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Optimizing Cayenne Pepper Growth through Liquid Organic Fertilizer and NPK Fertilizer Application

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Abstract
This research aims to determine the effect of applying liquid organic fertilizer and NPK fertilizer and their interactions, on the growth and yield of cayenne pepper plants (Capsicum frutescens L.) which was carried out in Kupang City, Oebobo District, East Nusa Tenggara starting in June 2023 until September 2023. This research method uses a randomized block design (RBD) arranged factorially with 2 factors. The first factor tried was liquid organic fertilizer (P) which consisted of 4 concentration levels, namely: P0 (0 cc L-1 water), P1 (25 cc L-1 water), P2 (50 cc L-1 water), and P3 (75 cc L-1 water). Meanwhile, the second factor that was tried was NPK (N) fertilizer which consisted of 4 dose levels, namely: N0 (0 kg ha-1), N1 (150 kg ha-1), N2 (300 kg ha-1) and N3 (450 kg ha-1). There were 16 combination treatments, each repeated 3 times so that 48 cayenne pepper plants were needed. This research results showed that the interaction between liquid organic fertilizer and NPK fertilizer had a real influence on almost all the variables observed except stem diameter and number of flowers formed. The highest average fruit weight per plant was obtained at a liquid organic fertilizer concentration of 25 cc L-1 water (P1), namely 110.17 g, or an increase of 12.32% when compared to treatment without liquid organic fertilizer, namely 98.08 g. Meanwhile, with NPK fertilizer treatment, the highest average fruit weight per plant was obtained at a dose of 150 kg ha-1, namely 115.25 g, or an increase of 26.41% when compared to the control (N0), which was only 91.17 g. The interaction of the POC concentration treatment of 75 cc L-1 water with an NPK fertilizer dose of 150 kg ha-1 (P3N1) gave the highest fruit weight gain of 133.00 g (P3N1) although supporting variables such as the growth of cayenne pepper plants gave different results. different in the treatment of liquid organic fertilizer concentration and NPK fertilizer dosage.

Keywords: *Cayenne pepper, liquid organic fertilizer, NPK fertilizer*

1. Introduction

Cayenne pepper has always been a potential strategic commodity issue for development. The focus on yields from this crop commodity is vulnerable to inflation and has a fluctuating price on the Indonesian market as consumption is high in the community as a kitchen spice. The use of cayenne pepper continues to increase every year in line with the increase in population and the development of industries that require raw materials for cayenne pepper [1]. Cayenne pepper production in Kupang, East Nusa Tenggara Province experienced an unstable spike in changes in 2020 (1866 tonnes), 2021 (2102.6 tonnes), and 2022 (1373.8 tons) [2]. Seeing this, a strategic approach is needed to increase the production of cayenne pepper which sustainably has good quality and quantity in various adaptations to soil and environmental conditions. Based on previous research, the results showed that cultivating cayenne pepper plants using polybags in a ratio of vertisol soil and a mixture of manure with a composition of 1:1 gave the best results in terms of the highest number and weight of cayenne pepper fruit per plant [3].

According to similar research, results show that in cultivating cayenne pepper plants, the use of NPK at a dose of 300 kg/ha provides the highest/best influence on each parameter such as root length, plant height, stem diameter, number of productive branches, number of fruits per plant, fruit weight. planting and dry weight of fruit planted [4]. Continuous use of NPK is not environmentally friendly,

this is because continuous use of inorganic fertilizer can disrupt the chemical balance of the soil, reduce the organic material content, be uneconomical, and cause environmental pollution [5]. Steps are needed to develop further alternatives such as liquid organic fertilizer as a substitute in achieving balanced fertilization between liquid organic fertilizer and NPK which is focused on the quality and quantity of the strategic crop of cayenne pepper.

