Effectiveness of Biofertilizer on Growth and Productivity of Eggplant (*Solanum melongena* L.)

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***Abstract*—Objectives of the research were (1) find out the effect of biofertilizer on growth and yield of eggplant (*Solanum melongena* L.), (2) find out the ability of biofertilizer in combinations of different doses of NPK against productivity of eggplant (*Solanum melongena* L.).The research was conducted at Merjosari, Lowokwaru Subdistrict, Malang from November 2016 to February 2017. The research used Randomized Block Design (RBD), as well as 7 treatments and 4 replications for each treatment. Treatments of the research included P0 (Control), P1 (NPK 100 %), P2 (Biofertilizer 100 %), P3 (Biofertilizer 100 % + NPK 25 %), P4 (Biofertilizer 100 % + NPK 50 %), P5 (Biofertilizer 100 % + NPK 75 %), and P6 (Biofertilizer 100 % + NPK 100 %). Parameters of the research were plant height (cm), leaf area per plant (cm^2), numbers of branching, numbers of fruit per plant, fresh weight of fruit (g), dry weight of fruit (g), and RAE. If any significant influence existed, it would be followed by comparative test among treatments using the Least Significant Difference (LSD) at level 5%. Results of the research showed that the application of biofertilizer solely tends to increase number of fruit and weight of fruit, but insignificant. The application of biofertilizer may increase number of fruit and weight of fruit along with the application of NPK, as shown by the application of 25% NPK, which may increase number of fruit up to 5.75 or 196 %, and weight of fruit for about 744.05 g/plant or 206 % in comparison with no application of fertilizer.**

***Index Terms*—food security, sustainable agriculture, marginal land, extensivication**

I. Introduction

Eggplant (*Solanum melongena* L.) is a kind of vegetable that belongs to *Solanaceae* family and it is potential to be developed. Many varieties of eggplant are found in the market, such as Periwi, Kartini, Yumi, and Mustang, as well as inbred and hybrid varieties. Eggplant can be consumed in fresh and processed forms, for example, in many kinds of cooked foods. Vitamin and nutritive contents of eggplant comprise of protein, fat, calcium, phosphor, iron, water, vitamin A, vitamin B, and vitamin C [1]. Based on data from Indonesia has produced 519,481 tons in 2011 and decreased in 2012 that produced 518,787 tons [2].

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Problem that affects productivity of eggplant is low nutrient content due to land degradation as a result of intensive application of inorganic fertilizers without balanced with organic material intake. Continuous application of inorganic fertilizers may increase the amount of heavy metals in the soil and the plant tissues, increase pH of the soil, and disturb soil structure, which affect on the reducing yield and quality of the harvest [3]. Effort to improve the fertilization system can be done by balancing the application between inorganic and organic fertilizers in the soil. One of the ways is the combined application between inorganic fertilizer and biofertilizer.

Biofertilizer is microorganism given to the soil to increase the nutrient taken by the plant from the soil and the air. Microorganisms that contained in biofertilizers include bacteria, fungi, and algae, which bind nitrogen in the atmosphere or converse the soluble phosphate and potassium in the soil and produce the available forms for the plant. Biofertilizer is source of renewed nutrients and environmentally safe in preserving continuation and soil fertility in long-term. Biofertilizer could bind nitrogen in the atmosphere and converse the soluble phosphate 20-40 kg nitrogen per 0.4 ha [4]. The objective of biofertilizer application was to increase soil fertility and efficiency of inorganic fertilizer application in order to create continual agroecosystem. Microbes, which may increase growth are as follow, Nitrogen fixation of non symbiotic bacteria *Azotobacter* sp. and *Azospirillum* sp.; Nitrogen fixation of symbiotic bacteria *Rhizobium* sp.; Phosphate-solubilizing bacteria *Bacillus subtillis*; Phosphate-solubilizing bacteria *Bacillus megaterium* and *Pseudomonas* sp.; microbe decomposer *Cellulomonas* sp.; microbe decomposer *Lactobacillus* sp.; and microbe decomposer *Saccharomyces cereviceae* [5]. Today, more inoculants and microbes are packed in the form of biofertilizer. Objectives of the research were (1) find out the effect of biofertilizer on growth and yield of eggplant (*Solanum melongena* L.), (2) find out the ability of biofertilizer in combinations of different doses of NPK against productivity of eggplant (*Solanum melongena* L.). Hypothesis of the research explained that the application of biofertilizer may reduce the application of inorganic fertilizer efficiently on growth and yield of eggplant (*Solanum melongena* L.).

