The Effect of Eggshell Organic Fertilizer on Vegetative Growth of Cayenne Pepper (*Capsicum frutescens* L)

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Robert Devi Anugrah[1], Rafvenia[1]*, Meitiyani[1], Luthpi Safahi[2]

[1]Biology Education, University of Muhammadiyah Prof. DR. HAMKA, Jakarta, Indonesia 13830

*rafvenia123@gmail.com

Abstract. The large demand for cayenne pepper makes farmers need to make efforts to increase crop production by increasing the efficiency of using fertilizers. The alternative fertilizer comes from household waste, namely egg shells. This study aims to determine the effect of eggshell organic fertilizer on vegetative growth of cayenne pepper (*Capsicum frutescens* L.). The research method used was an experimental method using a completely randomized design (CRD) with 6 treatments and 5 replications. The treatments were P0 (control), P1, P2, P3, P4, and P5 respectively, the treatment of eggshell organic fertilizer with a dose of 0; 45; 60; 75; 90; and 105 g. The treatments were given 3 days after transplanting and harvesting the plants 35 days after transplanting. Data for each parameter was tested for normality, homogeneity test, and analyzed by 1 factor ANOVA. Furthermore, the LSD test was carried out to determine the difference in effect between treatments. The best application of eggshell organic fertilizer was P4 treatment for parameters of root length and plant wet weight, respectively, 20.10 cm and 17.96 g, and P5 treatment for parameters of plant height and plant dry weight, respectively 54.80 cm and 3.00 g. The percentage of root length and wet weight of P4 treatment plants to control were 130.52% and 269.67%, respectively, while the percentage of plant height and dry weight of P5 treatment plants to control were 139.79% and 282.49%, respectively. The application of eggshell organic fertilizer can increase the vegetative growth of cayenne pepper.

1. Introduction

Vegetables and fruits have a role to supply the various needs of vitamins and minerals that are needed by the human body (Hansen, H., 2009; Wang, W., et.al. 2020). Therefore, the demand for vegetables and fruit continues to increase. One type of vegetable that has a fairly complete mineral and vitamin content is cayenne pepper (Del Río-Celestino, M. & Font, R., 2020).

The cayenne pepper plant known with its scientific name as *Capsicum frutescens* L. is a shrub that is in demand by the public because the cayenne pepper has a spicy taste. This spicy taste comes from the *capsaicin* compound. *Capsaicin* itself is a chemical that can cause a burning sensation at certain nerve receptors, so that the brain responds in the same way as the heat response (Haque, S.M. & Biswajit Ghosh. 2018). According to Cervantes-Hernández, et.al. (2019) *Capsaicin* can stimulate the release of endorphins which can relieve pain and cause a healthier feeling. Cayenne pepper which is often consumed by the public turns out to contain various substances that the body needs, namely vitamin A, vitamin B1, vitamin C, and important mineral salts such as calcium, phosphorus, and iron (Lingga, 2012).

The large demand for cayenne pepper on the market makes farmers need to make efforts to increase the production of cayenne pepper. One of the efforts that can be done is to increase the efficiency of fertilizer usage.

Fertilizer is a material that is added to the planting medium or plants to meet the nutrient needs for plants to reproduce well. Currently, it is highly recommended in agriculture to use organic fertilizers rather than inorganic fertilizers because the use of inorganic fertilizers would have a bad impact if given continuously (Lingga & Marsono, 2013; Brankov, M., et.al., 2020.). Organic fertilizers are made from raw materials mostly or wholly derived from organic materials such as plants and animals which have gone through an engineering process; solid or liquid. They are used to supply organic materials and to improve the physical, chemical and biological properties of the soil.

Various kinds of organic materials can be used in producing organic fertilizers, one of which is derived from household waste, namely egg shells (Lertchunhakiat, Krittiya, et.al., 2016). At present, egg shells are only waste that has no economic value, meaning that after the inside of the eggs is removed, the eggshells are usually thrown away. In fact, more than that, according to Butcher & Miles (2015), eggshells contain about 2.2 grams of calcium in the form of calcium carbonate. The average egg shell contains about 0.3% phosphorus and 0.3% magnesium and a small amount of sodium, potassium, zinc, manganese, iron and copper. The high calcium content has the potential to be used as organic fertilizer for plants.

The high calcium content in egg shells can function to activate the formation of root and seed hairs and strengthen the stems. Calcium can also be used to neutralize adverse soil conditions and compounds (Hadisuwito, 2012; Bartter, J., 2018). As explained by Rahmadina (2017), fertilizers from eggshell waste that have complete nutrients can have high selling value and can compete in the international market. Moreover, they can also be used as a producer of environmentally friendly products.

