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Growth and production of cayenne pepper (*Capsicum frutescens* L.) on various concentrations of bio-fertilizer and NPK fertilizer

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Abstract. This study aims to study the effect of various concentration of biological fertilizers and NPK dosages on the growth and production of cayenne pepper. The study was conducted at the Experimental Farm of the Faculty of Agriculture, Hasanuddin University, Makassar, from January to April 2019. The study was set as a two-factor factorial experiment using a randomized block design. The first factor was the concentration of the biological fertilizers, consisted of 0, 5, 10, and 15 mL L⁻¹ water. The second factor was the NPK fertilizer dosages, consisted of 0, 2, and 4 g per plant. The results show that the interaction between the application of 10 mL L⁻¹ water of the biological fertilizer and NPK fertilizer dosage of 4 g per plant resulted in the highest number of productive branches (50.78 branches) and production (1.17 tons ha⁻¹). Application of the biological fertilizer of 5 mL L⁻¹ water and NPK fertilizer dosage of 2 g per plant at the age of 15 days after planting (DAP) tended to provide the highest average plant height (13.94 cm), but higher concentration and dosage of 10 mL L⁻¹ water and 4 g per plant of bio-fertilizer and NPK, respectively, resulted in the highest plant at the 35 DAP (33.78 cm). The application of 2 g per plant NPK fertilizer gave the highest yield on the number of fruits per plant (68.00 fruits), and the weight of fruits per plant (64.14 g).

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1. Introduction

Cayenne pepper (*Capsicum frutescens* L.) is one of the horticultural crops of vegetables with a small fruits with a spicy flavor. Potency in developing this commodity, especially in Indonesia, lies in its economic value due to the increased demand for this type of chili. The increase can be attributed to the production of chili either to meet the national consumption or as an export commodity.

The productivity of cayenne pepper is determined by the cultivation technique applied. One component of the technologies that has a major effect on the productivity of cayenne peppers is fertilization. Cayenne pepper can be categorized in the type of vegetable that is very responsive to fertilization. According to Muchyar [1], main nutrients that determine the productivity and quality of cayenne pepper include Nitrogen (N), Phosphate (P), and Potassium (K). The chili plants require 10 tons ha⁻¹ manure and 250 kg ha⁻¹ NPK (16:16:16) which given in the first week after planting [2].

The use of synthetic fertilizers continuously and in high amounts can cause soil damage and reduce soil fertility, hence reduce crop productivity. One approach to suppress the use of high synthetic fertilizers in the agricultural sector is to utilize soil microbes [3]. Bio-fertilizers are defined as inoculants



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made from active living organisms with ability in binding certain nutrients or facilitate the availability of nutrients in the soil for plants. Bio-fertilizer technology is the use of biologically active products consisting of soil-fertilizing microbes to increase fertilizer efficiency, fertility and soil health, environmentally friendly and complementary to other sustainable components of technology [4].

Microbial content that is commonly found in biological fertilizers is phosphate solvent microbes, *Azospirillum* sp., *Azotobacter* sp., *Pseudomonas* sp., and cellulotic bacteria. Previous studies have shown that the use of bio-fertilizer in chili can reduce the need of synthetic fertilizers without affecting the plant production. The study of Wahyuningratri [5] shows that the application of biological fertilizers influenced the yield of chili on the production parameters. The use of the bio-fertilizer as much as 5 mL L⁻¹ per plant has been proven to increase the fruit fresh weight per plant by 41.71% and the number of harvested fruits by 43.90%. Suropti [6] reports that the use of bio-fertilizers on chili plants could reduce the use of NPK to a dose of 50% of the recommendations. This recent study aims to study the application of various concentrations of bio-fertilizers and NPK fertilizer dosages that appropriate for the growth and production of cayenne pepper.