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II. Materials and Methods

The research was conducted at Merjosari District, Lowokwaru Subdistrict, Malang at the altitude 500 m asl. The temperature ranges 20 - 28 ^{o}C and the rainfall is about 1000 - 1500 mm per year. The research was conducted from November 2016 to February 2017. Equipments used in the research were fruit scissors, tape measure, cutter, plastics, hand sprayer of 2 liter in volume, as well as Nict Voor scales type PS 1200, oven 21037 FNR, and Leaf Area Meter (LAM) type LI – 3100. Materials of the research included eggplant seeds of Mustang F1 variety, NPK fertilizer, soil and goat manure (3:1), biofertilizer of Biopenta, Bio-insecticide of *Beuveria* (Bio Care) and *Mantap* (Microbial Antagonist Plus).

The research used Randomized Block Design (RBD) along with 7 treatments and 4 replications for each treatment. The treatments were without any fertilizer (P0), NPK 100 % (P1), Biofertilizer 100 % (P2), Biofertilizer 100 % + NPK 25 % (P3), Biofertilizer 100 % + NPK 50 % (P4), Biofertilizer 100 % + NPK 75 % (P5), and Biofertilizer 100 % + NPK 100 % (P6). Parameters of the research were plant height (cm), leaf area per plant (cm^2), numbers of branching, numbers of fruit per plant, fresh weight of fruit (g) and dry weight of fruit (g). Assessment on used biofertilizer effectiveness was performed by comparing the obtained results against the tested fertilizers using standard and control treatments.

Data of the research was analyzed using F-test at level 5% in order to find out variance results of the treatments on growth and yield of ornamental chili. If results on analysis of variance showed significant difference, it would be followed by Least Significant Difference (LSD) test at level 5%.

III. Results and Discussions

A. Plant Height

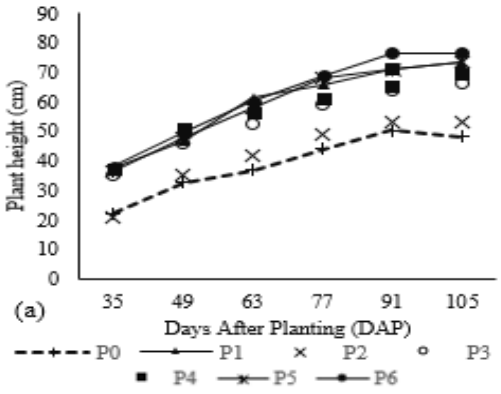

Figure 1. Plant height of eggplant

Applications of NPK 100 %, biofertilizer + NPK 75 % and biofertilizer + NPK 100 % may increase the plant height in comparison with the control starting from 34.24 %, 34.58 %, and 37.14 % (Fig. 1). Increasing plant height along with the application of biofertilizer was due to the ability of bacteria *Rhizobium* sp., *Azotobacter* sp. and *Azospirillum* sp. that could attach nitrogen in the air and become available for the plant, as well as phosphate-solubilizing bacteria *Bacillus subtillis*, *Bacillus megaterium* and *Pseudomonas* sp. N and P play essential roles during the initial phase of the plant's growth. Potential benefit of biofertilizer is the microorganisms, which particularly relate to N and P as the most essential nutrients required by the plant to attach nitrogen and fix it in diverse N_2-fixation systems [6].