Noviansyah (2015)'s research shows that the application of organic fertilizer mixed with eggshell and MSG waste with the addition of onion skin with a concentration of 7.5% has a good effect on the growth of curly red chili plants. Isniati (2009)'s study showed that compost with an addition of eggshell flour resulted in an average NPK percentage of N = 0.675%, P = 49.53%, and K = 0.767%. Research by Nurjayanti et al., (2012) showed that eggshells can be used as a substitute for lime to increase the pH of alluvial soils. Providing eggshell flour and taro compost can provide the same growth and yield of red chili plants to alluvial soils.

Therefore, to reduce the amount of waste that can cause environmental pollution, an environmentally friendly organic fertilizer needs to be produced with natural ingredients, namely egg shells. It is hoped that the use of egg shells as an organic fertilizer containing high enough calcium can increase the productivity and quality of growth of cayenne pepper plants, which can increase the production of cayenne pepper.

2. Methodology

Tools and Materials

The tools used in this study included seedling tray pots, 30 pieces of 20 × 20 cm polybags, digital scales, dry waste crusher/copper for crushing egg shells, oven for drying samples, hand sprayer, and ruler for measuring data.

The materials used in this study included cayenne pepper (*Capsicum frutescens* L.), Pelita F1 varieties obtained from agricultural shops, 15 kg of manure, 15 kg of red soil, 3 kg of eggshell waste obtained from household waste, and water.the literature review will be compiled based on the Systematic Literature Review.

Research Design

The method used in this research was an experimental method, using a completely randomized design research design (CRD) with 6 treatments and 5 replications. The treatments were P0 (control), P_1, P_2,

P_3, P_4, and P_5 s respectively. Meanwhile, eggshell organic fertilizer were treated with various doses, namely 0; 45; 60; 75; 90; and 105 g.

Research procedure

Preparation

The preparation phase involved collecting 3 kg of eggshell waste, which were then washed thoroughly and dried in the hot sun. After drying, the egg shells were kneaded until they were crushed. Afterwards, they were then crushed into flour using a dry waste crusher/copper and sieved to obtain a fine shell flour (Isniati, 2009).

The seeds were placed on the seeding medium and watered regularly using a hand sprayer. After growing uniformly, the seeds were transferred into polybags measuring 20 × 20 cm.

Implementation

The third day after moving the plant to polybags, powdered eggshells were spread evenly over the ground surface of the cayenne pepper. Eggshell flour was administered only once during the study and was carried out in the afternoon. Watering the plants was done 2 times a day, namely in the morning and evening.

Observation

Observations were made 35 days after transplanting with the parameters measured, namely plant height, root length, plant wet weight, and plant dry weight.

Data Collection

The measurement of plant height and root length was carried out using a ruler. To get the wet weight, the roots of the plants were washed clean and were then weighed with digital scales. Dry weight was obtained by drying the plants in the oven and then weighing them with a digital scale until a constant dry weight was obtained.

Data Analysis

Data analysis in this study used 1 factor ANOVA followed by the LSD test to determine the difference in effect between treatments.

3. Result and Discussion

The results of the research on the effect of giving eggshell organic fertilizer on growth parameters (plant height, root length, wet weight, and dry weight) of cayenne pepper (*Capsicum frutescens* L.) are listed in table 1.

Table 1. Results of average growth of cayenne pepper at various doses of eggshell organic fertilizer aged 35 HSPT

Dose (g)	Plant Height (cm)	Root Length (cm)	Wet Weight (g)	Dry Weight (g)
P_0 (0)	39,2^{a}	15,4^{a}	6,66^{a}	1,06^{a}
P_1 (45)	45,0^{abc}	18,1^{ab}	9,40^{ab}	1,48^{ab}
P_2 (60)	43,0^{ab}	17,8^{ab}	10,12^{ab}	1,56^{ab}
P_3 (75)	49,6^{bc}	19,9^{b}	14,66^{bc}	2,42^{bc}
P_4 (90)	53,6^{c}	20,1^{b}	17,96^{c}	2,99^{c}
P_5 (105)	54,8^{c}	19,4^{b}	17,14^{c}	3,00^{c}

Note: Numbers followed by the same superscript indicate that they are not significantly different

Data in Table 1 show that the response given by cayenne pepper to eggshell organic fertilizer varied widely. This is indicated by the fact that the cayenne pepper plant had varying growth rates for each treatment.

