

Comparison of Applications of Various Organic and Inorganic Fertilizers on the Growth and Yield of Cayenne Pepper

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Abstract

Cayenne pepper is one of the agricultural commodities that has high economic value and its demand continues to increase along with the development of the population. Efforts to increase the production and quality of various types of plants continue to be carried out, by utilizing various types of fertilizers. The purpose of this study was to determine the response of growth and yield of cayenne pepper using organic and inorganic fertilizers. This research was carried out at the Experimental Garden of the Local Waste Processing Site in Kusamba Village, Klungkung Regency, and the Laboratory of the Agrotechnology Study Program, Faculty of Agriculture, Warmadewa University, Denpasar from March to November 2021. The method used in this study was experimental, using a Randomized Block Design (RBD) with 1 factor and 4 replications. The variables observed were plant height, number of leaves, stem diameter, number of fruit, fruit weight per plant, and fruit weight per ha. The results showed that the application of various types of fertilizers can increase all observed variables. The best fertilizer for the growth and yield of cayenne pepper is NPK fertilizer.

Keywords: Organic fertilizer; household waste; compost; biochar; chili

1. Introduction

Cayenne pepper (*Capsicum frutescens* L.) is a plant from the Solanaceae family. Cayenne pepper is one of the agricultural commodities that have high economic value and its demand continues to increase along with the development of the population. Chili plants have a relatively long life and can bear fruit many times both in the rainy and dry seasons. Efforts to increase the production of chili plants can be done with good maintenance including providing various nutrients needed for growth and development. The use of organic fertilizers and inorganic fertilizers on chili plants can provide better growth [1]. However, for better results, the application of organic and inorganic fertilizers should not be combined [2].

Now the use of organic fertilizers is a step to reduce the use of chemical fertilizers because the use of chemical fertilizers without being balanced with organic fertilizers will cause nutrient degradation on agricultural land which will result in a decrease in production yields. To overcome this problem, the replacement of chemical fertilizers with organic fertilizers is the right solution [3]. In line with the principles of sustainable agriculture stated by [4] that the use of organic fertilizers will help reduce dependence on inorganic fertilizers (NPK). According to [5] the use of organic fertilizers is very important in the growth of plants, vegetables, flowers, and fruits because organic fertilizers can increase growth and good quality for all plants.

The use of organic matter is the most effective way, besides being able to reduce costs, organic fertilizers can restore macro and micronutrients in the soil and increase agricultural production [6]. Organic fertilizers can be made using waste that is in the environment around us such as

agricultural waste and livestock waste [7]. We can find organic materials such as compost, green manure, manure, crop residues (straw, stove, corn cobs, sugar cane bagasse, and coconut fiber), livestock waste, industrial waste, and household waste [8]. Organic fertilizers made from household waste have begun to be developed to improve the quality of agricultural land, especially to restore various soil nutrients and minerals [9]. One of them is organic fertilizer produced by the Local Waste Processing Center (TOSS) in the Klungkung area of Bali, namely the processing of household waste or plant litter that is processed into organic fertilizer by local farmers. According to [10] that waste recycling can be done through the composting process, compost has good benefits for plants, besides that compost can replace soil organic matter, and maintain porosity and soil fertility.

The availability of nutrients can also be achieved by the addition of biochar mixed with manure, able to improve the physical and chemical properties of the soil to increase the growth and production of chili plants [11]. The use of biochar as a soil ameliorant is the right way to achieve sustainable agriculture [12]. [13], [14] stated that the application of biochar was able to increase the organic C present in the soil, and was also able to improve the physical and chemical properties of the soil (nutrient retention of N, P, K, Ca, and Mg). C-organic is a functional part of organic matter which plays an important role in improving the physical, chemical, and biological properties of soil [15]. Biochar is a carbon-rich solid material produced by heating biomass with a limited oxygen supply [16]. The biochar used in this study is the result of burning household waste which is made into pellets and used as fuel for power plants.