B. Leaf Area per Plant

Based on data for average leaf area of eggplant (Fig. 2), leaf area by the treatment of biofertilizer + NPK 100 % showed wider leaf area than other treatments. Treatment of NPK 100 % showed higher yield than the control and biofertilizer. On leaf area, however, biofertilizer + NPK 100 % did not show any significant difference with biofertilizer + NPK 75 % and biofertilizer + NPK 25 % (P3). The application of biofertilizer + NPK 100 % may increase leaf area for about 74.27 %. Meanwhile, the application of NPK 100 % may increase leaf area 73.78 %, biofertilizer + NPK 75 % for about 71.43 % and biofertilizer + NPK 25 % for about 58.11 %. It indicated that the application of biofertilizer and reduced dose of NPK may increase leaf area, so that they may reduce the excessive dose of inorganic fertilizer. N plays actively as one of essential nutrients for the growth of eggplant, such as numbers of leaf and leaf area. Numbers of leaf and leaf area are directly proportional to photosynthetic ability of the plant. If greater numbers of leaf and leaf area were found, they would have better ability to produce photosynthate in all parts of the plant. Sufficient N will increase the plant's ability to form leaf [7].

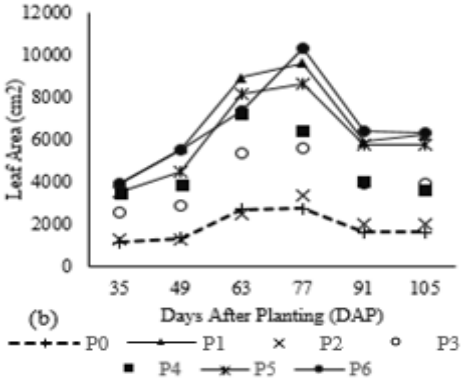

Figure 2. Leaf area of eggplant

C. Number of Branching

Fig. 3 shows that the branching along with the application of biofertilizer + NPK 100 % was better than other treatments, but it did not show significant difference with the treatment of NPK 100 % and

biofertilizer + NPK 75 %. The application of biofertilizer + NPK 100 % may increase numbers of branching 65.22 % in comparison with the application of NPK 100 % for about 61.90 % and biofertilizer + NPK 75 % for about 62.50 %. It was due to biofertilizer and NPK 75 %, as well as 100 % may produce more optimal growth than other treatments, so that the roots will be able to absorb the nutrients more effectively. The application of nitrogen will increase the vegetative growth, particularly on numbers of branch. Nitrogen is beneficial for growth and development of the plant tissues, stimulates branching and productivity of the plant [8].

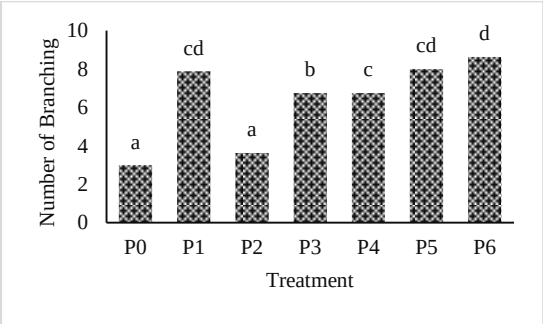

Figure 3. Number of branching of eggplant

D. Number of Fruit per Plant

Results of the research showed that the application of biofertilizer + NPK 100 % may increase number of fruit 82.14 %, biofertilizer + NPK 75 % for about 81.71 % and NPK 100 % for about 78.57 %. Meanwhile, the application of biofertilizer may increase number of fruit for about 42.31% (Table I). Formation and development on numbers of fruit are highly affected by the plant's hormone. Fruit development is highly affected by auxin formation in the growing seeds and other parts of the fruit to supply food reserves in order to increase fruit development. Moreover, microorganisms that produce auxin are *Azotobacter* sp., and *Azosprillium* sp. as microbe, which attaches nitrogen and plays as growth regulator [9].

