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Response of Biofertilizer Application and Alkali Supplement Fertilizer on the Growth and Yield of Curly Red Chili (*Capsicum annuum* L.)

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ABSTRACT

Chili is one of the important vegetables in the culture of Indonesian society, but its productivity is still low. This research aimed to determine the response of biofertilizer application and alkali supplement fertilizer on the growth and yield of chili. This research was conducted in Integrated Field Laboratory, University of Lampung, and arranged in a randomized block design (RBD) consisting of two factors, namely biofertilizer (0, 4, and 8 ml/plant) and alkali supplement fertilizer (0, 0,05, and 0,1 gram/plant). Each experiment included 3 repetitions. Observation consists of plant height, number of flowers, number of fruit, fruit length, and fruit weight per plant. Data were analyzed using analysis of variance (ANOVA), followed by Least Significant Difference (LSD) at 5% level of significance. Results showed that biofertilizer and alkali supplement fertilizer had a significant effect on growth and production variables. The highest production was obtained in the biofertilizer treatment of 8 ml/plant combined by alkali supplement fertilizers dose of 0,1 gram/plant with weight of 436.70 grams/plant.

1. INTRODUCTION

Red curly chili (*Capsicum annuum* L.) is one of the vegetables with high economic value and is suitable to be developed in tropical areas such as Indonesia. Indonesian peoples can hardly be separated from chili plants, because chili is often used as a spice in cooking. In addition to the demand for household needs, significant consumption is also seen in the food industry, medicine and herbal medicine industries. The Indonesian people's preference for chili is proven by the large per capita consumption for chili in 2018 which reached 3 kg/capita/year (Pusdatin Kementerian Pertanian, 2018).

Based on BPS (2018), red chili production on a national scale reached 1.206 million tons in 2018. Lampung specifically produced 50,203 and 45,380 tons in 2017 and 2018. This production has not yet met the demand for chili. The average production of curly red chili in Lampung province only reached 7.39 tons/ha, whereas according to Wiyono *et al.* (2012) the potential yield that can be achieved is greater, namely 16-32 tons/ha. The low

productivity of curly red chili is not only influenced by inefficient application of cultivation techniques carried out by farmers, but also caused by the condition of agricultural land in the Lampung region which is generally ultisol soil. Ultisol soils are characterized by low pH (average <4.50), high Al saturation, low macronutrients such as N, K, Ca, and Mg, and low organic matter content. This causes intrinsic problems in achieving optimal productivity. Provide just fertilizer is not enough to supply of nutrients source, but it is also necessary to provide organic matter with proper management and quantity in order to overcome the limitations on ultisol soils (Sujana & Pura, 2015).

Farmers' efforts to control limits on ultisol soils are generally conducted by applying chemical fertilizers. However, if this provision is carried out excessively in the long term it will cause other problems in the soil. Soil can turn out to be dense, hard, and will be difficult to cultivate. These changes can reduce the ability of the soil to hold water and inhibit the development of plant roots. To reduce soil degradation, it is necessary to have organic inputs in the form of organic fertilizers, either liquid, solid, or organic fertilizers containing microbes (biological fertilizers) plus alkaline complementary fertilizers. The application of organic biological fertilizers can provide ecological and economic benefits, because biological fertilizers contain active soil microbes that can function as binder for certain nutrients or facilitating the availability of nutrients in the soil for plants (Simanungkalit, 2006). The use of biological fertilizers is expected to be able to replace inorganic fertilizers up to 50% in horticultural crop farming and effectively increase crop productivity by 20% - 50% (Suwandi et al., 2015).

The activity of microorganisms is influenced by the level of soil acidity. At neutral soil pH, the activity of microorganisms is generally in optimum conditions and increases with increasing soil pH. Therefore, the addition of alkaline complementary fertilizers is expected to increase the pH of ultisol soils so that soil microorganisms can develop optimally. Besides containing macro nutrients, alkaline complementary fertilizers also contain micro nutrients needed by plants that are not available in basic fertilizers or biological fertilizers.

Fertilization given in a combination of biological fertilizers with complementary alkaline fertilizers is a balanced and environmentally friendly agricultural cultivation technique. Microbes in biological fertilizers have the potential to improve soil quality, both physical, chemical and biological properties of the soil and provide nutrients such as N, P, and K through mechanisms resulting from microbial activity. Meanwhile, the application of complementary alkaline fertilizer containing complete macro and micro nutrients will meet the needs and balance of plant nutrients and function as a catalyst so that it can support optimal growth and production. Therefore, this study uses a combination of biological fertilizers and alkaline complementary fertilizers which are expected to have a synergistic effect on both factors to increase the growth and production of curly red chili. Specifically, this study was conducted to determine the effect of the application of biological fertilizers and alkaline complementary fertilizers and the interaction between the two treatment factors on the growth and production of curly red chili.

2. MATERIALS AND METHODS

2.1. Materials

The experiment was carried out at the Integrated Field Laboratory, Faculty of Agriculture, University of Lampung. The materials used in this study include, curly red chili seeds (Indrapura Paten), biological fertilizers (containing bacteria *Azospirillum sp.*, *Azotobacter sp.*, *Lactobacillus sp.*, *Pseudomonas sp.*, phosphate solubilizing microbes,

cellulosic microbes, Indole Acetic Acid (IAA) hormone, alkaline phosphatase enzymes, and acid phosphatase enzymes), alkaline complementary fertilizer with the contents as given in Table 1, and water. The equipments included hand sprayer, ruler, water hose, digital scale, bamboo stake, hoe, meter, sickle, bucket, plastic cup, and stationery.