Inorganic fertilizer is a type of compound fertilizer that contains N (nitrogen), P (phosphorus), and K (potassium). The NPK element contained in it is 15% where this element is needed during the vegetative phase of plants [17]. The imbalance in the use of NPK fertilizers in the long term will affect the microbial life in the soil [18]. Good methods and management in chili cultivation will determine the success of chili production and yield [19]. In addition, the selection of the right chili varieties can contribute to the success of organic products which results in high-quality chili production [20]. This study aims to determine the response of growth and yield of cayenne pepper using organic fertilizer combined with biochar and NPK fertilizer.

2. Materials and Methods

This research was conducted at the Experimental Garden of the Local Garbage Processing Site in Kusamba Village, Klungkung Regency, and the Laboratory of the Agrotechnology Study Program, Faculty of Agriculture, Warmadewa University, Denpasar from March to November 2021. Soil and fertilizer testing were carried out at the Soil Science Laboratory, Udayana University. The materials used are cayenne pepper seeds, TOSS fertilizer, Bio Alam Asri organic fertilizer, and NPK fertilizer. Planting is done in the afternoon, and application of TOSS fertilizer, TOSS + biochar fertilizer, and natural bio-fertilizer is given a week before planting at a dose of 20 tons/ha. For plant maintenance, the installation of stakes is carried out to help plants grow upright, reducing physical damage to plants due to fruit loads and wind. Pruning of water shoots was carried out at the age of 15, 30, and 45 DAP. Harvesting is done when the chilies are red. Harvesting is done 5 times.

The variables observed were: plant height (cm), number of leaves (strands), stem diameter (mm), number of fruit planted (fruit), the weight of fruit planted (g), and weight of harvested fruit/ha (tons). The data obtained from the results of this study were statistically processed by analysis of variance (ANOVA), whereas if the results of the variance showed a significant effect, it was continued with the Duncans test.

3. Results and Discussion

The significance of the effect of the application of various types of fertilizers on large red chili plants is presented in Table 1. From table 1 it can be seen that the effect of the type of fertilizer treatment has a very significant effect ($P < 0.01$) on all observed variables.

Table 1. Significance of the effect of application of various types of fertilizers on cayenne pepper plants

No	Variable	Treatment Fertilizer Type
1	Plant height 28 days after planting (cm)	**
2	Plant height 42 days after planting (cm)	**
3	Plant height 56 days after planting (cm)	**
4	Number of leaves 21 days after planting (strands)	**
5	Number of leaves 28 days after planting (strands)	**
6	Number of leaves 35 days after planting (strands)	**
7	Stem diameter 63 days after planting (mm)	**
8	Stem diameter 70 days after planting per plant (mm)	**
9	Number of fruit per plant (fruit)	**
10	Planting fruit weight (g)	**
11	Fruit weight per hectare (tons)	**

Information: * = significant effect ($P < 0.05$), ** = very significant effect ($P < 0.01$), ns = not significant ($P \geq 0.05$)

a. Initial soil test results, TOSS compost fertilizer, and commercial organic fertilizer

Initial soil testing and TOSS compost were carried out at the Soil Science Laboratory, Faculty of Agriculture, Udayana University (Table 2). The results of the soil test showed that the pH value of the soil H₂O was 7.2. This indicates that the soil conditions tend to be neutral. The DHL value shows 1.89 mhos/cm, which means that the soil is not included in the saline category. The C-Organic content of the soil showed a result of 2.02%, which was included in the medium category. N total shows a value of 0.1%, into the low category. The available P content shows the results of 119.16 ppm, which is in the high category. The available K results show a value of 250.34 ppm, which is in the very high category. The air-dry moisture content showed a value of 3.49% and a field capacity of 43.86%. sand content of 41.27%, silt 38.33%, and clay 20.41% included in the category of clay texture.