Realizing steps to develop the quality and quantity of cayenne pepper products using liquid organic fertilizer substitution, a potential innovation was obtained from a farmer group in Kupang Regency, East Nusa Tenggara which utilized a formula from using various local ingredients in making liquid organic fertilizer. Derived from various raw materials, the liquid organic fertilizer concentration is set at a concentration of 25 cc L^{-1} water, 50 cc L^{-1} water, and 75 cc L^{-1} water. This refers to the results of similar research which used various raw materials in making liquid organic fertilizer, where it was said that a liquid organic fertilizer concentration of 50 cc L^{-1} water was the optimum dose which could provide an increase in growth and yield of cayenne pepper in various parameters; plant height, number of branches, crown diameter, age at which flowering begins and fruit weight per plant and cayenne pepper yield [6]. In another similar study, data was obtained that the application concentration of liquid organic fertilizer with a concentration of 50 cc L^{-1} of water provided the fastest flowering age parameters and the highest average number of fruits which was best for chili plants such as red chilies [7]. Determining the concentration of fertilizer using liquid organic fertilizer was mentioned which stated that giving a liquid organic fertilizer concentration that is too high will suppress plant growth and vice versa if the dose given is too low it will also suppress growth or not stimulate plant growth in the vegetative phase and generative phase [8].

2. Materials and Methods

The location for carrying out this research is in an artificial greenhouse in Kupang City, East Nusa Tenggara Province, which is located at Kejora Street, Kel. Oebufu, District. Oebobo, which is located at coordinates 10°10'38" S 123°36'42"E with an average temperature of 27 °C and an altitude of 101 meters above sea level (asl) in the period from June to September 2023 This research used a randomized block design (RBD) arranged in a factorial manner with 3 replications. There are 2 factors studied: The first factor is the administration of liquid organic fertilizer carried outaccording to the treatment, namely P_0 (0 cc L^{-1} water), P_1 (25 cc L^{-1} water), P_2 (50 cc L^{-1} water), andP_3 (75 cc L^{-1} water), at intervals of once every 2 weeks when the plants are 14 days after planting, 28days after planting, 42 days after planting, 56 days after planting, 70 days after planting. The secondfactor is that NPK fertilizer is given according to the treatment, namely N_0 (0 kg ha^{-1}), N_1 (150 kg ha^{-1}), N_2 (300 kg ha^{-1}), and N_3 (450 kg ha^{-1}), given 4 times with the same amount of dose when the plants were 21 days after planting, 35 days after planting, 49 days after planting, and 63 days after planting. Based on the two factors above, 16 treatment combinations were repeated3 times, so 48 polybag experimental plots were used. Liquid organic fertilizer lab test results andsoil analysis results can be seen in Tables 1 and 2.

Table 1. Results of liquid organic fertilizer analysis

No	Types of Analysis	Mark	Information	Method
1	pH	7.3	Neutral	Potentiometry
2	C-organic (%)	0.78	Very low	Walkley&Black
3	N-total	0.09	Very low	Total/Distillation
4	P-available	157.06	Very high	HNO_3/F-AAS
5	K-available	374.50	High	HNO_3/F-AAS

Source: Results of liquid organic fertilizer analysis in the soil laboratory of the Faculty of Agriculture, Udayana University 17 May 2023

The materials used in this research were cayenne pepper seeds of the Cakra Putih variety produced by PT BISI International (BISI), vertisol soil, manure mixture, water, NPK Mutiara 16-16-16 fertilizer, and liquid organic fertilizer produced by a farmer group P4S GS Organik, located in East Penfui, Central Kupang District, Kupang Regency, East Nusa Tenggara Province. This farmer group has been successful independently in developing and producing liquid organic fertilizer using a variety of local ingredients in its formulation. Making this liquid organic fertilizer uses 5 kg of fine goat manure, 5 kg of papaya fruit waste, 5 kg of green vegetable waste, 5 kg of banana stems, green

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leaves; lamtoro, moringa, and Gamal 5 kg, and eco-enzyme 250 ml. Each ingredient obtained is fermented in a 150-liter fermentation vat anaerobically. Starting by mixing 10 liters of water with 100 ml of EM4 decomposer and 200 ml of local sugar. This mixing is carried out to produce a mixed decomposer solution. After the mixing is complete, the next step is to add the other ingredients along with water until the fermentation vat is full and then ferment for 14 days. The tools used in this research were: polybag 40 x 40 (10 kg), 20-litre bucket, farming shovel, sieve, digital scale, digital pH meter, hand tally counter, measuring cup, vernier calipers, meter, stationery, camera for documenting.

