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Application of Organic Fertilizer to Increase Growth and Yield of Organic Eggplant (*Solanum melongena*, L.) in Ultisols

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ABSTRACT: *Fertilizer provides nutrients for plant growth and development. In organic farming, organic fertilizer is the only source of plant nutrients instead of synthetic fertilizers. Organic fertilizers include manure, compost, vermicompost, and organic material derived from livestock wastes, plant waste, and weeds. The effectiveness of the fertilization highly depends on the type and dose of organic fertilizer. This study aimed to determine the best combination of organic fertilizer types and doses on the growth and yield of purple eggplant (Solanum melongena, L.).The experimental design was a Completely Randomized Block Design (RCBD) with two factors and replicated three times. The first factor was organic fertilizer, which consisted of chicken manure, cow manure, Wedelia (Wedelia trilobata L.) compost, and Siam weed (Eupathorium odoratum L.) compost. The second factor was the dose of organic fertilizer consisted of 5, 10, and 15 tons/ha. No fertilization was assigned as control. Organic fertilizers increased plant height, stem diameter, the number of leaves, leaves greenness, the number of branches, fresh plant weight, fruit/plant, and fruit weight/plant. Chicken manure exhibited a better growth yield than other types of organic fertilizers. Meanwhile, Wedelia compost and Siam weed compost had a no different effects on plant growth and yield. The dose of organic fertilizer did not affect the growth and yield of eggplant. Chicken manure at a dose of 15 tons/ha yielded the highest plant height and fruit weight*

KEYWORDS -*eggplant, organic farming, organic fertilizer, ultisol*

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I. INTRODUCTION

Fertilization is an essential factor in plant cultivation. Fertilizers determine the growth and yield of plants. There are two types of fertilizers, namely synthetic fertilizers and organic fertilizers. However, the continuous and overuse of synthetic fertilizers can reduce the physical and chemical fertility of the soil, resulting in decreased land productivity and plant growth. The negative impact caused by synthetic fertilizers on the environment and humans can be eliminated by using organic fertilizers. Organic fertilizers not only provide plant nutrients but also improve soil quality [1] [2][3] [4]

Sources of organic fertilizers include plant, animal, and human wastes. Each manure has different characteristics depending on the source, such as chicken, goat, cow, etc. In general, the nutrient content of manure is lower than that of synthetic fertilizers. Chicken manure contains organic-C (26.60%), N (3.80%); P (0.50%), K (2.85%), and S (0.62%). The nutrient content of cow manure is C (20.10%), N (1.62%), P (0.45%), K (0.29%) and S (0.55%) [5]

Although the nutrient content is relatively low, manure can improve soil fertility and provide nutrients for plant growth and yield. Chicken manure increases soil N, P, and K content and eggplant growth and yield [6]. [7] reported that chicken manure at a dose of 40 tons/ha increased plant height, number of leaves, number of branches, number of fruits, and fruit weight of purple eggplant plants. Cow manure also increased soil N, P, and K content [8] and eggplant growth and yield [9]. Cow manure at a dose of 15 tons/ha increased crop yields. Besides manure, another type of organic fertilizer is compost.

Compost is a decomposition of plants, animals, and organic waste. Sources of organic compost are from various types of plants, including weeds such as Wedelia (*Wedelia trilobata* L.) and Siam weed (*Chromolaenaodorata* L.). Wedelia compost contains 21.50% Organic-C, 2.17% N, 0.44% P, 2.01% K, 0.17% S, and 18.61% lignin [5]. Wedelia compost at a 20 tons/ha dose resulted in higher growth and yield of sweet corn than vermicompost, water hyacinth compost, and leaf litter compost [10]. The application of wedelia compost at a dose of 23 tons/ha increased the growth and yield of green mustard, indicated by an increase in the number of leaves, crown length, crown fresh weight, and plant fresh and dry weight [11]. Siam weed compost

contains 34.40% Organic-C, 2.42%N, 0.26%P, 1.6% K, 1.04% S, and 13.50% lignin [5]. Siam weed compost and Wedelia compost also increased the growth and yield of corn [12]. [13] reported that Siam weed compost at a dose of 10 tons/ha produced 15.61 tons/ha of shallots, while Siam weed compost at 0.5 g/plant increased the growth of oil palm seedlings [14].