Table 2. Soil Test Results, TOSS Compost Fertilizer, and Asri Natural Bio Organic Fertilizer

Parameter	Soil	TOSS Compost Fertilizer	Asri Natural Bio Fertilizer
	Grade	Grade	Grade
pH H ₂ O	7.2	7.3	8.19
DHL	1.89 mmhos/cm	1.21 mmhos/cm	-
C Organic	2.02%	20.63%	25.18%
N total	0.1%	0.62%	1.49%
P available	119.16 ppm	350.81 ppm	2.01%
K available	250.34 ppm	426.17 ppm	1.99%
Water Content	Air Dry 3.49%	5.88%	-
Texture	Field Capacity 43.86%	-	29.16%
	Sand 41.27%		
	Dust 38.33%		
	clay 20.41%		

The results of the TOSS compost fertilizer test showed a pH value of 7.3 H₂O, this was included in a neutral condition. The DHL value is 1.21 mhos/cm. The C-Organic content of the fertilizer showed a yield of 20.63%, which was included in the very high category. N total shows a value of 0.62%, into the high category. The available P content shows the results of 350.81 ppm, in the very high category. The available K results show a value of 426.17 ppm, which is in the very high category. The dry air moisture content shows a value of 5.88%.

Asri Natural Bio Organic Fertilizer testing was carried out at the Testing Laboratory of BPTP NTB. The test results of Bio Alam Asri organic fertilizer show a pH value of H₂O 8.19, this is included in the alkaline category. The C-organic content of the fertilizer showed a yield of

25.18%, which was included in the very high category. N total shows a value of 1.49%, into the high category. The available P content showed a result of 2.01%, falling into the very high category. The available K results show 1.99%, which falls into the very high category. And 29.16% field capacity.

The soil test aims to determine the availability of nutrients in the soil [21]. In general, soil organic matter describes the fertility, stability, and level of soil erosion. Soil pH describes the threshold for physical and chemical activity. Nitrogen, phosphate, and potassium, describe the nutrients available to plants [22]. Fertilizer can be used as a soil enhancer, increasing microorganisms in the soil and supporting sustainable agricultural production [23]. Fertilization management needs to be applied to maximize the nutrient content in the fertilizer [24]. Fertilizers supply food for plants and help increase the yield of different crops by improving soil fertility. Fertilization not only increases the yield of the first crop in a rotation but also provides benefits for subsequent crops [25].

b. Plant Height

The results of the analysis are in Table 3. Show that there is a significant difference between the treatments given to the maximum plant height at the age of 28 DAP, 42 DAP, and 56 DAP. The maximum plant height at 28 DAP was found in the NPK fertilizer treatment, which was 39.38 cm, while the lowest was in the control treatment, which was 28.94 cm. Observations of maximum plant height at the age of 42 days after planting were found in the NPK treatment, which was 82.19 cm, while the lowest was in the control treatment, which was 61.25 cm. Likewise, the observation of maximum plant height at the age of 56 days after planting was found in the NPK treatment, which was 117.81 cm while the lowest was in the control treatment, which was 99.38 cm.

Table 3. The average plant height was 28 DAP, 42 DAP, and 56 DAP, in the type of fertilizer treatment.

Treatment	Plant Height (cm)		
	28 DAP	42 DAP	56 DAP
Control	28.94 b	61.25 b	99.38 b
TOSS Compost Fertilizer	33.19 a	72.63 a	110.00 a
TOSS Compost Fertilizer + Biochar	34.50 a	74.75 a	112.69 a
Asri Natural Bio Fertilizer	35.88 a	77.50 a	114.91 a
NPK Fertilizer	39.38 a	82.19 a	117.81 a

Note: The numbers followed by the same letter in the same column are not significantly different in Duncans' 5% test

A study [26] that the use of NPK fertilizer had a significant effect on the age of 42 days on cayenne pepper plants. According to [27] the growth of cayenne pepper can be influenced by the addition of organic matter. One of the organic materials, namely biochar, can give a significant effect on plant height, total wet weight per plant, and total oven-dry weight per plant [28]. In the vegetative growth of plants, namely the growth of leaves, stems, and roots, the main nutrient needed is N [29].

c. Number of Leaves

Table 4 shows that there was a significant difference between the treatments given in observing the maximum number of leaves at the plant. The maximum number of leaves at the age of 21 days after planting was obtained in the NPK treatment, which was 16.44 leaves, while the lowest was in the control treatment, which was 11.44 leaves. The maximum number of leaves at the age of 28 days after planting was obtained in the NPK fertilizer treatment, namely 23.75 strands while the lowest in the control treatment was 18.44 strands. Likewise, in observing the maximum number of leaves at the age of 35 days after planting, the NPK treatment gave the highest number of leaves, namely 42.31 leaves, while the lowest was in the control treatment, which was 31.50 leaves.