The implementation of this research began with the preparation of the planting medium used, which was a mixture of soil and manure with a volume ratio of 1:1 in polybags. The cayenne pepper seeds used were 5 weeks old and were transplanted into individual polybags, followed by routine maintenance such as watering, weeding, and pest control. Fertilization with liquid organic fertilizer is carried out by dissolving every 4 levels of concentration into 1 liter of water, while every 4 levels of NPK fertilizer are dissolved in water to be poured into the planting medium. Cayenne pepper harvesting is carried out in three stages to influence the quality and durability after harvest.

The variables observed in this study were plant height, stem diameter, number of branches, number of leaves per plant, number of flowers formed, number of fruits per plant, fruit weight per plant, and dry weight of fruit per plant. Observations were carried out every 2 weeks and the observation data were tabulated and then analyzed statistically using analysis of variance according to the design used. First, a diversity test is carried out to obtain a variance test. If the treatment has a real effect, then the analysis continues to look for the single influence of each factor with the LSD test at 5% and 1% levels.

Table 2. Results of soil analysis of the experimental site

No	Types of Analysis	Mark	Information
1.	Texture		
	- Sand (%)	28.56	Clay
	- Dust (%)	17.98	
	- Clay (%)	53.46	
2.	Water Content		
	- Air Dry (%)	12.49	
	- Field Capacity (%)	44.61	
3.	pH	7.2	Neutral
4.	Electrical Conductivity (mmhos/cm)	0.59	Very Low
5.	N-total (%)	0.15	Low
6.	P-available (ppm)	61.17	Very high
7.	K-available (ppm)	276.28	High
8.	C-organic (%)	3.07	High

Source: Results of liquid organic fertilizer analysis in the soil laboratory of the Faculty of Agriculture. Udayana University 17 May 2023

3. Results and Discussion

3.1. Results

Based on the results of statistical analysis, the significance of the influence of Liquid Organic fertilizer concentration (P) and NPK dosage (N) and their interaction (P×N) on all observed variables is presented in Table 3.

Based on Table 3, shows that the interaction of liquid organic fertilizer concentration & NPK fertilizer dosage (P×N) had no significant effect ($P<0.05$) on stem diameter and number of flowers formed. A single treatment of Liquid Organic Fertilizer (P) and NPK Fertilizer (N) had a significant ($P>0.05$) to very significant ($P>0.01$) effect on all observed variables except for the stem diameter, fruit weight, and dry weight variables fruit had no significant effect ($P>0.05$).

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Table 3. Significant effect of treatment on concentration of liquid organic fertilizer and NPK dose and interaction on the observed variables.

No.	Variable	Treatment		
		P	N	P x N
1	Plant height per plant (cm)	*	**	**
2	Stem diameter per plant (mm)	**	ns	ns
3	Number of branches per plant (Branches)	**	**	*
4	Number of leaves per plant (leaves)	**	**	**
5	Number of flowers per plant (florets)	**	**	ns
6	Number of fruits per plant (fruit)	**	**	**
7	Fruits weight per plant (g)	ns	**	**
8	Fruits dry weight per plant (g)	ns	**	**

Note: ns = non significant (P<0.05); * = significant (P>0.05); ** = very significant (P>0.01)

Table 4. Average plant height, stem diameter, number of branches, and dry weight of fruit in the liquid organic fertilizer concentration and NPK dose treatment for cayenne pepper plants.

Treatment	Plant height (cm)	Stem diameter (mm)	Number of branches (branches)	Dry weight of fruits (g)
Liquid organic fertilizer (P)				
P_0 (0 cc L^{-1} water)	61.88 a	0.96 b	13.42 b	20.09 b
P_1 (25 cc L^{-1} water)	57.50 b	0.95 b	14.75 a	22.34 a
P_2 (50 cc L^{-1} water)	59.04 b	1.12 a	16.17 a	21.66 a
P_3 (75 cc L^{-1} water)	58.82 b	1.14 a	14.58 a	22.18 a
LSD 0.05	2.81	0.07	0.86	2.05
NPK (N)				
N_0 (0 kg ha^{-1})	53.82 c	1.00 b	13.33 b	18.59 b
N_1 (150 kg ha^{-1})	59.05 b	1.04 a	14.08 b	22.91 a
N_2 (300 kg ha^{-1})	62.53 a	1.08 a	15.75 a	22.37 a
N_3 (450 kg ha^{-1})	61.83 a	1.05 a	15.75 a	22.40 a
LSD 0.05	2.81	0.07	0.86	2.05