2. Methodology

The research was conducted in the Experimental Farm of the Faculty of Agriculture, Hasanuddin University, Makassar from January to April 2019. The materials used in this study were Dewata chilli F1 seed variety, Feng Shou biological fertilizer that contains a variety of specific types of microbes, atonic, water, NPK fertilizer (16:16:16), and chicken manure. The tools used in this study were hoes, tractors, digital scales, cameras, meters, treatment boards, and writing instruments.

The study was conducted as an experimental research using a randomized block design (RBD) consisting of two treatments. The first factor set was the treatment of biological fertilizers, consisted of Control (0 mL L⁻¹ water), 5, 10, and 15 mL L⁻¹ water. The second factor was NPK fertilizer treatment, consisted of Control or 0 g per plant, 2 and 4 g per plant. The treatments were repeated three times.

2.1. Land preparation and planting

Following land clearing from the previous crop, land was ploughed as deep as 30 cm to form beds with a size of 300 cm x 200 cm and height of 30 cm for each bed. Distance between beds used was 50 cm and a distance between replications of 100 cm was set.

Chili seeds, previously soaked in Atonic solution for 12 hours, were germinated using flannel cloth and covered with dark cloth. After the seeds germinated, the seeds were replanting in small pots contained soil media + chicken manure with a ratio of 2:1 and maintained for 25 days. Before transplanting onto the beds at 20 days after sowing (DAS), seedlings were bud pruned to stimulate the acceleration of stem and leaf growth. At 25 DAS, a selection was carried out to determine healthy and uniform seedlings to be transplanted to the beds. Seedlings were planted using 50 x 60 cm planting distances with a plant population of 15 plants per bed, resulted in a total number of 540 plants.

2.2. Fertilizer application

Chicken manure of 10 tons ha⁻¹ were applied previously as basic fertilizer before the seedlings were transferred onto the beds. Bio-fertilizer treatment was applied three times, namely at 10 days after planting (DAP), 20 DAP, and 30 DAP. The fertilizer was conducted by spraying the rhizosphere of the plants with the bio-fertilizer according to the concentration. On the other hand, NPK synthetic fertilizer was applied once at 7 DAP.

2.3. Data analysis

Observation were made on the growth and production of the cayenne pepper plants. Data were analysed using a two-way analysis of variance (ANOVA) based on randomized blocked design. Further test was conducted when the treatments had significant effect on the parameter observed using Tukey's Honestly Significance Difference (HSD) test at level of 5% to determine the differences between means.

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3. Results

3.1. Plant height

Analysis of variance results show that the treatment of biological fertilizer concentrations, the treatment of NPK fertilizer doses, and the interaction between the two treatments had no significant effect on the height of the cayenne pepper at 15 and 35 DAP. The average plant height of the plants, 15 and 35 DAP, on different bio-fertilizer concentration and NPK fertilizer dosage treatments are shown in figure 1 and figure 2, respectively.

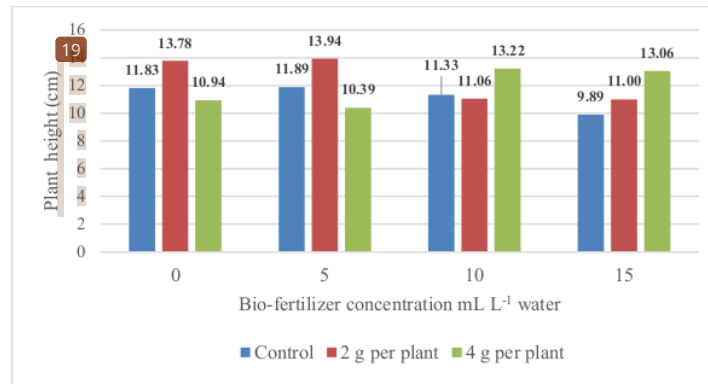


Figure 1. Average of plant height of cayenne pepper plants at 15 days after planting (DAP) on different concentration of bio-fertilizer and NPK dosages.