Table 4. The average number of leaves was 21 DAP, 28 DAP, and 35 DAP in the type of fertilizer treatment.

Treatment	Number of leaves (strands)		
	21 DAP	28 DAP	35 DAP
Control	11.44 b	18.44 b	31.50 b
TOSS Compost Fertilizer	13.06 a	20.50 a	36.13 a
TOSS Compost Fertilizer + Biochar	14.44 a	21.56 a	37.13 a
Asri Natural Bio Fertilizer	15.50 a	23.00 a	39.13 a
NPK Fertilizer	16.44 a	23.75 a	42.31 a

Note: The numbers followed by the same letter in the same column are not significantly different in the Duncans 5% test

Leaf growth is part of vegetative growth, where the most needed nutrient plays a role, namely nitrogen (N). According to [30] that the application of compost and biochar can increase the number of leaves on cayenne pepper plants. Leaves are the main organ where photosynthesis takes place. According to [31] that organic fertilizer from urban waste can increase the number of leaves of chili plants because it has high availability of nutrients such as N, P, K, and a low C/N ratio. It was observed [1] that the application of organic and inorganic fertilizers had a significant effect on plant height and the number of leaves.

d. Stem Diameter

The results of the analysis in Table 5 show that there is a significant difference in the average stem diameter of the plantations. The stem diameter at the age of 63 days after planting was highest in the NPK fertilizer treatment, which was 15.02 mm, while the lowest was in the control treatment, which was 12.61 mm. In the observation of plant age 70 days after planting, the highest average stem diameter was found in the NPK fertilizer treatment, namely 17.85 mm, and the lowest in the control treatment, namely 14.85 mm. [32] stated that the use of solid organic fertilizer had a significant effect on stem diameter of cayenne pepper, number of fruits per plant, and fruit weight per plant.

Table 5. The Average stem diameter of 63 DAP and 70 DAP in the treatment of this type of fertilizer.

Treatment	Stem Diameter (mm)	
	63 DAP	70 DAP
Control	12.61 b	14.85 d
TOSS Compost Fertilizer	14.24 a	15.31 c
TOSS Compost Fertilizer + Biochar	14.56 a	16.25 bc
Asri Natural Bio Fertilizer	14.93 a	16.98 ab
NPK Fertilizer	15.02 a	17.85 a

Keterangan: Angka-angka yang diikuti oleh huruf yang sama pada kolom yang sama adalah tidak berbeda nyata pada uji Duncans 5%

The use of compost mixed with biochar can increase the growth and production of cayenne pepper plants because compost can provide nutrients needed by plants while biochar can maintain nutrient balance and improve soil conditions [33]. [34] also stated that increased growth and yield of plants can be achieved by using compost because compost can increase enzyme activity, microbial activity, respiration, and availability of nutrients for crops. The application of compost gave a significant effect on plant height, flowering time, and harvest age. Meanwhile, the application of NPK fertilizer increased stem diameter, fruit length, and fruit weight. The application of NPK fertilizer tends to increase crop yields when compared to the application of compost [35].

e. Number of fruits, fruit weight, and fruit weight per hectare

Based on the results of the variance, it was found that the application of various fertilizers had a very significant effect on the number of fruit planted, the weight of the fruit planted, and the weight of the fruit per hectare. The average number of fruit planted, the weight of fruit planted and the weight of fruit per hectare with various fertilizer treatments can be seen in Table 6.

Table 6. The average number of fruit, fruit weight, and fruit weight per hectare in the type of fertilizer treatment.