Note: Numbers followed by the same letter on the same factor mean not significantly different on the 5% LSD Test

Table 5. The average number of leaves per plant, number of flowers formed, number of fruits per plant, and fruit weight per plant in the liquid organic fertilizer concentration treatment and NPK dosage for cayenne pepper plants

Treatment	Number of leaves (leaves)	Number of flowers (florets)	Number of fruits (fruit)	Fruits weight (g)
Liquid organic fertilizer (P)				
P_0 (0 cc L^{-1} Water)	129.92 d	120.08 c	89.83 c	98.08 b
P_1 (25 cc L^{-1} Water)	152.42 c	144.58 b	105.92 b	110.17 a
P_2 (50 cc L^{-1} Water)	176.50 b	189.17 a	113.33 a	107.42 a
P_3 (75 cc L^{-1}Water)	225.25 a	197.00 a	114.50 a	109.25 a
LSD 0.05	6.42	21.65	3.00	9.72
NPK (N)				
N_0 (0 kg ha^{-1})	200.33 a	138.42 b	97.42 c	91.17 b
N_1 (150 kg ha^{-1})	158.58 d	171.33 a	107.42 b	115.25 a
N_2 (300 kg ha^{-1})	159.08 c	180.50 a	111.58 a	112.42 a
N_3 (450 kg ha^{-1})	166.08 b	160.58 a	107.17 b	106.08 a
LSD 0.05	6.42	21.65	3.00	9.72

Note: Numbers followed by the same letter on the same factor mean not significantly different on the 5% Duncan Test.

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Table 6. Average fresh weight of fruit due to the interaction effect of applying liquid organic fertilizer (P) and NPK fertilizer (N)

Treatment	N_0	Notation	N_1	Notation	N_2	Notation	N_3	Notation
P_0	67.67	l	85.33	ij	109.33	fg	130.00	a
P_1	85.67	i	127.00	ab	116.33	c	111.67	ef
P_2	97.67	hi	115.67	d	114.00	e	102.33	h
P_3	113.67	ef	133.00	a	110.00	fg	80.33	k

Note: The average value followed by the same letter in the same treatment means that it is not significantly different in the 5% Duncan test

3.2 Discussions

Based on the research data, it can be seen that the interaction of the two fertilizer treatments has not been able to provide maximum influence on all variables such as plant height, stem diameter, and number of flowersformed. These two fertilizer treatments provide different results in the growth and final results of planting cayenne pepper. This can be seen in the P_1N_1 treatment which has more influence on plant growth, but in the P_3N_1 treatment, it has more influence on the final result of fruits weight per plant. Even though not all variables havea significant or very significant effect, the interaction between the two has an insignificant effect. This interaction is thought not to occur because the performance of liquid organic fertilizer is not influenced by thepresence of NPK fertilizer and vice versa. In previous research, it was stated that liquid organic fertilizer is a solution resulting from the decomposition of organic material originating from plant residues, animal waste, and human waste which contains more than one nutrient element. The advantage of this liquid organic fertilizeris that it can quickly overcome nutrient deficiencies, does not experience problems in leaching nutrients, and can provide nutrients quickly [9], whereas according to similar research, NPK fertilizer has high solubilityso it dissolves more quickly. available to plants [10]. Not only is it based on the speed of dissolution of nutrientsupplies in the soil, but this is also predicted by the plant's ability to process the nutrients obtained from the two fertilizers, especially since both fertilizers contain more or less the same nutrients. Apart from the influence offertilizer obtained by cayenne pepper plants, the surrounding environment is also a factor that can influence the growth of plant height, widening of stem diameter, and the appearance of the number of flowers formed. Environmental factors that influence the growth of cayenne pepper plants include environmental temperature and soil pH [11]. A good air temperature for the growth of chili plants is 25-27°C during the day and 18-20°Cat night. Nighttime temperatures below 16°C and daytime temperatures above 32°C can thwart fertilization [12]. The appropriate soil acidity (pH) level is 6-7 [11]. Chilies can grow well in a soil pH range of between 6.5 – 6.8. Apart from pH and temperature, the influence of porous media increases the absorption capacity of spray water, increases air circulation in the planting media, and facilitates drainage in the planting media. However, if the media does not have a good level of porosity, this is thought to cause the composition of air and water to be less balanced so that the media hardens easily, root penetration is poor, and root developmentand weight are less than optimal. the fruit that is formed is less than optimal and natural [3]. Therefore, usinga mixture of vertisol soil planting media with manure can help improve the physical properties of the soil because it contains organic material which will help the process of improving the physical properties of the soil, especially soil porosity. In this way, the soil or planting medium can store water and nutrients for longer because the porosity of the medium is good so plant growth and development can be guaranteed.