Plant Height

Based on the data presented in table 1, the lowest average height of cayenne pepper was shown by control plants with a value of 39.2 cm. After that there was an increase in P_1 with a value of 45.0 cm. However, there was a decrease back in P_2 with an average of 43.0 cm compared to treatment P_2. Meanwhile, P_3, P_4, and P_5 continued to increase with values of 49.6 cm, 53.6 cm, and 54.8 cm respectively. P_5 treatment gave the highest effect on plant height with an average value of 54.8 cm.

The normality test showed that the data on the height of the cayenne pepper was normally distributed. The results of the homogeneity test showed that the height data of the cayenne pepper had homogeneous variants. ANOVA 1 factor test showed that giving egg shells had a significant effect on the height growth of cayenne pepper.

The LSD test results showed that giving eggshells as organic fertilizer on the control results (P_0) was significantly different from P_4 and P_5, significantly different for P_3, but not significantly different for P_1 and P_2. P_1. was not significantly different from P_2, P_3, P_4, and P_5. P_2 was significantly different from P_4 and P_5, but not significantly different from P_3. P_3 was not significantly different from P_4 and P_5. P_4 is not significantly different from P_5. High percentage of treatment cayenne pepper 45; 60; 75; 90; and 105 g of eggshell organic fertilizer to control were 114.79; 109.69; 126.53; 136.73; and 139.79% respectively.

Plant Root Length

Based on the data presented in table 1, the lowest average root length of cayenne pepper was shown by control plants with a value of 15.4 cm. Then, there was an increase in P_1 with a value of 18.1 cm. There was also a decrease in the value of P_2 with a value of 17.8 cm compared to treatment in P_1. In the P_3 and P_4 treatments, there was an increase in the values of 19.9 cm and 20.1 cm respectively. Treatment P_5 decreased its value to 19.4 cm, but had a better average than control plants. The P_4 treatment gave the highest effect on the root length of the plant with an average value of 20.1 cm.

The normality test showed that the root length data of cayenne pepper was normally distributed. The homogeneity test showed that the root length data of cayenne pepper had homogeneous variants. One factor ANOVA test showed that giving egg shells had a significant effect on root length growth of cayenne pepper.

The LSD test explained that giving eggshells as organic fertilizer to the control results (P0) was significantly different from P_3 and P_4, significantly different from P_5, but not significantly different from P1 and P2. P1 was not significantly different from P2, P_3, P_4, and P_5. P2 was not significantly different from P_3, P_4, and P_5. P_3 was not significantly different from P_4 and P_5. P_4 was not significantly different from P_5. The percentage of root length of cayenne pepper treatment 45; 60; 75; 90; and 105 g of eggshell organic fertilizer to control were 117.53; 115.58; 129.48; 130.52; and 125.97% respectively.

Plant Wet Weight

Data presented in table 1 showed the lowest average wet weight of cayenne pepper by control plants with a value of 6.66 g. It continued to increase in P_1, P_2, P_3, and P_4 with the mean values of 9.40; 10,12; 14.66; and 17.96 g respectively. However, in the P_5 treatment the average value obtained decreased to 17.14 g, but had a higher value than the control treatment, namely 6.66 g. P4 treatment gave the highest effect on plant wet weight with an average value of 17.96 g.

The normality test showed that the wet weight data for cayenne pepper was normally distributed. The results of the homogeneity test showed that the wet weight data of the cayenne pepper had a homogeneous variation. One factor ANOVA test showed that giving eggshells had a very significant effect on the growth of wet weight of cayenne pepper.

The LSD test results showed that giving eggshells as organic fertilizer on the control results (P0) was significantly different from P_3, P_4 and P_5, but not significantly different from P_1 and P_2. P_1 was significantly different from P_4 and P_5, but not significantly different from P_2 and P_3. P_2 was significantly different from P_4 and P_5, but not significantly different from P_3. P_3 was not significantly different from P_4 and P_5. P_4 is not significantly different from P_5. The percentage of wet weight of cayenne pepper treatment 45; 60; 75; 90; and 105 g of eggshell organic fertilizer towards control were 141.14; 151.95; 220.12; 269.67; and 257.36% respectively.

Plant Dry Weight

Data presented in table 1 showed that the lowest average dry weight of cayenne pepper was shown by control plants with a value of 1.06 g. Then, all treatments increased with the average value of treatment P_1, P_2, P_3, P_4, and $P_5$with the average value of 1.48; 1.56; 2.42; 2.99; and 3.00 g respectively. P5 treatment gave the highest effect on plant dry weight with an average value of 3.00 g.

