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The Effects of Organic and Inorganic Fertilizers on Red Chili Plants

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Abstract

Red chili is one of the commodity crops grown in Indonesia. One of the factors that affect the production of red chili plants is fertilization. The application of organic fertilizer affects the yield and growth of red chili plants. This study aims to determine the response of the growth and development of red chili plants to the application of organic and inorganic fertilizers combined with biochar. This study 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 from March to November 2021. Soil and fertilizer testing were carried out at the Soil Science Laboratory, Udayana University. The study used an experimental method, the experimental design used was a one-factor randomized block design with 4 replications/block. The parameters observed were plant height, number of leaves, stem diameter, number of fruit per plant, fruit weight per plant, and fruit weight harvested per hectare. Based on the data obtained, the type of fertilizer treatment had a very significant effect on all observed variables except for plant height at 21 DAP per plant, the number of leaves at 21 DAP per plant, and the number of leaves at 28 DAP per plant had a significant effect on the treatment given. The application of NPK fertilizer gave the best results on all parameters except for the stem diameter parameter. On the stem diameter parameter, the application of asri nature fertilizers gives the best result. Control treatment (without fertilizer) gave the lowest yield in all observations.

Keywords: growth; horticulture

1. Introduction

Red chili (*Capsicum annum*) is a plant that belongs to the *Solanaceae* plant family. Red chili is a vegetable commodity that cannot be abandoned by people in every life. High demand every day because red chili is a strategic commodity. Waste is an important problem and must be considered by the world [1]. Waste is the remaining material that is disposed of from production and household products that are no longer used. Waste is divided into 2 parts, namely organic and inorganic. The rest of the material in the form of waste generated by human activities is dominated by organic waste, which is 80% per day of the total waste generated. For this reason, if this waste is managed properly, it will provide great benefits to human life by reducing, reusing, and recycling [2]. The reuse of household material waste so that the volume of material wasted is small, even non-existent or zero is one way to reduce piles of waste [3]. The organic waste provides essential nutrients for plants and maintains soil fertility and stimulates plant growth and yield [4].

Plant growth, yield, and quality can be affected by various cultural practices, although performance depends primarily on their genetic structure [5]. In the future, the crop will depend on

the scope of increasing the optimal amount of organic fertilizer, crop absorption, and utilization under tropical conditions, pest and disease attacks, yield, and price of production [6]. Efforts to increase the production and quality of various types of plants continue to be carried out, including the use of various types of fertilizers. Recently, the use of organic fertilizers has been increased and the use of chemical fertilizers has been reduced [7].

Organic waste is a significant part of municipal solid waste [8]. The discovery of fertilizers made from household waste has begun to be developed to improve the quality of agricultural land, especially to restore various nutrients and soil minerals [9]. Likewise, fertilizers are produced by community farmers or local governments from the processing of household waste or plant litter, one of which is fertilizer produced by the local garbage processing center in the Klungkung area of Bali. The use of organic fertilizers can improve soil organic carbon [10]. Sources of organic fertilizer raw materials are available in large quantities including waste, both household waste, restaurants, agricultural markets, livestock, and other types of organic waste. Organic waste can not only be made into compost or solid fertilizer. Organic waste can also be made from organic liquid fertilizer which has many benefits also for composting. Organic fertilizers are very important for the growth of plants, vegetables, flowers, and fruits because organic fertilizers provide good growth with superior quality for all plants [11]. The C/N ratio of organic matter is considered a key parameter in assessing the degree of mineralization and the pattern of nutrient release [12]. Organic fertilizers release nutrients more slowly than NPK fertilizers [13].

Organic fertilizers have the necessary nutrients for better development. The suitability and usefulness of organic fertilizers are due to the availability of high NPK content, which can increase the fertility of agricultural soil. They also act as substrates for soil microorganisms causing increased activity of decomposing microbes in the soil thereby increasing organic matter and releasing nutrients for plant uptake. They can improve the physical properties of the soil [14]; [15]. Organic matter is a safe source of plant nutrients with no detrimental effects on plants and soil [16]. The organic management system results in increased soil organic matter and N levels due to the incorporation of animal manure and compost [17].