Chili plants often show symptoms of chlorosis at a pH > 7.0, namely stunted plants and yellowing leaves due to a lack of the nutrient element iron (Fe). From the results of the research that has been carried out, it notonly has an insignificant influence on plant height, stem diameter, and number of flowers formed but also has a real to very real influence on other variables such as the number of branches, number of leaves, number of fruits, fruits weight, and dry weight of fruit. This refers to the research statement regarding liquid organic fertilizer which states that giving too high a concentration of liquid organic fertilizer will suppress plant growth and conversely if the dose given is too low it will also suppress growth or not stimulate plant growth. both in the vegetative and generative phases

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[8]. As a result of this excess concentration, the optimization process for fruit formation decreases, resulting in lower fruit weight. The same thing also happens if the dose of NPK fertilizer given is too high, as stated in previous research which states that the more doses of NPK fertilizer given, the more efficient use of nutrients can be [13]. It can be seen that the numberof flowers formed does not have a significant effect, while the number of fruits has a significant effect. This isthought to be because flower formation requires different nutrients for its performance, which is slightly different from fruit formation in cayenne pepper.

Liquid organic fertilizer treatment at a concentration of 25 cc L^{-1} water (P_1) gave the highest average fruitsweight of harvested fruit per plant, namely 110.17 g or an increase of 12.32% when compared to the control (P_0), which was only 98.08 g. In the variable number of harvested fruits per plant, the highest average was obtained at a concentration of 75 cc L^{-1} of water (P_3), namely 114.50 fruits, or an increase of 27.46% compared to those without liquid organic fertilizer (P_0), namely only 89.83 fruits. The highest average number of flowers per plant was obtained at a concentration of 75 cc L^{-1} water (P_3), namely 197.00 flowers, an increase of 64.05% when compared to without liquid organic fertilizer (P_0), namely only 120.08 flowers (Table 5). The highest average number of leaves per plant was obtained at a concentration of 75 cc L-1 water (P_3), namely 225.25 pieces, an increase of 73.37% when compared to without liquid organic fertilizer (P_0), namely only 129.92 pieces (Table 5). The higher yield reflected by the fruit weight per plant is supported by the increase in yield component variables such as in this study the number of leaves, number of flowers, number of fruits, and number of branches.

This cannot be separated from the influence of the treatment given, especially the function of the nutrientscontained in liquid organic fertilizer which has a nutrient content that can be said to be complete because it contains macro and micronutrients as well as microorganisms originating from the materials used. The elementNitrogen (N) is useful for increasing plant growth, chlorophyll, and protein content. The results of the formationof chlorophyll and protein in the leaves will be distributed to all other parts of the plant as energy for growth and development processes such as increasing plant height, widening branches, flower growth, leaf growth, and providing energy for fruit formation [14]. The P nutrient also influences leaf surface expansion, which increases the rate of plant photosynthesis [15]. Apart from that, the P nutrient also influences the formation of flowers which then become the place for fruit to emerge. Apart from N and P, the K nutrient contained in fertilizer also affects the number of leaves which is in line with similar research where it is said that the role of K in growth is to improve assimilation transport, regulate the opening and closing of stomata, and a lack of Kcan cause leaves to turn yellow and fall. Apart from that, having lots of leaves will have a good influence on the growth of other plant parts [16]. According to a research reference, how much fruit there is can be by the P (phosphorus) and K (potassium) content [17].