Figure 1 shows that the treatment of biological fertilizer of 5 mL L⁻¹ water and NPK fertilizer 2 g per plant resulted in the highest average plant height 15 DAP (13.94 cm) while the treatment concentration of fertilizer biological of 15 mL L⁻¹ water without NPK fertilizer showed the lowest average height of plants (9.89 cm).

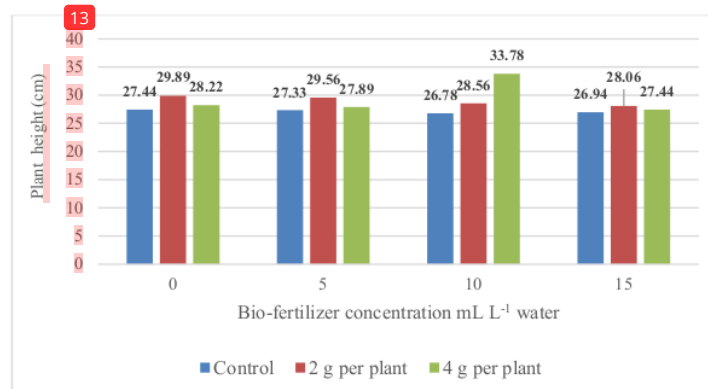


Figure 2. Average of plant height of cayenne pepper plants at 35 days after planting (DAP) on different concentration of bio-fertilizer and NPK dosages.

Similarly, control plants without application of NPK fertilizer also resulted in the shortest plant at 35 DAP (26.78 cm) while plants treated with 10 mL L⁻¹ water of biological fertilizer and 4 g per plant NPK fertilizer tended to result in the highest plant at 35 DAP (33.78 cm).

3.2. Number of productive branches

Number of productive branches of the cayenne pepper significantly affected by the application of bio-fertilizer and NPK. The average number of productive branches in the interaction effect of biological fertilizer and NPK fertilizer treatments are shown in table 1.

Table 1. Average number of productive branches (branches) of cayenne pepper on different concentration of bio-fertilizer and NPK dosages.

Bio-fertilizer	NPK dosage			Tukey's HSD _{Bio-fert.0.05}
	0 g per plant	2 g per plant	4 g per plant	
0 mL L ⁻¹	39.67 ^a	45.33 ^a	35.89 ^b	6.13
5 mL L ⁻¹	33.89 ^{bc}	41.33 ^a	41.11 ^a	
10 mL L ⁻¹	35.78 ^b	39.89 ^b	54.22 ^a	
15 mL L ⁻¹	33.67 ^b	46.33 ^a	37.22 ^b	
Tukey's HSD _{NPK0.05}	5.75			

Numbers followed by the same letter in the row (abc) and column (xyz) means are not significantly different based on Tukey's HSD at level of 5%.

Table 1 shows that the treatment of 10 mL L⁻¹ water of biological fertilizer and 4 g per plant NPK fertilizer showed the highest number of productive branches with an average value of 54.22 branches and the lowest was shown by the application of bio-fertilizer of 15 mL L⁻¹ water without NPK fertilizer (33.67 branches).

3.3. Number of fruits per plant

Variance analysis shows that the NPK fertilizer dosage treatment had a significant effect on the fruit number per plant of the cayenne pepper. No significant effect both the bio-fertilizer and the interaction between the two factors. The average number of fruits per plant in the treatment of biological fertilizers and NPK fertilizer are shown in table 2.

Table 2. Average number of fruit per plant (fruit plant⁻¹) of cayenne pepper on different concentration of bio-fertilizer and NPK dosages.

Bio-fertilizer	NPK dosage		
	0 g per plant	2 g per plant	4 g per plant
0 mL L ⁻¹	52.22	68.89	63.78
5 mL L ⁻¹	38.56	66.67	57.22
10 mL L ⁻¹	52.67	74.78	55.11
15 mL L ⁻¹	56.56	61.67	66.44
Average	50.00 _b	68.00 _a	60.64 _a
Tukey's HSD _{NPK0.05}	11.05		

Numbers followed by the same letter in the row (abc) means are not significantly different based on Tukey's HSD at level of 5%.

