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The Effect of Tofu Liquid Waste as Liquid Organic Fertilizer on The Growth and Production of Cayenne Pepper *(Capsicum frutescens* L. *)*

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Abstract

This research aims to determine the effect of giving POC to tofu waste production of cayenne pepper plants, as well as knowing the effective POC dose for cayenne pepper plants. This research was carried out from November 2022 to January 2023 and took place in Sea Village, Kolaka Regency. This type of research includes experimental research consisting of 5 treatments and 4 replications to obtain 20 polybags with a total of 20 research plants. The parameters observed were the number of fruits (fruit) and fruit weight (grams). The research results show that from the parametric test using analysis of variance (ANOVA), the parameter data value for the number of fruit is 0.082 and the weight of the fruit is 0.225; the significance value is more than 0.05, thus H0 is accepted and H1 is rejected. So it can be concluded that there is no significant effect of giving tofu waste POC on the production of cayenne pepper plants.

Keywords: Cayenne Pepper Plants (*Capsicum frutescens* L.), Tofu Waste POC, and Production

A. Introduction

Cayenne pepper is an herbaceous plant from the eggplant family (Solanaceae) that has the scientific name *Capsicum frutescens* L. Chili originates from the American Continent, specifically Peru, and spreads to the countries of the American Continent, Europe, and Asia, including Indonesia and other Southeast Asia (Said, 2017).

Chili plants like dry areas and are often found at an altitude of 0.5 to 1250 meters above sea level. Cayenne pepper plants can grow well in soil that is fertile, loose, free from nematodes, has a pH of 5.5–6.5, and has sufficient water. The most ideal chilies are planted with a sunlight intensity between 60% and 70%, while the ideal length of light for the growth of chili plants is 10–12 hours (Alif, 2017).

Cayenne pepper (*Capsicum frutescens* L.) is a type of horticultural plant known as the spice plant with the highest level of use because, apart from adding flavor to dishes, cayenne pepper also has a high nutritional content. Based on the results of modern medical research, chilies contain a lot of vitamin A to prevent blindness (Ketut, 2012). In addition, 100 grams of cayenne pepper contain 103 calories of energy, 4.7 grams of protein, 2.4 grams of fat, 19.9 grams of carbohydrates, 45 mg of calcium, 8 mg of phosphorus, 11 mg of vitamin A, and 70 mg of vitamin C. Chili fruit also contains capsaicin, capsanthin, carotenoids, volatile alkaloids, resin, and vitamins A and C. The capsaicin content gives chilies a spicy taste and has the effect of improving blood flow and numbing the skin (Said, 2017).

Based on statistical data, the production of cayenne pepper plants in Kolaka district over the last 3 years has decreased. In 2018, cayenne pepper production was 1,767 t/ha; in 2019, it was 1,250 t/ha; and in 2020, it was 1,111 t/ha (Aljaninansya et al, 2022).

One effort to increase the production of cayenne pepper plants is by providing organic fertilizer to add nutrients to the soil. Most or all of this organic fertilizer comes from organic materials, both plants and animals that have gone through an engineering process in solid or liquid form, for example liquid tofu waste which is used to provide plant nutrients and can improve the physical, chemical and biological properties of the soil (Nugraha, 2013).

The tofu industry, in its processing process, produces solid and liquid waste. Tofu liquid waste is very dangerous if it is thrown away directly without processing it first, because this waste can change and reduce the quality of the water around the tofu industry (Hadiyanto, 2018). Based on the results of observations made in the tofu industry in Sabilambo Village, Kolaka Regency, liquid tofu waste from the industry was disposed of directly without any prior processing. This causes the waste to emit an unpleasant odor and can pollute the air and the environment around the industry, one of which is polluting river water.

Tofu liquid waste has a high organic content, one of which is protein. If the protein in liquid waste is decomposed by soil microbes, it will release N compounds, which will ultimately be absorbed by plant roots (Nurman et al., 2017). In addition, tofu wastewater has very high levels of N, P, and K. Total N levels reached 43.37 mg/L, total P levels reached 114.36 mg/L, and total K levels reached 223 mg/L (Kusumawati et al., 2015). Therefore, tofu liquid waste has the potential to become liquid organic fertilizer, increasing chili plant production. Based on this, researchers are interested in conducting research on the effect of tofu liquid waste on the productivity of cayenne pepper plants (*Capsicum frutescens* L.).