Organic farming is one method that takes a long time to produce good and environmentally friendly agricultural production [18]. NPK fertilizer is one of the commercial fertilizers sold in the market. The application of NPK fertilizer can help meet the needs of big red chilies after transplanting and other critical stages. However, the application ratio of the three components in fertilizers differs according to the type of crop and soil. The imbalance in the N-P-K ratio in the soil can be exacerbated by repeated fertilization in monoculture systems which can result in disturbances to the soil ecosystem [19].

The addition of biochar can be done to increase plant growth so that it can grow optimal biochar can bind carbon, produce very porous fiber and charcoal, and can hold nutrients and water in the soil [20]. Research [21], [22], the application of biochar to the soil can increase C levels, retention of water and nutrients in the soil, and can restore soil fertility. The biochar used in this study is the result of burning household waste which is made into pellets and used as fuel for power generation. Selection of the right chili varieties with the application of appropriate cultivation and management practices can contribute to the success of organic production resulting in the production of high-quality chili [23]. This study aims to determine the response of the growth and development of red chili plants to the application of organic and inorganic fertilizers combined with biochar.

2. Materials and Methods

This research used an experimental method, with the experimental design used was a one-factor randomized block design with 4 replications/block. The factors studied were the type of organic fertilizer, NPK, and control factors. The treatment was tested using experimental plots. 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 from March to November 2021. Soil and fertilizer testing were carried out at the Soil Science Laboratory, Udayana University.

The ingredients used are big chili seeds. The fertilizers used are organic waste fertilizer, Asri Natural Bio (ANB) Fertilizer, and NPK, fertilizer from organic waste + biochar, and this organic fertilizer is given a week before planting at a dose of 20 tons/ha. The composition of the results of the analysis of the physical and chemical properties of these fertilizers can be seen in table 2.

For plant care, stakes are installed to support the plants so they don't collapse and pruning of water shoots is done at the age of 15, 30, and 45 Day After Planting (DAP). Observations of plant growth were carried out from 14 DAP to 56 DAP and harvest observations started from 63 DAP to 100 DAP. Harvesting is done when 90 percent of the chilies change color from green to red. Harvesting is done 5 times.

The variables observed were plant height, number of leaves, stem diameter, number of fruit per plant, fruit weight per plant, and fruit weight harvested per hectare. The data obtained from the results of this study were statistically processed by analysis of variance (ANOVA), meanwhile, if the results of the variance show a significant effect, it is continued with Duncan's 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. In Table 1 it can be seen that the type of fertilizer treatment had a very significant effect ($P<0.01$) on all observed variables except plant height at 21 DAP per plant, the number of leaves at 21 DAP per plant, and the number of leaves at 28 DAP per plant had a significant effect ($P<0.05$) to the treatment given.

Table 1
Significance of the effect of application of various types of fertilizers on large red chili plants

No	Variable	Treatment Fertilizer Type
1	Plant height 21 DAP per plant (cm)	*
2	Plant height 42 DAP per plant (cm)	**
3	Plant height 63 DAP per plant (cm)	**
4	Number of leaves 21 DAP per plant (sheet)	*
5	Number of leaves 28 DAP per plant (sheet)	*
6	Number of leaves 35 DAP per plant (sheet)	**
7	Stem diameter 63 DAP per plant (mm)	**
8	Stem diameter 70 DAP per plant (mm)	**
9	Number of fruits per plant (g)	**
10	Fruit weight per plant (g)	**
11	Fruit weight per plant (ton)	**

Note : * = have a real impact ($P<0,05$), ** = very real effect ($P<0,01$), ns = not real ($P\geq0,05$)

3.1 Initial Soil Test Results and Organic Waste Fertilizer

The results of the soil test showed that the pH value of the soil H_2O was 7.2. This indicates that the soil conditions tend to be neutral. The salinity value shows the number 1.89 mmhos/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 is a medium category. Total Nitrogen shows a value of 0.1%, which falls into the low category. The phosphorus available content shows the results of 119.16 ppm, it is the high category. The potassium available results show a value of 250.34 ppm, it is a very high category. Air dry moisture content shows a value of 3.49% and a field capacity is 43.86%. The content of sand is 41.27%, dust 38.33%, and clay 20.41% belong to the category of clay texture (Table 2).