Table 2 shows that the biggest number of fruits per plant obtained by plants treated with NPK fertilizer of 2 g per plant (68.00 fruits) that significantly different from control plants which showed the lowest number of fruits per plant (50.00 fruits).

3.4. Fruit weight per plant

Analysis of variance shows that the NPK fertilizer dosage treatment had a significant effect on the parameter of fruit weight per plant. The average number of fruits per plant in the treatment of biological fertilizers and NPK fertilizer are shown in table 3.

Table 3. Average fruit weight per plant (g plant^{-1}) of cayenne pepper on different concentration of bio-fertilizer and NPK dosages.

Bio-fertilizer	NPK dosage		
	0 g per plant	2 g per plant	4 g per plant
0 mL L ⁻¹	47.67	64.33	58.67
5 mL L ⁻¹	33.44	61.67	54.56
10 mL L ⁻¹	47.67	71.89	51.78
15 mL L ⁻¹	51.33	58.67	60.78
Average	45.03 _b	64.14 _a	56.44 _a

Tukey's HSD_{NPK0.05} 11.72

Numbers followed by the same letter in the row (abc) means are not significantly different based on Tukey's HSD at level of 5%.

Table 3 shows that the highest average fruit weight per plant was obtained in the 2 g per plant NPK fertilizer treatment (64.14 g) which is significantly different from control treatment that showed the lowest fruit weight per plant (45.03 g).

3.5. Production per hectare

Analysis of variance results show that there was a significant interaction effect of both bio-fertilizer and NPK fertilizer treatments on the production per hectare of cayenne pepper. The average of the plant production of the cayenne pepper in the treatment of biological fertilizer concentration and NPK fertilizer dosage treatment are shown in table 4.

Table 4. Average of production per hectare (ton ha^{-1}) of cayenne pepper on different concentration of bio-fertilizer and NPK dosages.

Bio-fertilizer	NPK dosage			Tukey's HSD _{Bio-fert.0.05}
	0 g per plant	2 g per plant	4 g per plant	
0 mL L ⁻¹	0.76 _{ab} ^{yz}	1.01 _a ^z	1.06 _a ^y	0.08
5 mL L ⁻¹	0.69 _{ab} ^z	1.15 _a ^x	0.99 _a ^{yz}	
10 mL L ⁻¹	0.84 _{bc} ^y	1.04 _b ^{yz}	1.17 _a ^x	
15 mL L ⁻¹	0.95 _b ^x	1.11 _a ^x	1.02 _b ^y	
Tukey's HSD _{NPK0.05}	0.07			

Numbers followed by the same letter in the row (abc) and column (xyz) means are not significantly different based on Tukey's HSD at level of 5%.

Based on the Tukey's HSD test at the level of 5% in table 4, the highest production of cayenne pepper was obtained by the application of 10 mL L⁻¹ water biological fertilizer and 4 g per plant NPK fertilizer (1.17 tons ha⁻¹) and was significantly different from the treatment of 5 mL L⁻¹ of water biological fertilizer treatment without NPK fertilizer which showed the lowest average of production of the cayenne pepper plant (0.69 tons ha⁻¹).

4. Discussion

The results in this recent study show that based on the variance analysis, treatment combination of biological fertilizers with NPK fertilizer significantly affected the number of productive branches parameter and production per hectare but the interaction did not have any significant effect on other observational parameters. The interaction between biological fertilizer and NPK fertilizer showed the highest results in the application of 10 mL L⁻¹ water biological fertilizer with a dose of 4 g per plant NPK fertilizer which gave the highest average productive branches, namely 54.22 branches and the highest production of 1.17 tons ha⁻¹.