The results of research by Buulolo et al (2022) show that the use of liquid tofu waste as liquid organic fertilizer has an effect on the growth of stem height, stem diameter and number of leaves of purple eggplant (*Solanum melonhena* L). Research conducted by Mardhiana et al, 2021 with the title Influence Tofu liquid waste fertilizer affects the growth and yield of corn plants Sweet (*Zea mays* L.). The results of this research are: Use of waste fertilizer Tofu liquid in sweet corn plants, the parameters observed were high plants, number of leaves, number of cobs, weight of cobs, wet weight of plants and plant dry weight showed that treatment (P5) with a concentration of 600ml of tofu liquid waste can provide the highest results on sweet corn plants.

B. Literature Review

1. Morphology of Cayenne Pepper *(Capsicum frutescens L)*

Root Cayenne pepper (*Capsicum frutescens* L) plants consist of main (primary) and lateral (secondary) roots. Root tertiary in the form of root fibers that come out of the lateral roots. Root length primary around 35-50 cm, and lateral roots around 35-45 cm (Julianti, 2014). Cayenne pepper plants have round, dark green stems and has a hard and woody structure. The main stem of a chili plant cayenne ranges between 20-28 cm and stem diameter between 1.5-2.5 cm (Effendi dkk., 2018). Round leaves Eggs are elongated or ovoid, lanceolate in shape, with a pointed base and tip which narrows. They are located alternately on the stem and form a spiral pattern (Tjandra, 2011). The flower of the cayenne pepper plant is a single shaped flower star. Flowers grow downwards in the leaf axils with flower crowns White. Shaped pollen oval, consisting of three segments, shiny yellow. In one sari box develops 11,000-18,000 pollen grains (Astri, 2015). The shape of the cayenne pepper fruit is upright, sometimes drooping, oval,

straight or curved with a long tapered tip 1-5cm. The fruit is attached to a long stalk and has a delicious taste spicy. The fruit is attached to a long stalk and has a spicy taste (Alif, 2017).

2. Classification of Cayenne Pepper *(Capsicum frutescens L)*

Classification of Cayenne Pepper (*Capsicum frutescens* L.) The classification of cayenne pepper plants according to Simpson (2010) is as follows:

Kingdom : Plantae
Division : Magnoliophyta
Class : Dicotyledonae / Magnoliopsida
Order : Solanales
Family : Solanaceae
Genus : *Capsicum*
Species : *Capsicum frutences* L.

3. Content and Benefits of Cayenne Pepper

Cayenne pepper is a plant that has many ingredients. These ingredients include capsaicin, capsanthin, carotenides, alkaloids, resins, and essential oils. Apart from that, chilies are also rich in vitamins A, B, and C (Tjandra, 2011). Cayenne pepper also contains the nutrients protein, fat, carbohydrates, calcium (Ca), phosphorus (P), iron (Fe), vitamins, and alkaloid compounds such as capsaicin, flavonoids, and essential oils (Prajnanta (2007) in Arifin (2010).

According to Setiadi (2006) in Arifin (2010), cayenne pepper contains the most vitamin A compared to other chilies. Fresh cayenne peppers contain 11,050 SI of vitamin A, while dried cayenne peppers contain 1,000 SI. Meanwhile, fresh green chilies only contain 260 vitamin A, fresh red chilies 470, and dried red chilies 576 SI.

4. Tofu Industrial Waste

The tofu industry, in the processing process, produces waste, both solid waste and liquid waste. Waste is one of the causes of environmental pollution, which can have a negative impact on living things around it (Mardliyah & Suryo, 2018). Solid waste is produced from the filtering and clumping processes. The liquid waste produced is from the washing, boiling, pressing, and molding of tofu. However, until now, a number of tofu industries have not followed through on processing the waste produced (Mulyaningsih et al., 2013).

The amount of liquid waste produced by this industry is relatively large. Liquid waste from tofu production is thrown directly into the sewer without undergoing prior processing. If this is done continuously, the liquid waste that is disposed of has the potential to pollute the environment and cause an unpleasant odor because it still contains protein and carbohydrate compounds that can be fermented (Handayani & Niam, 2018).