This study aims to determine the best type and dose of organic fertilizer on the growth and yield of purple eggplant and determine the combination between the type and dose of organic fertilizer on the growth and yield of purple eggplant.

II. METHODOLOGY

The research was carried out from March 2019 to July 2019 at the Department of Agricultural Production, Faculty of Agriculture, Bengkulu University. The soil at the study site was Ultisols with a pH ranging from 4-5 and Histosols with a pH ranging from 5-6.The design used in this study was a Completely Randomized Block (RCBD) with two factors and replicated three times. The first factor was organic fertilizer consisting of chicken manure, cow manure, Wedelia compost, and Siam weed compost. The second factor was the dose of organic fertilizer consisting of 5, 10, and 15 tons/ha. The control treatment was without fertilization.

The size of the plots was 3.5 m x 2.5 m (length x width), the distance between the plots was 0.5 m. Organic fertilizer was applied a week before planting. Seedlings were planted at a 75 cm x 50 cm spacing. The plant was watered to maintain soil moisture. Pest, including insects, diseases, and weeds, was manually controlled. Eggplant was harvested eight weeks after planting (WAP).

The variables observed included plant height, stem diameter, number of leaves, leaf greenness, fresh crop weight, fruit length, fruit diameter, fruit weight, number of fruit per plant, and fruit weight per plant. Data were analyzed using analysis of variance (ANOVA), F test at 5% level. Treatment mean separation was tested using DMRT (Duncan's Multiple Range Test) at the 5% level.

III. RESULTS AND DISCUSSION

During the course of the study, the average water availability was low indicated by rainfall for four months. The first two months the rainfall about 90 mm/month; however, the rainfall dropped to 61mm in the third month and even lower at the end of the experiment. Even though the eggplant was watered, apparently water availability was not sufficient for water requirement for the plant growth, mainly at the end of the experiment.

The study showed that eggplant growth had an average plant height of 49.79 cm, stem diameter 0.60 cm, leaf number 10.45, leaf greenness 49.00, number of branches 3.08, and plant weight 54.14 g. This result was lower than those reported by [15], where the height of eggplant var. Mustang reached up to 68.69 cm with the number of leaves of 47.92.[16] also indicated that the variety has a plant weight of 161.46 g. Table 1. shows the average growth and yield of eggplant.

Table 1. The growth and yield of eggplant

No	Variables	Max	Min	Average	StD	CV (%)
1	Plant height (cm)	85.00	17.22	49.79	13.13	9.49
2	Stem diameter (cm)	1.15	0.25	0.60	0.24	23.77
3	Leaves number	34.33	2.44	10.45	6.45	43.15
4	Leaves greenness	62.33	36.52	49.00	5.52	8.87
5	Number of branches	7.30	0.18	3.08	2.08	41.15
6	Plant weight (g)	236.67	10.00	54.14	47.42	57.43
7	Fruit length (cm)	17.00	8.75	12.57	1.91	16.29
8	Fruit diameter (cm)	4.16	2.45	3.45	0.42	13.15
9	Fruit weight (g)	125.00	20.00	69.18	25.62	42.03
10	Number of fruit/plant	6.06	1.00	3.30	1.66	37.13
11	Fruit weight/plant (g)	459.09	22.50	201.41	115.70	38.43

Note: Max= maximum, Min = minimum, StD = Standard Deviation, CV = Correction Factors

This study also showed that eggplant fruit length was 12.57 cm, fruit diameter 3.45 cm, fruit weight 69.18 grams, number of fruit/plants 3.30, and fruit weight/plant 201.41 g. This result is lower than its potential

yield of the similar variety in which the variety fruit length is 24 cm, fruit diameter 5 cm, fruit weight 150-200 g, number of fruit/plant 25, and fruit weight/plant 4-5 kg.

Analysis of variance showed an interaction between the type and dose of organic fertilizer on plant height and fruit weight/plant. The type of organic fertilizer significantly affected plant height, stem diameter, number of leaves, leaves greenness, number of branches, crops weight, number of fruit/plant, and fruit weight /plant. Meanwhile, the dose of organic fertilizer only had a significant effect on stem diameter (Table 2).