Production obtained in this study did not achieve the potential productivity of 10 tons per hectare of cayenne pepper due to environmental factors such as high rainfall that led to pests and diseases that attacked the plants. According to Widodo [7], chili plants are known as plants that are not very resistant to high rainfall. High rainfall at flowering stage can cause the loss of flowers so that the fruit is reduced. In addition, the assumption of five times the harvest can be seen as relatively low chili production. The harvest interval for cayenne pepper is usually 3 - 5 days and the chili harvest period ranged between 1-2 months after the first harvest, hence there will be 15-18 times the harvest [8].

In addition to weather factors on the ground, cayenne pepper plants were also attacked by fruit flies. Syukur [9] states that fruit flies (*Bractocera dorsalis* Hendel) is among the main pests in chili plants, these pests are polyphagic (many hosts), symptoms of fruit flies in chili fruit are marked with the discovery of black dots and if the fruit splits, there are grubs (larvae) of the fruit flies. Female insects put maggots in the fruit, namely by jabbing its ovipositor on young fruit (still green). Furthermore, the larvae live in chilies until they rot and fall. Severe attacks occur in the rainy season, this is caused by ovipositor puncture marks contaminated by fungi so that the affected fruit decays quickly and falls. The installation of adhesives and the application of insecticides on cayenne pepper plants have been carried out to reduce the intensity of attacks by fruit flies. As a result of these pests so that the yield of cayenne pepper obtained in this study could not reach its productivity which could reach 10 tons ha⁻¹.

The results of variance show that biological fertilizer treatment had no significant effect on 11 parameters observed. The effect of biological fertilizer as a whole did not have a significant effect on the growth and production of cayenne pepper. This is due to environmental conditions that are less than optimal so that the influence of microorganisms becomes ineffective. This is consistent with the opinion of Simarmata et al. [10] stating that the effectiveness of microorganisms is related to various abiotic soil environmental factors (nutrient concentration, pH, water content, temperature, soil treatment, and fertilizer / pesticide use) and biotic factors (microbial interactions, bacterial species, and competition between bacteria).

The results of variance showed that NPK fertilizer treatment significantly affected the parameters observed for the number of fruits per plant and fruit weight per plant. The NPK fertilizer dosage treatment of 2 g per plant showed the highest average number of fruits per plant (68 fruits), while the control treatment showed the lowest average number of fruits per plant (50 fruits). The treatment of 2 g NPK fertilizer per plant had the highest average fruit weight per plant (64.14 g), while the treatment without NPK fertilizer had the lowest average number of fruits per plant (45.03 g).

Chili plants can grow and produce perfectly if the nutrients needed are met. Provision of macro nutrients (N, P, K) in chili plants is very necessary because macro nutrients are nutrients needed in large quantities that play an important role as food for plants. This is in accordance with the opinion of Susiyani et al. [11] which states that the provision of nutrients in plants is very influential on the photosynthesis process which will affect the growth and production of hybrid chili plants.

According to Hardjowigeno [12], the N element contained in fertilizer functions to stimulate the vegetative growth of plants so that plants can synthesize amino acids and proteins and arrange chlorophyll (green colour), in addition, the P element given also serves to encourage the growth of chili plant height and elements K which plays a role in the process of photosynthesis so that chili plants can flourish which affects the dry weight of plants

5. Conclusions

- The interaction of biological fertilizer concentration of 10 mL L⁻¹ water with NPK fertilizer 4 g per plant resulted in the highest number of productive branches (54.22 branches) and the production of cayenne pepper (1.17 tons ha⁻¹).
- Application of biological fertilizer of 5 mL L⁻¹ water and NPK fertilizer 2 g per plant at the age of 15 DAP tends to provide the highest average plant height (13.94 cm), biological fertilizer concentration of 10 mL L⁻¹ water and NPK fertilizer 4 g per plant at the age of 35 DAP tends to provide the highest average plant height (33.78 cm).

- Application of NPK fertilizer dosage of 2 g per plant gives the highest yield **on the number of fruits per plant** (68 fruits) **and** weight of fruit **per plant** (64.14 g).

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