According to Aliyenah et al. (2015), the nutrient content in tofu waste has the potential to be developed as liquid fertilizer. In line with Hikmah's (2016) statement, tofu liquid waste contains a lot of organic material, including tofu liquid waste containing 40–60% protein, 25–50% carbohydrates, and 10% fat. With the nutrients contained in tofu liquid waste, it can be used as organic fertilizer for agricultural cultivation.

According to Desiana et al (2013), tofu liquid waste can be used as a new alternative for fertilizer because the waste contains the nutrients needed by plants. The presence of several elements in tofu industrial wastewater, such as N, P, and K, in certain amounts is required by plants for their growth.

5. Impact of Tofu Waste Pollution on the Environment

According to Zulfa (2019), industrial wastewater, if not managed properly, will have a negative impact on the surrounding environment. The effect of high N and P levels on waters is eutrophication (excessive compounds caused by the emergence of freshwater pollution). Apart from that, tofu liquid waste also contains harmful microorganisms such as *Eshericta* sp., which can disrupt body health (Anniza et al., 2017).

According to Makiyah (2013), tofu liquid waste still contains very high levels of organic materials. If the liquid waste is disposed of directly without any prior processing, it will cause pollution, such as causing an unpleasant odor and reducing dissolved oxygen in the water, which can result in disturbances to organisms living in the water because their lives depend on the surrounding environment. In line with Zulfa (2019), this causes a decrease in the

concentration of dissolved oxygen in the water that exceeds the threshold because the high concentration of organic substances in tofu liquid waste, including ammonia, will cause a decrease in the oxygen content in the water, resulting in the death of water biota due to dissolved oxygen. no longer available

C. Methodology

1. Research Design

The type of research used in this research is quantitative research with experimental methods. The procedures carried out in this research include sowing cayenne pepper seeds, preparing planting media, planting, applying organic fertilizer from tofu liquid waste, maintenance, observation, and harvesting.

2. Instruments

The tools and materials used in this research were 30x40 cm polybags, rulers, scales, measuring cups, soil, cellphones, soil testers, liquid tofu waste, water, and cayenne pepper seeds.

This research used a randomized group design (RAK) with 5 treatments and 4 replications.

Table 1. Research design

Treatment	Test			
	1	2	3	4
P0 (0 mL)	$P0_1$	$P0_2$	$P0_3$	$P0_4$
P1 (150 mL)	$P1_1$	$P1_2$	$P1_3$	$P1_4$
P2 (300 mL)	$P2_1$	$P2_2$	$P2_3$	$P2_4$
P3 (450 mL)	$P3_1$	$P3_2$	$P3_3$	$P3_4$
P4 (600 mL)	$P4_1$	$P4_2$	$P4_3$	$P4_4$

The treatment given is:
P0: without giving tofu liquid waste (control)
P1: giving 150ml tofu liquid waste
P2: giving 300ml of tofu liquid waste
P3: giving 450ml of tofu liquid waste
P4: giving 600ml tofu liquid waste

Production parameter data was carried out through direct experiments by measuring the number of fruit and fruit weight. The number of fruits is calculated by the appearance of the ovaries; this fruit calculation cannot be calculated from the appearance of the flowers because all the flowers do not necessarily become ovaries, while the weight of the plant fruit per polybag is obtained by weighing the entire plant intact and done after harvest using a scale.

Environmental parameter data is carried out by measuring temperature, humidity, soil pH, light intensity using a soil tester, and soil texture in the morning and evening.

3. Techniques of Data Analysis

The data obtained was processed using Microsoft Excel and SPSS 25. Before carrying out the hypothesis test, a prerequisite test is carried out, namely the normality test and homogeneity test. If the data obtained meets the prerequisite tests or normality test, it is analyzed parametrically with the analysis of variance (ANOVA) test. If not, it will be tested non-parametrically with the Kruskal-Wallis test.

The normality test is carried out to find out whether the samples taken in the research produce normal data or not. The data normality test functions as a statistical prerequisite for parametric tests.