Nitrogen functions to accelerate plant growth, one of which is branches. If the productive branches are higher, it can increase the production of chili plants. The productive branches are where the chili fruit sticks [18]. The research results showed that the weight and dry weight of cayenne pepper fruits had no significanteffect on the single liquid organic fertilizer treatment. It is suspected that there are external factors that influenceweight and dry weight. Among them are the effects of the pests that attack, causing the weight to be insignificant compared to the fertilizer treatment given so that it affects the dry weight of the chilies. The weightand dry weight of a plant are always directly proportional, so if the weight of a cayenne pepper is high, the plant also has a high dry weight.

NPK fertilizer treatment at a dose of 150 kg ha^{-1} (N_1) gave the highest average fruit weight harvested per plant, namely 115.25 g, or an increase of 26.41% when compared to the control (N_0), which was only 91.17g (Table 5). In the variable number of harvested fruits per plant, the highest average was obtained at a dose of 300 kg ha^{-1} (N_2), namely 111.58 fruits or an increase of 14.53% compared towithout NPK fertilizer (N_0), namely only 97.42 fruit (Table 5). The highest average number of flowers per plant was obtained at a concentration of 300 kg ha^{-1} (N_2), namely 180.50 flowers, an increase of 30.40% when compared to without NPK fertilizer (N_0), namely 138.42 flowers. The high fruitweight from the NPK fertilizer treatment cannot be separated from other yield component factors which are the same as the liquid organic fertilizer treatment.

Starting with the growth of leaves on each plant the N nutrient from NPK fertilizer is available for leaf formation, cell division, and enlargement processes so that leaves will form more quickly

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and make the leaves greener in color. The growth of leaves on each plant will help other plant parts to grow and develop because they get photosynthate which plays an important role in the survival of cayenne pepper. Apart from this, the P element also influences the process of leaf formation. Next is flower formation, where flower formation is influenced by the nutrient P. Following the opinion of previous researchers, it is stated that element P has a lot of influence on flowering and development, fruit hardness, fruit color, vitamin content,and accelerates fruit ripening [18]. Factors that influence the fruit formation process are internal factors, such as genes, and external factors such as sunlight and nutrient content. The branches formed as a result of NPK fertilization treatment have a good impact on other parts of the cayenne pepper plant, this is because without branches the leaves, flowers, and fruit cannot appear and stick until harvest time. Nitrogen is one of the nutrientsfound in NPK fertilizer which functions to stimulate overall growth, especially in stems, branches, and leaves [19].The K nutrient functions to transport carbohydrates which function as a catalyst and increase the sugar contentin the fruit so that the fruit is fuller and heavier [20]. Dry weight is an illustration of the number of nutrients transported by plants and distributed to all plant organs. so that the highest dry weight value is the impact of optimal nutrient absorption by plants. In the research data, it can be seen that the application of NPK fertilizeraffects the dry weight of the fruit more than the application of liquid organic fertilizer. This is thought to be the result of the greater weight of the fruit, which influences the dry weight of the fruit.

4. Conclusion

Based on the research results, it can be concluded as follows:

1. POC fertilizer treatment with a concentration of 25 cc L^{-1} water (P_1) gave the highest fruit weight, namely 110.17 g, or an increase of 12.32% when compared to the control (P_0), which was only 98.08 g. This is supported by an increase in each of the other supporting variables which shows an increase due to giving POC with a concentration of 75 cc L^{-1} water (P_3).
2. NPK fertilizer treatment at a dose of 150 kg ha^{-1} (N_1) gave the highest fruit weight harvested per plant, namely 115.25 g, or an increase of 26.41% when compared to the control (N_0), which was only 91.17 g. This is supported by an increase in each of the other supporting variables which showsan increase due to the application of NPK fertilizer at a dose of 300 kg ha^{-1} (N_2).
3. The interaction between the POC concentration treatment of 75 cc L^{-1} of water with the NPK fertilizer at a dose of 150 kg ha^{-1} (P_3N_1) gave the highest fruit weight gain of 133.00 g.

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