Table 2
Initial Soil Test Results and Organic Waste Fertilizer

Parameter		Units	Soil	Organic Waste Fertilizer	Asri Nature Fertilizer
			Results	Results	Results
pH H_2O			7.2	7.3	8.9
Salinity		mmhos/cm	1.89	1.21	-
C Organic		%	2.02	20.63	25.18
Nitrogen Total		%	0.1	0.62	1.49
Phosphorus Available		ppm	119.16	350.81	2.01
Potassium Available		ppm	250.34	426.17	1.99
Water Content	Air Dry	%	3.49	5.88	-
	Field Capacity	%	43.86		29.16
Texture	Sand	%	41.27		
	Dust	%	38.33		
	clay	%	20.41		

The results of the organic waste fertilizer test show the pH value of H_2O 7.3, this is included in the neutral condition. The salinity value shows 1.21 mmhos/cm. The C-organic content of the fertilizer showed a yield of 20.63%, this is a very high category. The total Nitrogen value shows 0.62%, which is in the high category. The phosphorus available content shows 350.81 ppm, which falls into the very high category. The potassium available results show 426.17 ppm, which falls into the very high category. The air-dry moisture content shows a value of 5.88%.

Asri nature bio-organic fertilizer testing was carried out at the Testing Laboratory of BPTP NTB. The test results of asri nature biofertilizer show a pH value of H_2O 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.

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 [24]. Fertilization management needs to be applied to maximize the nutrient content in the fertilizer [25]. Fertilizers supply food to plants and help increase the yield of different crops by improving soil fertility [26]. Fertilization not only increases the yield of the first crop in a rotation but also provides benefits for subsequent crops [27].

3.2 Maximum Height per Plant

Plant height observations were made 3 times. Based on the observational data in Table 3, it was found that there were differences in results in each treatment. At 21 DAP there was a significant difference between organic waste fertilizer and organic waste fertilizer added with biochar, while in

the treatment of biochar with commercial fertilizer and NPK fertilizer there was no significant difference. This indicates that the addition of biochar can increase plant growth. According to [28] the ability of biochar, which is useful in maintaining moisture, can help plants in times of drought, can act as a trigger for plant growth, and maintain nutrients in the soil so that nutrients in the soil are not easily lost in the leaching process in the soil and will ultimately affect yield increases. We all know that when nutrients are supplied through inorganic or organic forms, yields and crop quality increase significantly [29]. However, if the availability of nutrients is less than the amount needed by the plant, then the metabolism will be disturbed, which can be seen visually from the irregularity of its growth. [30]. At 42 DAP there was a significant difference between the fertilizer treatments given. Plants treated with organic fertilizer had a plant height of 62.69 cm, a plant height for organic waste+Biochar fertilizer treatment was 64.25 cm, a commercial organic fertilizer treatment had a plant height of 68.81, and a plant height for NPK fertilizer treatment was 67.56 cm. At 63 DAP, there was a significant difference between waste organic fertilizer and organic waste + biochar fertilizer. Meanwhile, between organic waste+Biochar organic fertilizers, commercial fertilizers, and NPK fertilizers, there was no significant difference. Organic matter added to sandy soil can promote plant growth [31].

Table 3
The Average Plant Height 21 DAP, 42 DAP, and 63 DAP, in the Treatment of Fertilizer Types.