Table 2. F-calc. of variables plant growth and the yield of eggplant on various types and doses of organic fertilizers.

No	Variable	F-calc.			
		Block	OF type	OF dose	Interaction
1	Plant height	7.16**	46.67**	3.24ns	10.3**
2	Stem diameter	21.63*	3.45*	10.09**	0.62ns
3	Leaves number	9.23**	5.51**	1.43ns	1.72ns
4	Leaves greeness	3.11ns	6.04**	0.29ns	1.06ns
5	Number of branches	17.14**	7.41**	0.47ns	2.23ns
6	Crop weight	12.29**	6.45**	1.58ns	1.81ns
7	Fruit length	1.30ns	0.21ns	1.65ns	0.54ns
8	Fruit diameter	2.12ns	0.32ns	0.66ns	0.43ns
9	Fruit weight	1.35ns	0.06ns	0.83ns	0.47ns
10	Number of fruit/plant	3.97**	4.05**	0.31ns	2.23ns
11	Fruit weight/plant	4.85**	4.11**	0.01ns	4.03*

Note: *= significantly different at 5% level, ns= not significantly different at 5% level, OF = organic fertilizer

The Combination Effects of Type and Dose of Organic Fertilizer on Plant Height and Fruit Weight.

The study indicated that chicken manure at a dose of 15 tons/ha produced higher plants than doses of 5 and 10 tons/ha, while the different doses of cow manure and Siam Weed compost did not affect plant height. Wedelia compost at a dose of 5 tons/ha had higher plants (54.07 cm) than the doses of 10 and 15 tons/ha (Table 3).

Table 3. Interaction of type and dose of organic fertilizer on plant height (cm).

Fertilizer types	Dosage ton/ha		
	5	10	15
Chicken manure	55.62 b A	56.03 b A	79.33 a A
Cow manure	54.70 a A	58.18 a A	53.92 a B
Wedelia compost	54.07 a A	40.63 b B	40.67 b C
Siam weed compost	44.44 a A	40.63 a B	40.70 a C

Note: the numbers followed by the same letter in the same column (capital letter) and row (lowercase) are not significantly different in the 5% DMRT test.

Chicken manure and cow manure applied at 10 tons/ha produced higher plants than Wedelia compost and Siam weed compost at the same dose. Meanwhile, chicken manure at a dose of 15 tons/ha produced a higher plant height (79.33 cm) than the other three types of organic fertilizers (Table 3). The application of manure, both chicken manure and cow manure, at a dose of 15 tons/ha produced higher plants than Wedelia and Siam weed compost.

Chicken manure at a dose of 15 tons/ha produced the highest plant (79.33 cm). This might have been related to the N contribution by chicken manure for plants growth and development. Chicken manure contains highest N content (3.8%), while in cow manure (1.62%), Wedelia compost (2.17%), and Siam weed compost (2.42%) [5]. Nitrogen deficiency in plants lowers plant growth. The process of photosynthesis is disrupted so that plants do not develop normally [17]. The results of this study are in line with [18] where the application of chicken manure at a dose of 20 tons/ha resulted in the highest plant growth rate, leaf area, and plant dry weight.

Table 4. Combination Effects of type and dose of organic fertilizer on fruit weight (g)

Fertilizer types	Dosage ton/ha		
	5	10	15
Chicken manure	185.27 c A	297.47 a A	259.3 b A
Cow manure	123.75 a B	168.75 a B	224.3 a B
Wedelia compost	251.38 a A	129.16 a B	87.5 a C
Siam weed compost	-	125.00 a B	118.75 a B

Note: the numbers followed by the same letter in the same column (capital letter) and row (lowercase) are not significantly different in the 5% DMRT test.

The fruit weights were not significantly different in cow manure, Wedelia compost, and Siam weed compost at doses of 5, 10, and 15 tons/ha. However, chicken manure at a dose of 10 tons/ha produced a higher fruit weight (297.47 g) than the doses of 15 tons/ha (259.3 g) and 5 tons/ha (185.27 g). Chicken manure at doses of 10 and 15 tons/ha produced the highest fruit weight/plant of 297.47 g and 259.3 g, respectively, compared to those of cow manure, Wedelia compost, or Siam weed compost at the same doses (Table 4).