The normality test showed that the dry weight data of cayenne pepper was normally distributed. The results of the homogeneity test showed that the dry weight data of the cayenne pepper had homogeneous variants. One factor ANOVA test showed that giving eggshells had a very significant effect on the dry weight growth of cayenne pepper plants.

The LSD test explained that giving eggshells as organic fertilizer to the control results (P_0) was significantly different from P_4 and P_5, significantly different from P_3, but not significantly different from P_1 and P_2. P_1 was significantly different from P_5, significantly different from P4, but not significantly different from P2 and P3. P2 was significantly different from P_4 and P_5, but not significantly different from P_3. P_3 was not significantly different from P_4 and P_5. P_4 was not significantly different from P5. The percentage of dry weight of treatment cayenne pepper 45; 60; 75; 90; and 105 g of eggshell organic fertilizer to the control were 139.74; 147.27; 227.50; 281.54; and 282.49% respectively.

Control plants showed the lowest yields on parameters such as plant height, root length, wet weight, and plant dry weight compared to plants treated with eggshell organic fertilizer. This is because the plants only absorb the nutrients present in the growing media without providing additional nutrients. As the plants' needs for nutrients cannot be fulfilled optimally, the growth and metabolic activity of the cayenne pepper plant is disrupted and its development is hampered. In accordance with Lakit (2011), if the availability of nutrients is less than the amount needed by plants, the plant's metabolism will be disturbed, which can be seen visually from irregularities in its growth.

The height of the cayenne pepper treatment P5 (dose 105 g) gave the best results. This is due to the availability of nutrients in the form of nitrogen and manganese elements at optimal levels, which makes the absorption of these elements in accordance with what cayenne pepper plants need.

As explained by Lingga & Marsono (2013), nitrogen plays a role in the formation of green leaves which is useful in the process of photosynthesis as it functions to stimulate overall growth, especially stems, branches and leaves, alongside forming protein, fat, and various other organic compounds. The element manganese plays a role in helping the photosynthesis process, the formation of several plant enzymes, the formation of various vitamins, and the absorption of nitrogen by roots from the soil.

Root length of cayenne pepper treatment P_4 (dose 90 g) gave the best results. This is possible because the phosphorus and calcium content in the eggshell organic fertilizer have met the nutritional needs of the cayenne pepper plant roots.

The benefits of phosphorus in plants are to transport metabolic energy in plants, stimulate flowering, stimulate root growth, stimulate seed formation, and stimulate plant cell division and enlarge cell tissue. The function of calcium for plants is to activate the formation of root and seed hairs and to strengthen the stems. Calcium can be used to neutralize adverse soil conditions and compounds (Hadisuwito, 2012).

Wet weight of cayenne pepper treatment P_4 (dose 90 g) gave the best results. This is due to the availability of nitrogen, potassium and magnesium in sufficient quantities for the growth of cayenne

pepper. Nitrogen is needed for the growth of cayenne pepper during vegetative growth and plays a role in forming cells, tissues and plant organs.

Potassium element functions to help form protein and carbohydrates and to strengthen the plant, making leaves not falling off easily. It can also be a source of strength for plants to deal with drought and disease. Magnesium plays a role in helping chlorophyll work, where all plants receive the same nutrients in all parts of the plant (Lingga & Marsono, 2013).

Dry weight of cayenne pepper treatment P_5 (dose 105 g) gave the best results. This is due to the availability of nitrogen and magnesium in optimal amounts, making the growth of cayenne pepper plants is effective. Nitrogen and magnesium elements play a role in the formation of green leaves which are useful in the photosynthesis process (Lingga & Marsono, 2013).

According to Advinda (2018), the dry weight parameter is often considered more significant than the wet weight parameter. This is understandable because the increase in wet weight may be due to water absorption, so changes in wet weight can occur due to changes in water absorption by plants. However, after photosynthesis occurs, there is an increase in dry weight which indicates ongoing growth.

4. Conclusion

Eggshell organic fertilizer affects the growth of cayenne pepper (*Capsicum frutescens* L.). The application of eggshell organic fertilizer that gave the best results was P_4 with an average value of root length and plant wet weight, 20.1 cm and 17.96 g respectively, or 130.52% and 269.67% to the control. The application of eggshell organic fertilizer also gave the best results in the P_5 treatment with an average value of plant height and plant dry weight, 54.8 cm and 3.00 g respectively, or 139.79% and 282.49% of the control.

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