TABLE I. AVERAGE NUMBER OF FRUIT, FRESH WEIGHT OF FRUIT AND DRY WEIGHT OF FRUIT DUE TO THE APPLICATION OF BIOFERTILIZER AND NPK DOSE

Treatment	Number of Fruit per Plant (piece)		Fresh Weight of Fruit (g/tan)		Dry Weight of Fruit (g/tan)	
P0	1.88	a	243.05	a	17.78	a
P1	8.75	de	1030.38	cde	87.05	cd
P2	3.25	ab	489.26	ab	34.26	ab
P3	5.75	bc	744.05	bc	57.11	bc
P4	7.25	cd	826.76	bcd	64.34	bc
P5	10.25	e	1191.93	de	96.28	d
P6	10.50	e	1400.81	e	105.46	d
LSD 5%	2.79		393.43		30.31	

Notes: Numbers followed by the same letter in the same column do not show significant difference at LSD test of 5%, ns = not significant, dap = days after planting, g = gram, tan = plant, P0 = Control, P1 = NPK in standard dose 100%, P2 = biofertilizer, P3 = biofertilizer + NPK 25%, P4 = biofertilizer + NPK 50%, P5 = biofertilizer + NPK 75%, P6 = biofertilizer + NPK 100%.

E. Fresh Weight of Fruit

Fresh weight of fruit as presented in Table I shows that the application of biofertilizer + NPK 100 % produced higher fresh weight of fruit than other treatments, but it did not show significant difference with the application of NPK 100 % and biofertilizer + NPK 75 %. However, the application of biofertilizer + NPK 100 % may increase fresh weight of eggplant 82.65 % in comparison with NPK 100 % for about 76.41 %, and biofertilizer + NPK 75 % for about 79.61 %. Furthermore, the application of biofertilizer may increase fresh weight of eggplant 50.32 %. It was due to the content level of nitrogen, phosphor, and potassium in NPK 100 %, biofertilizer + NPK 75 % and biofertilizer + NPK 100 % have higher nutrients than other treatments. Nutrient contents, particularly higher nitrogen, may maximize the plant growth especially its height. The higher the plant is, it will increase numbers of branch and leaf. The increasing numbers of leaf will be followed by the increasing amount of chlorophyll.

F. Dry Weight of Fruit

Based on average dry weight of eggplant (Table I), the application of biofertilizer + NPK 75 % and biofertilizer + NPK 100 % produced higher dry weight of fruit than other treatments, but they did not show significant difference with the application of NPK 100 %. Moreover, the application of biofertilizer + NPK 75 % and biofertilizer + NPK 100 % may increase dry weight of fruit for about 81.54 % and 83.15 %, respectively, in comparison with the application of NPK 100 % for about 79.58 %. Meanwhile, the application of biofertilizer was 48.12 %. It was due to the application of NPK 100 %, biofertilizer + NPK 75 % and biofertilizer + NPK 100 % contain high nitrogen, phosphor, and potassium. High nutrient, particularly nitrogen, will make the plants grow optimally. The increase height will be followed by the increase numbers of branch and leaf. More leaves will produce more photosynthates. Distribution of photosynthate to the whole parts of the plant will be utilized for the plant growth and development, not only for vegetative growth, but also the reproductive organs growth [10].

IV. CONCLUSION

Based on results of the research, some conclusions are drawn as follow:

1. The application of biofertilizer solely has not been able to increase components of the plant growth, such as plant height, number of leaf, leaf area and branch, but along with the application of NPK as inorganic fertilizer, 25% to 75%, may increase plant height, number of leaf, leaf area and branch, in comparison with no application of fertilizer. Moreover, the application of biofertilizer + NPK 100% may produce higher leaf area than the treatment of NPK 100 %.

2. The application of biofertilizer solely tends to increase number of fruit and weight of fruit, but insignificant. The application of biofertilizer may increase number of fruit and weight of fruit along with the application of NPK, as shown by the application of 25% NPK, which may increase number of fruit up to 5.75 or 196 %, and weight of fruit for about 744.05 g/plant or 206 % in comparison with no application of fertilizer.

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