Chicken manure at a dose of 10 tons/ha produced a higher fruit weight/plant than the other treatments (297.47 g (Table 4). This result is associated with the higher nutrient content of chicken manure than cow manure, Wedelia compost, and Siam weed compost. The nutrient availability leads to better plant growth, causing higher crop yield. [19] reported that organic fertilizer, cow bio urine in combination with NPK fertilizer increased the number of fruits, fruit weight, fruit length, and eggplant fruit diameter.

Effect of Organic Fertilizers Types on the Growth and Yield of Eggplant

In general, the application of organic fertilizers improved plant growth, as indicated in Table 5. The application of organic fertilizers improved plant growth, despite the lack of water during the experiment. Compared to control treatment, application of organic fertilizer increased plant height by 13.6 cm (Siam weed compost) to 35.33 cm (chicken manure), Stem diameter by 0.05 cm (cow manure) to 0.25 cm (chicken manure), the number of leaves by 0.5 (Siam weed compost) to 9.4 (chicken manure); the number of branches by 0.4 (Siam weed compost) to 3.2 (chicken manure), and fresh plant weight by 3.02 g (Siam weed compost) to 66.72 g (chicken manure) (Table 5).

Table 5. Effect of organic fertilizer types on eggplant growth

Fertilizer types	Plant height (cm)	Stem diameter (cm)	No of leaves	Leaves greenness	No of branches	Crop weight (g)
Control	28.34 d	0.47 b	6.9 b	46.64 b	1.8 b	31.67 b
Chicken manure	63.67 a	0.72 a	16.3 a	54.89 a	5.0 a	98.39 a
Cow manure	55.61 b	0.52 b	10.4 b	49.15 b	3.1 b	53.09 b
Wedelia compost	45.13 c	0.54 b	8.8 b	46.82 b	2.5 b	37.90 b
Siam weed compost	41.93 c	0.65 ab	7.4 b	45.94 b	2.2 b	34.69 b

Note: the numbers followed by the same letter in the same column are not significantly different at the 5% DMRT test.

A previous study showed that cow manure increased plant height and fruit number of eggplant [20]. [21] reported that solid organic fertilizer of oil palm waste at a dose of 34 tons/ha increased the growth and yield of eggplant. Vermicompost at 30 g/plant increased the number of fruits, and at 90 g/plant increased the number of leaves and stem diameter of eggplant [22], while Siam weed compost at a dose of 0.5 kg/plant increased the growth of oil palm seedlings[14].

In this study, the improvement of eggplant growth may have been related to the soil conditions after applying the organic fertilizer. Nutrient content in selected organic fertilizer is reflected in Table 6.

Table 6. Nutrient content of N, P, and K in several types of organic fertilizers

Fertilizer types	N (%)	P (%)	K (%)
Chicken manure	3.80	0.50	2.85
Cow manure	1.62	0.45	0.29

Wedelia compost	2.17	0.44	2.01
Siam weed compost	2.42	0.26	1.6

Source : Sismiyanti, et al. (2018)

The application of organic fertilizers can improve the soil chemical, biological, and physical properties. Bokashi Wedelia increases the C-organic content of the soil and soil moisture and replaces the role of synthetic fertilizers[23]. Wedelia and Siam Weed compost can also replace the role of synthetic N fertilizer in chili plants [24]. [8] reported that the application of compost and manure increased organic C, soil N content, soil aggregate stability, soil porosity, moisture content, and soil pH but decreased soil density and bulk density.

Other studies also confirmed that organic matter in the soil increased soil cation exchange capacity, a source of macro and micronutrients, retains nutrients due to leaching, forms organic bonds to microelements Fe, Zn, Mn to remain available to plants. It also had good buffering capacity against changes in soil pH, increased soil CEC and neutralizes pesticide residues in the soil [25].

Biologically, organic matter in the soil supports microbial growth, thereby improving soil aeration, providing energy for soil microbial life, increasing the activity of microorganisms (soil microbes), and improving soil health [25]. The soil physical, chemical, and biological fertility greatly determine the productivity of vegetable crops in the dry land. Therefore, the application of organic matter in dryland can increase eggplant plant growth. Chicken manure improves plant growth performance better than other organic fertilizers because chicken manure contains higher macronutrients (N, P, and K).