Fertilizer Treatment	Plant height (cm)		
	21 DAP	42 DAP	63 DAP
Control	37.54 b	59.81 d	77.25 b
Organic waste	39.46 ab	62.69 cd	83.13 ab
Organic waste+biochar	40.18 a	64.25 bc	84.69 a
Asri nature bio	41.52 a	68.81 a	88.38 a
NPK	41.21 a	67.56 ab	88.63 a

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

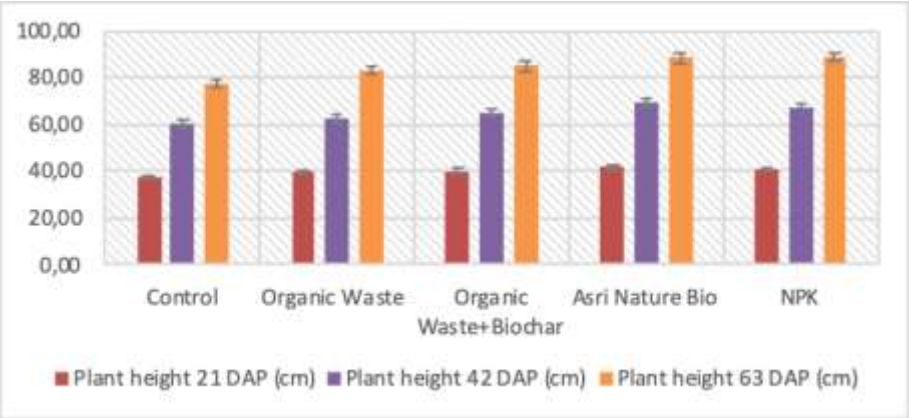

Figure 1
The Average Plant Height 21 DAP, 42 DAP, and 63 DAP, in the Treatment of Fertilizer Types

3.3 Maximum Number of Leaves per Plant

Based on Table 4, the maximum number of leaves showed an increase in each observation. At 21 DAP the highest number of leaves was found in the organic fertilizer treatment organic waste + biochar with 42.31 and the lowest was found in the control treatment without treatment with 35.69.

At 28 DAP the highest number of leaves was found in the NPK treatment with 68.81 and the lowest was found in the control treatment with 43.77. At 35 DAP the highest number of leaves was found in the NPK treatment with 134.06 strands and the lowest was in the control treatment with 100.44. The application of organic fertilizers can also affect the growth of plant leaves [32]; [33]. The number of leaves produced is greatly influenced by the application of different organic fertilizers [34]. Mineral nutrition has a good effect on the growth of red chili. Nitrogen is an important part of chlorophyll and helps in protein synthesis. The increase in the number of leaves per plant occurs because of the adequate amount of nitrogen provided by the environment and balanced nutrition for plants [28].

Table 4

Average Number of Leaves 21 DAP, 28 DAP, and 35 DAP on Types of Fertilizer Treatment.

Treatment	Number of Leaves (sheet)		
	21 DAP	28 DAP	35 DAP
Control	35.69 b	43.77 c	100.44 d
Organic waste	41.88 a	53.38 bc	112.88 cd
Organic waste+biochar	42.31 a	56.13 ab	123.85 abc
Asri nature bio	40.50 ab	56.46 ab	134.02 ab
NPK	41.56 a	68.81 a	134.06 a