The hypothesis is as follows:
H0 = Data is regularly distributed
H1 = Data is not distributed regularly

Criterion Testing

- If the *sig value* is > 0.05, then the data is normally distributed or H0 is accepted and H1 is rejected

- If *the sig value is* < 0.05, then the data is not normally distributed or H0 is rejected and H1 is accepted

After the normality test, a homogeneity test was carried out. The homogeneity test was carried out to determine whether the samples taken in the study had homogeneous variance or not.
The hypothesis is as follows:

H0 = Population variances are the same
H1 = Population variance is not the same

Criterion Testing
- If the *sig value* is > 0.05, then the data is homogeneous or H0 is accepted and H1 is rejected
- If the *sig value is* < 0.05, then the data is not homogeneous or H0 is rejected and H1 is accepted

The analysis of variance (ANOVA) test is carried out if the normality and homogeneity test assumptions are met. The anova test used is the one-way ANOVA test using the SPSS 25 program, with the following hypothesis

H0 = no significant effect
H1 = there is a significant influence

Testing Criteria
- If *Asymp.sig* > 0.05, then there is no significant effect or H0 is accepted and H1 is rejected
- If *Asymp.sig* < 0.05, then there is a significant influence or H0 is rejected and H1 is accepted

D. Findings and Discussion

1. Findings

a. Data on production parameters of cayenne pepper plants

Measurement of production parameter data on cayenne pepper plants is calculated after the harvest period or the final results of growth on cayenne pepper plants.

Table 2. Calculation of Production Parameter Results for Cayenne Pepper Plants (*Capsicum frutescens* L.)

Parameter	Treatment	Test				Amount	Average
		I	II	III	IV		
Number of fruits	P0 (control)	6	2	11	11	30	**7.5**
	P1 (150 ml)	14	11	22	16	63	**15.75**
	P2 (300 ml)	16	12	17	14	59	**14.75**
	P3 (450 ml)	8	12	6	18	44	**11**
	P4 (600 ml)	12	10	16	19	57	**14.25**
	Amount	**56**	**47**	**72**	**78**	**253**	
Fruit weight	P0 (control)	3.1	1.5	9.1	11.3	25	**6.25**
	P1 (150 ml)	7.5	7.4	17.9	13.9	46.7	**11,675**
	P2 (300 ml)	11.1	9.1	14.7	15.9	50.8	**12.7**
	P3 (450 ml)	6.2	9.1	4.8	14.5	34.6	**8.65**
	P4 (600 ml)	9.1	8.3	13.6	13.9	44.9	**11,225**
	Amount	**37**	**35.4**	**60.1**	**69.5**	**202**	

Table 2 shows the average results of different cayenne pepper plant production parameters in each treatment, including the number of fruit and fruit weight. The results of calculating the highest number of fruit on cayenne pepper plants were in the P1 treatment with a dose of 150 ml, which had an average of 15.75 (fruit), compared to the P0 treatment (without fertilizer), which had an average of 7.5 (fruit).). Meanwhile, the results from the analysis of fruit weight measurements on cayenne pepper plants were highest in treatment P2 with 300 ml, which had

an average of 12.7 grams, compared to treatment P0 (without fertilizer), which had an average of 6.25 grams.

b. Requirements Testing

1) Normality test

The normality test is a statistical test that evaluates the distribution of data in a set of data or variables to determine whether the data is regularly distributed. The normality test was carried out using the Shapiro-Wilk method in the SPSS program for sample sizes of less than 50. A significance level of more than 0.05 indicates that the data is regularly distributed. The results of the normality test are presented in table 4 below:

Table 4. Normality test results on the parameters of fruit number and fruit weight (g), on Cayenne Pepper (*Capsicum frutescens* L.) plants.

Parameter	Shapiro-Wilk	statistics	df	sig.	Note.
Number of fruits		0.967	20	0.692	normal
Parameter	**Shapiro-Wilk**	**statistics**	**df**	**sig.**	**Note.**
Fruit weight		0.947	20	0.321	normal

In table 4, the normality test on the parameters, number of fruit and fruit weight, shows that the data comes from a normal population because there are treatments that have a significance value greater than 0.05, so H0 is accepted and H1 is rejected.