The application of chicken manure can increase soil N, P, and K levels and the growth and yield of purple eggplant [6]. In contrast to plant growth, yield and yield components did not show significant differences due to the application of organic fertilizers (Table 6). The decomposition and demineralization of organic matter require water. Underwater shortage conditions, the decomposition and mineralization of organic matter are hampering so that plants cannot utilize the nutrients contained in organic fertilizers. In the early stages of growth, plants can use the nutrients produced by the mineralization process. However, these nutrients are no longer sufficient to support fruit formation and development.

Table 7. Effect of type of organic fertilizer on yield and yield components

Fertilizer types	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g/buah)	Fruit number per plant	Fruit weight per plant (g)
Control	13.04	3.56	72.23	4.5 a	299.58 a
Chicken manure	12.26	3.49	68.96	4.1 a	247.35 ab
Cow manure	12.98	3.52	71.77	2.7 ab	179.70 ab
Wedelia compost	12.49	3.28	67.54	3.2 ab	169.64 b
Siam weed compost	12.41	3.45	65.62	2.0 b	122.92 b

Note: the numbers followed by the same letter in the same column are not significantly different at the 5% DMRT test.

Effect of Organic Fertilizer Dosage on Eggplant Growth and Yield

The decomposition of organic fertilizer in the soil is highly dependent on the availability of soil moisture. Low soil moisture will lower the decomposition process. The higher dose of organic fertilizer did not influence plant growth (Table 8 and 9). Under water shortage conditions, the availability of nutrients for plant growth is restricted. During plant productive, plants need more nutrients for the process of forming and filling fruit, so the limited availability of nutrients due to lack of water cause flowers and ovules to fall, and the fruit cannot develop properly [26]. The growth performance, yield, and yield components of plants are presented in Table 8 and Table 9.

Table 8. Effect of organic fertilizer dosage on eggplant growth.

Dosage	Plant height (cm)	Stem diameter (cm)	Leaves number	Leaves greenness	Branch number	Crop weight (g/plant)
0 ton/ha	28.34	0.47 b	6.9	46.63	1.8	31.66
5 ton/ha	52.21	0.48 b	9.4	49.12	3.1	44.72
10 ton/ha	48.87	0.59 ab	12.4	48.55	3.6	67.31
15 ton/ha	53.65	0.74 a	10.4	49.90	0.2	56.1

Note: the numbers followed by the same letter in the same column are not significantly different at the 5% DMRT test.

Table 9. Effect of organic fertilizer dosage on eggplant yield.

Dosage	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Fruit number	Fruit weight (g/plant)

0 ton/ha	13.04	3.56	72.23	4.5	299.58
5 ton/ha	11.56	3.28	60.02	3.5	194.68
10 ton/ha	12.53	3.47	67.14	3.2	193.13
15 ton/ha	13.41	3.55	78.69	2.9	193.84

Note: the numbers followed by the same letter in the same column are not significantly different at the 5% DMRT test.

Tables 8 and 9 show that eggplant plants fertilized with different doses had no significant effect on plant growth and yield except for stem diameter. Due to lack of water, plant height, stem diameter, number of fruits, the greenness of leaves, number of branches, fresh plant weight, fruit length, fruit diameter, fruit weight, number of fruit per plant, and fruit weight per plant were much lower than the description of Mustang variety eggplant. The length and width of the stomata on eggplant leaves decrease in the lack of water[27]. [16] reported that increasing the dose of manure resulted in the growth and yield of purple eggplant varieties Mustang and Antaboga, which were not significantly different. Plant height, the number of leaves, stem diameter, plant weight, and fruit weight did not increase with increasing doses of organic fertilizer. Besides environmental factors, the application method of organic fertilizers also affects the growth and development of plants[28].

IV. CONCLUSIONS

1. Organic fertilizers increase plant height, stem diameter, number of leaves, leaves greenness, number of branches, fresh plant weight, fruit/plant, and fruit weight/plant.
2. Application of chicken manure provided better growth performance than other types of organic fertilizer. Meanwhile, Wedelia compost and Siam weed compost had no different effects on plant growth and yield.
3. The dose of organic fertilizer did not affect the growth and yield of eggplant.
4. Chicken manure at a dose of 15 tons/ha yielded the highest plant height and fruit weight.

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