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

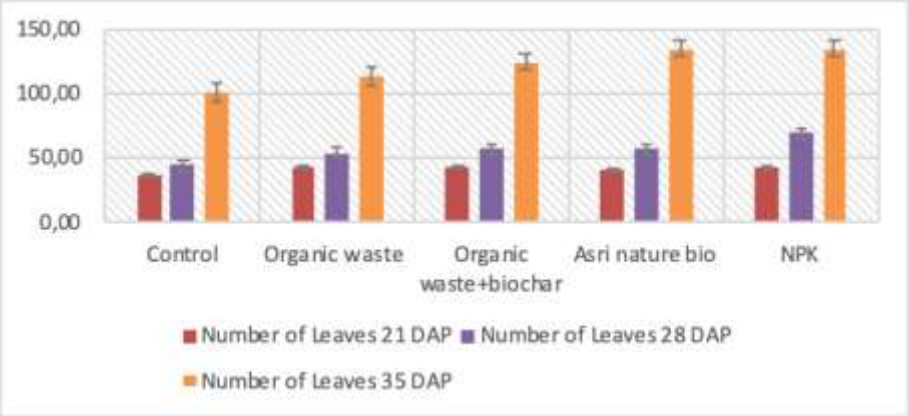

Figure 2

The Average Number of Leaves is 21 DAP, 28 DAP, and 35 DAP on Fertilizer Treatment

3.4 Stem Diameter per Plant

Table 5 shows the mean stem diameters observed at different times. The results showed that there was a significant difference between the treatments given. It was seen that there was an increase in stem diameter between 63 DAP and 70 DAP. The largest stem diameter at 63 days after planting was found in the commercial fertilizer treatment with 13.69 mm while the lowest was in the control treatment with 12.34 mm. Likewise with the observation of 70 DAP the highest stem diameter was found in commercial fertilizers with 15.05 mm while the lowest was in the control treatment with 13.11 mm. Plants show different responses to given fertilizers or nutrients [35] so the right dose can show a positive effect on plant height, stem diameter, and flowering process [22].

Table 5
Average stem diameter of 63 DAP and 70 DAP on fertilizer treatment.

Treatment	Stem Diameter (mm)	
	63 DAP	70 DAP
Control	12.34 b	13.11 b
Organic waste	13.28 a	14.43 a
Organic waste+biochar	13.33 a	14.83 a
Asri nature bio	13.73 a	15.05 a
NPK	13.69 a	15.03 a

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

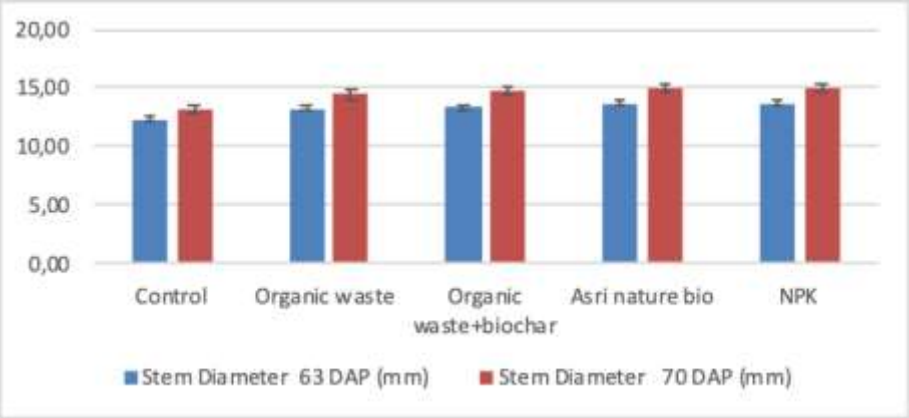

Figure 3
The Average diameter of stems aged 63 and 70 days after treatment with several types of fertilizers

3.5 Number of Fruits per Plant, Weight of Fruits per Plant, and Weight of Fruits per Hectare

Table 6 shows the number of fruit planted, the weight of fruit planted, and the weight of fruit per hectare. Based on the table, it can be seen that the treatment of various types of fertilizers has a very significant effect on the number of fruits per plant. The highest number of fruit was obtained in the NPK fertilizer treatment while the lowest number of fruit was found in the control treatment. The cumulative number of fruits harvested from each sub-plot was recorded by counting the fruits during the fruiting stage until the end of harvest [36].