Treatment	Number of fruits per plant (fruit)	Planting fruit weight (g)	Fruit weight per hectare (tons)
Control	20.88 b	617.10 c	6.17 c
TOSS Compost Fertilizer	26.49 a	785.25 b	7.85 b
TOSS Compost Fertilizer + Biochar	27.76 a	905.90 ab	9.06 ab
Asri Natural Bio Fertilizer	28.85 a	914.95 ab	9.15 ab
NPK Fertilizer	29.63 a	918.23 a	9.18 a

Note: The numbers followed by the same letter in the same column are not significantly different in the Duncans 5% test

Based on Table 6 above, it can be seen that the treatment of various types of fertilizers has a significant effect on the number of plants planted. The highest number of fruit was found in the NPK fertilizer treatment reaching 29.63 fruit and the lowest fruit was in the control, namely 20.88 fruit. The highest fruit weight in the NPK fertilizer treatment reached 918.23 g, while the lowest in the control treatment was 617.10 g. Likewise for fruit weight per hectare, in the NPK fertilizer treatment, the highest fruit weight per hectare reached 9.18 tons/ha while the lowest was in the control treatment, which was 6.17 tons.

The use of NPK fertilizer in chili plants can meet macro-nutrient needs during the formation of flowers, seeds, and fruit and helps the formation of carbohydrates, proteins, fats, and other compounds [36]. According to [37] that optimal absorption of NPK fertilizer was able to increase the number of flowers. NPK fertilizer will help chili plants to produce chlorophyll which will later give greener leaves, and stronger stems, plants will be more resistant to disease and drought, increase root system growth, stimulate flower growth and increase fruit size [38]. The dose of fertilizer given is also very influential on the number of flowers, number of fruit, plant wet weight, and wet weight of cayenne pepper fruit [39]. [40] also added that the application of NPK fertilizer could increase the weight of the fruit planted and the number of fruit planted on the cayenne pepper plant.

4. Conclusion

Based on the data obtained, the type of fertilizer treatment had a very significant effect ($P < 0.01$) on all observed variables. Based on observations, the maximum height of the plant was obtained with NPK treatment reaching 117.81 cm, commercial organic fertilizer 114.91 cm, TOSS + Biochar organic fertilizer 112.68 cm, and TOSS organic fertilizer 110.00 cm. The maximum number of leaves in the plant was obtained from treatment with NPK fertilizer, namely 42.31 strands, commercial organic fertilizer 39.13 strands, TOSS + Biochar organic fertilizer 37.13 strands, and TOSS organic fertilizer 36.13 strands. The highest plant stem diameter was obtained from the treatment of NPK fertilizer, namely 17.85 mm, commercial organic fertilizer 16.98 mm, TOSS + Biochar organic fertilizer 16.25 mm, and TOSS organic fertilizer 15.31 mm. The highest number of fruit crops was obtained in the treatment of NPK fertilizer, which was 29.63 fruit, commercial organic fertilizer was 28.85 fruit, organic fertilizer TOSS + Biochar 27.76 fruit, and organic fertilizer TOSS 26.49 fruit. The highest fruit weight was obtained from NPK fertilizer treatment, namely 918.23 g, commercial organic fertilizer at 914.95 g, TOSS + Biochar organic fertilizer at 905.90 g, and TOSS organic fertilizer at 785.25 g. The highest fruit weight per hectare was obtained from NPK fertilizer treatment of 9.18 tons/ha, commercial organic fertilizer at 9.15 tons/ha, TOSS + Biochar organic fertilizer at 9.06 tons/ha and TOSS organic fertilizer at 7.85 tons/ha.

Acknowledgments

The author would like to thank the Klungkung Regency Government, Bali Province for being allowed to conduct research in Kusamba Village, precisely at the Local Waste Processing Site (TOSS) as well as testing the organic fertilizer produced by TOSS. The authors also thank all

lecturers and friends of the Master of Agricultural Sciences for their guidance and direction, and also for their support so that the authors can complete this research properly.

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