2) Homogeneity Test

The homogeneity test is a prerequisite test in statistical analysis that must be proven whether two or more groups of sample data come from a population with the same variance or not. The homogeneity test was carried out in the SPSS program with a significance level of more than 0.05, indicating homogeneous data. The homogeneity test results are presented in table 6 below:

Table 6. Homogeneity test results on the parameters number of fruit and fruit weight (g), on Cayenne Pepper (*Capsicum frutescens* L.) plants.

Parameter	Levene statistics	df1	df2	sig.	Note.
Number of Fruits	0.711	4	15	0.597	homogeneous
Fruit Weight	1,178	4	15	0.360	homogeneous

In table 6, the homogeneity test on production parameters shows that all data is homogeneous because it has a significance value greater than 0.05, so H0 $_{is}$ accepted and H1 is rejected.

c. Hypothesis test

After testing the requirements, a hypothesis test is carried out for decision-making based on data analysis, both from control experiments and from treatment experiments.

Based on table 7 in the analysis of variance (ANOVA) hypothesis test, it is known that the significance value for the number of fruit and fruit weight is greater than 0.05, so it is not significant, so H 0 is accepted and H 1 is rejected. From the analysis of variance (ANOVA) test, it can be concluded that tofu liquid waste does not have a real influence on the parameters of fruit number and fruit weight in cayenne pepper plants

Table 7. Parametric test with *analysis of variance* (*ANOVA*) on the parameters of fruit number and fruit weight (g) on Cayenne Pepper (*Capsicum frutescens* L.) plants.

Parameter		Sum of Squares	Df	Mean Square	F	Sig.
Number of fruits	Between Groups	183,300	4	45,825	2,553	0.082
	Within Groups	269,250	15	17,950		
	Total	452,550	19			
Parameter		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Fruit weight	Between Groups	109,725	4	27,431	1,605	0.225
	Within Groups	256,395	15	17,093		
	Total	366.120	19			

d. Environmental parameter data

Table 8 Environmental parameters (Temperature and Light intensity)

Observation time	**Temperature**		**Light intensity**	
	Morning	Afternoon	Morning	Afternoon
Preliminary data	-	32 ºC	-	500 Lux
10 HST	29 ºC	28 ºC	550 Lux	350 Lux
20 HST	25 ºC	24 ºC	250 Lux	200 Lux
30 HST	24 ºC	26 ºC	350 Lux	200 Lux
40 HST	28 ºC	31 ºC	500 Lux	500 Lux
Average	27.4		377.7	

Table 9 Environmental parameters (Soil moisture and pH)

Observation time	**Soil moisture**		**Soil pH**		**Soil texture**
	Morning	Afternoon	Morning	Afternoon	
Preliminary data	-	6.5	-	6.3	Sandy clay
10 HST	7	7.29	6.05	6.05	
20 HST	7	7	6,7	6,8	
30 HST	7	7.15	7	7	
40 HST	7	7	6,7	6.6	
Average	6.9		6.5		

In table 8 are are measurements of environmental parameters including temperature and light intensity which are measured in the morning and evening, measurements are carried out every 10 days. In table 4.9 are measurements including soil moisture and soil pH, which are measured in the morning and evening. Measurements are carried out every 10 days. Meanwhile, soil texture observations were carried out after the research.

2. Discussion

a. Number of fruit on cayenne pepper plants

Observation of the number of cayenne peppers is calculated at the time of harvest or the final yield of each cayenne pepper plant by counting manually or one by one. Calculations were carried out at the end of the study, when the plants were 2.5 months old. The highest number of cayenne pepper fruit growth was in treatment P1 (150 ml) with an average of 15.75 (fruit), while the lowest growth in fruit number was in treatment P0 (control) with an average of 7.5 (fruit).

In the normality and homogeneity test for the number of fruits, it was discovered that the data came from a normal and homogeneous population because it had a significance value greater than 0.05, so it was declared that it met the basic assumptions in the analysis of variance. Therefore, a further parametric test was carried out, namely the analysis of variance

(ANOVA) test. The analysis of the parametric test can be seen in Table 4.7. The significance value for the number of fruits is 0.082, more than 0.05, so the results are not significant. It can be concluded that the application of tofu liquid waste fertilizer has no effect on increasing the difference in the number of fruit on cayenne pepper plants.