Based on the Table above, the application of various types of fertilizers gives a difference in the average weight of red chilies per plant. In the treatment of NPK fertilizer, the highest fruit weight per plant was 611.93 g, while the control treatment without treatment had the lowest fruit weight with 378.14 g. According to [37], Fruit weight can be affected by the availability of macronutrients needed so that it can activate meristematic cells and can facilitate photosynthesis, causing increased leaf growth and photosynthesis, then the resulting photosynthate results will be more and will increase the production of fruit weight.

Table 6
The average number of fruit, fruit weight per plant, and fruit weight per ha in the treatment of fertilizer types.

Treatment	Number of fruits per plant (fruits)	Fruit weight per plant (g)	Fruit weight per ha (ton)
Control	24.10 d	378.14 c	15.13 c
Organic waste	33.25 bc	495.34 b	19.81 b
Organic waste+biochar	38.75 abc	554.25 ab	22.17 ab
Asri nature bio	39.73 ab	573.89 ab	22.96 ab
NPK	40.67 a	611.93 a	24.48 a

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

Fruit weight is the character of the yield component which is used as a yield measure [38]. The yield of fruit weight per hectare gives a very significant difference between the treatments given. This can be seen from the highest yields found in the treatment of NPK fertilizer with 24.48 tons/ha and the lowest was found in the control treatment without treatment with 15.13 tons/ha. Based on the data on the application of organic fertilizer, it can be seen that there is a difference between the treatments of giving organic fertilizer. [39] stated that the application of organic fertilizer had a significant effect on the difference in fruit weight of chili plants. Organic fertilizers can increase the availability of nutrients, especially further protein synthesis and can significantly increase the number of fruits and the weight of fresh and dried fruit to accelerate the mobility of photosynthesis [40].

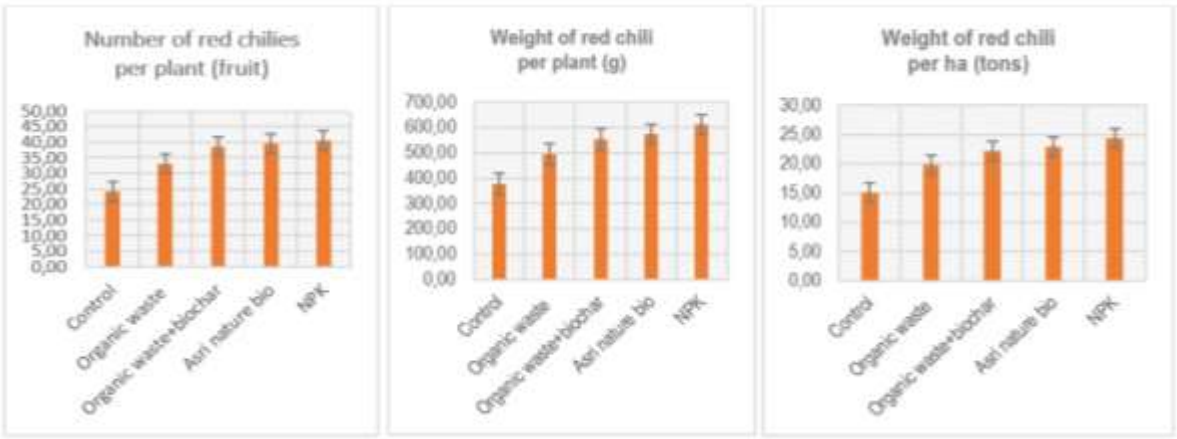

Figure 4
The average number of fruit, fruit weight per plant, and fruit weight per ha in the type of fertilizer treatment

4. Conclusion

Based on the data obtained, the type of fertilizer treatment had a very significant effect on all observed variables except for plant height at 21 DAP per plant, the number of leaves at 21 DAP per plant, and the number of leaves at 28 DAP per plant had a significant effect on the treatment given. The application of NPK fertilizer gave the best results on all parameters except for the stem diameter parameter. On the stem diameter parameter, the application of asri nature fertilizers gives the best result. Control treatment (without fertilizer) gave the lowest yield in all observations.

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