at harvest 1 and harvest 2 tends to yield larger fruit weights compared to biopore compost (BC). The biopore compost treatment at harvest 1 shows the lowest fruit weight, while entering harvest 2, the fruit weight tends to be optimal.

The average fruit weight of purple eggplant with combinations of organic and inorganic fertilizer factors in Figure 9 shows that the concentration of 0 grams in the composter compost mixture (GM+CC) tends to be larger than the biopore compost mixture (GM+BC) and manure fertilizer (GM). Conversely, at a concentration of 1 gram in the biopore compost mixture (GM+BC), it tends to be larger than the composter compost mixture (GM+CC) compared to manure fertilizer (GM). Concentrations of 2 grams and 3 grams in the composter compost mixture and biopore compost mixture treatments tend to be lower than manure fertilizer. The treatment with 2 grams in the composter compost mixture is 32.38% larger than the biopore compost mixture, while the treatment with 3 grams in the composter compost mixture is 25.14% lower than the biopore compost mixture.

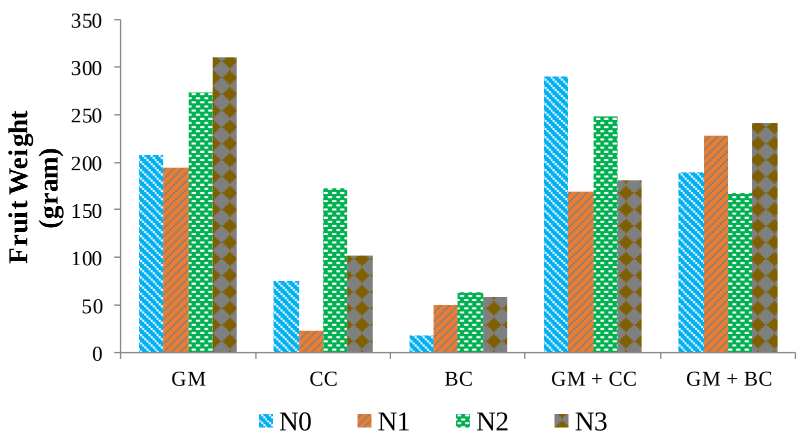




Note: GM: goat manure, CC: composter compost, BC: *bio-pore* compost

Figure 5. The effect of organic fertilizer and inorganic fertilizer on harvest time

The treatment of composter compost (CC) and biopore compost (BC) without manure fertilizer regarding inorganic fertilizer shows that at 0 grams concentration, the composter compost (CC) treatment has a higher value compared to biopore compost. At 1 gram concentration, the biopore compost (BC) treatment shows an increase in fruit weight, while the composter compost shows a decrease. The biopore compost (BC) treatment shows successive increases in fruit weight, whereas the composter compost (CC) treatment experiences a significant increase at the 2 gram concentration (N2), while the 3 gram concentration (N3) shows a decrease in fruit weight (Figure 6).



Note: GM: goat manure, CC: composter compost, BC: *bio-pore* compost

Figure 6. The influence of organic and inorganic fertilizers on fruit weight in purple eggplant plants

According to Hartoyo and Anwar (2018), the increase in fruit weight growth is influenced by the role of nutrients such as N, P, and K. NPK fertilizers can enhance physiological processes that result in increased production in the generative part of the eggplant, particularly in the formation and size of fruits.

Conclusion

The treatments that resulted in the highest value for eggplant plant height growth, number of leaves, increase in biomass, and number of fruits were manure, manure + composter compost, and manure + *bio-pore* compost. Meanwhile, NPK fertilizer with a concentration of 3 grams had the highest value on plant growth and eggplant plant physiology.

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