It is suspected that liquid fertilizer from tofu waste has not been able to influence the growth of fruit because the nutrients in the tofu waste are not fulfilled. One of the most important nutrients is phosphorus. According to Fahmi (2016), nitrogen is not really needed in the fertilization process, while phosphorus and potassium are two of the nutrients needed for generative growth. Plants that have entered the generative phase, especially flowering, require sufficient availability of the nutrients phosphorus and potassium. One of the factors that plays a role in flowering is the nutrient P. As stated by Lingga & Marsono (2002) in Puspitasari & Elfarisna (2017), the element P is very necessary in the process of assimilation and respiration and is very needed for the generative development of plants, namely accelerating the flowering process. This is reinforced by Sutedjo's (2008) statement in Puspitasari & Elfarisna (2017) that flower formation requires sufficient P nutrients because good flower formation will produce maximum fruit.

In research that has been carried out, the fruit of cayenne pepper plants was attacked by pests. This is thought to be an external factor that influences the growth of fruit numbers. During the research, fruit flies were found to be plant pest organisms (OPT) on cayenne pepper plants, thus having a negative influence on the quality of the fruit on the plants. According to Komang & Wayan (2020), the pests that often attack cayenne pepper plants are fruit flies. The level of fruit maturity affects the life of fruit flies. Chilies that have entered the fruit ripening process are able to attract fruit flies to obtain food and as a place to lay eggs, so that many fruits are attacked by diseases caused by this organism. This is in line with the opinion of Juanda & Edi (2015), who stated that fruit fly attacks on chilies are characterized by black spots at the base of the fruit. Black dots are a manifestation of female fruit fly eggs. Inside the fruit, the eggs will hatch into caterpillars so that the caterpillars that have hatched will eat the chili fruit. As a result, on the skin of the chili, the black dots expand and cause fruit rot. Fruit that is rotten will fall off, and if there are still caterpillars in the rotten fruit, it will infect other chili plants.

b. Fruit weight of cayenne pepper plants

Observation of the weight of the cayenne pepper fruit is weighed after the harvest period or the final result of the growth of the cayenne pepper plant using a digital scale. Calculations were carried out at the end of the study, when the plants were 2.5 months old. The highest weight of cayenne pepper fruit was in treatment P2 (300 ml) with an average of 12.7 grams, while the lowest weight of cayenne pepper fruit was in treatment P0 (control) with an average of 6.25 grams.

In the normality and homogeneity test of fruit weight, it was discovered that the data came from a normal and homogeneous population because it had a significance value greater than 0.05, so it was stated that it met the basic assumptions in the analysis of variance; therefore, a further parametric test was carried out, namely the analysis of variance (ANOVA) test. The analysis of the parametric test can be seen in Table 4.7. The significance value for fruit weight is 0.225, more than 0.05, so the results are not significant. It can be concluded that the application of tofu liquid waste fertilizer has no effect on increasing the difference in the number of fruit on cayenne pepper plants.

It is suspected that the liquid fertilizer from tofu waste has not been able to affect the weight of the fruit because the nutrients in the tofu waste are not fulfilled. One of the most important nutrients is potassium. According to Meylia & Koesriharti (2018), who stated that the K nutrient plays a role in improving the quality of the harvest, it influences fruit development and increases the weight of fresh fruit because the K nutrient plays a role in fruit development in cayenne pepper plants. This is in line with the opinion of Hapsari et al. (2017), who state that the higher the photosynthesis results, the food reserves contained in the plant will be used to increase the weight of the fruit because the K nutrient plays a role in strengthening the existing tissue in the plant and helps the process occur. plant photosynthesis (Prawiti et al., 2021)

Tofu liquid waste contains the nutrient K of 1.34%,, which is an essential nutrient and is needed by plants (Al Amin et al., 2017). Meanwhile, the nutrient requirements for cayenne pepper plants require K of 3.0% (Agricultural Research and Development Agency, 2017)

E. Conclusion

Treatment using tofu liquid waste did not have a significant effect on the production of cayenne pepper (*Capsicum frutescens* L.), namely on the parameters of fruit number (fruit) and fruit weight (grams). The effective dose of tofu liquid waste for plant height, number of leaves, number of branches, and fruit weight is P2 (300 ml), while the number of fruits is P1 (150 ml).

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