Table 1. Nutrients composition of alkaline complementary fertilizer

Element	Content	Unsur	Kandungan
Nitrogen(N)	0,23%	Mangan (Mn)	2,37 ppm
Phosphate (P ₂ O ₅)	12,70%	Cooper (Cu)	< 0,03 ppm
Kalium (K)	0,88%	Zink (Zn)	11,15 ppm
Magnesium (Mg)	25,92 ppm	Molibdenum (Mo)	35,37 ppm
Sulfur (S)	0,02%	Borron (B)	0,25%
Ferum (Fe)	36,45 ppm	Carbon (C)	6,47%
Chlor (Cl)	0,11%	Natrium (Na)	27,42%
Calsium (Ca)	< 0,05 ppm	Cobalt (Co)	9,59 ppm
Alumunium	< 0,4 ppm		

Sumber: PT Citra Nusa Insan Cemerlang, 2011

2.2. Experimental Design

The method used in this study was a Randomized Block Design (RAK) which consisted of 2 factors with 3 replications. The first factor is biological fertilizers, consisting of: H0 = no application of biological fertilizers; H1 = giving 2 times of biological fertilizer 1 week after planting (WAP) and 5 WAP (dose of 4 ml/plant); H2 = application of 4 times biological fertilizer in 1 WAP; 4 WAP, 7 WAP, and 10 WAP (8 ml/plant dose). The second factor is alkaline supplementary fertilizer, consisting of P0 = no alkaline supplementary fertilizer; P1 = application of alkaline complementary fertilizer 1 time/week (dose of 0.05 gram/plant); P2 = application of complementary alkaline fertilizer 2 times/week (dose of 0.1 gram/plant). The application of NPK and TSP fertilizers was carried out after one week of transplanting chili seedlings at the age of 28 days. The application is done by spreading it in a circle around the plant and then covering it with soil to reduce losses due to evaporation.

The number of sample plants in this study were 54 plants. Homogeneity of variance between treatments was tested using the Bartlett test and data additivity was tested using the Tukkey test. Furthermore, the difference in the mean value of the treatment was tested using the BNT test at the 5% level. This study used plant height (cm) variables measured at 75 DAP, number of flowers per plant, number of fruit (grams), fruit length (grams), and fruit weight per plant (grams). Observations of production variables were carried out from the beginning to the end of harvest (harvest time was 20 WAP).

3. RESULTS AND DISCUSSION

3.1. Plant Height

The results of the analysis showed that the treatment of biological fertilizers and alkaline complementary fertilizers had a significant effect on plant height. However, there was no significant interaction between treatments (Table 2).

Biological fertilizer treatment with a dose of 8 ml/plant resulted in the highest plant height of 81.09 cm. It is suspected that the biofertilizer at a dose of 8 ml/plant contains more microorganisms that help plants to achieve maximum growth compared to other doses. If the number of microorganisms is high, the activity of microorganisms is also

higher, so that the need for food supply for growth can be fulfilled. Biofertilizers contain microorganisms, such as *Azospirillum* sp. and *Azotobacter* sp., known as plant growth promoting Rhizobacteria (PGPR). According to Cecagno *et al.* (2015), PGPR can increase the number of active bacteria around plant roots. The PGPR isolate used was thought to trigger root development, thereby supporting increased absorption of water and nutrients from the soil and being able to affect plant height. Kanchana *et al.* (2018), reported that *Azospirillum* sp. and *Azotobacter* sp. able to fix nitrogen, dissolve phosphate, and produce phytohormones such as IAA. IAA is the active form of the auxin hormone found in plants that functions to promote cell development, stimulate the formation of new roots and stimulate growth.

Table 2. Independent effect of application of biological fertilizers and alkaline complementary fertilizers on plant height at 75 DAP

Treatment	Plant height (cm)
H0	67,65c
H1	74,26b
H2	81,09a
BNT 5%	6,24
P0	68,82b
P1	73,19b
P2	80,89a
BNT 5%	6,24

Note: numbers followed by the same letter are not significantly different at an error rate of 5%

In the alkaline complementary fertilizer treatment, the best plant height was obtained at a dose of 0.1 gram/plant. It is suspected that the application of 0.1 gram alkaline complementary fertilizer/plant has a higher N nutrient content than the 0.05 gram/plant treatment and without alkaline complementary fertilizer. Availability of sufficient nutrients by giving the right dose can increase the uptake of N nutrients by curly chili plants, and can further encourage plant height growth. As stated by Munawar (2011) that in addition to the formation of protein, the element N is a constituent of chlorophyll which is indispensable for the photosynthesis process. Adequate supply of N for plants can increase photosynthetic activity in plants and encourage or promote good vegetative growth. Gardner *et al.* (1991), explained that plants with sufficient nutrient availability will trigger good metabolic activities, such as increasing the process of cell division, cell elongation and tissue formation, which in turn will increase plant height growth.

Plant height will have implications for the emergence of production branches. The taller the plant, the higher the tendency to have many branches. Red chili plants produce fruit on secondary branches, so by knowing the height of the plant it is hoped that its potential can be estimated in generating production branches and fruit that can be produced.

3.2. Number of Flowers and Fruits

The research data showed that there was a significant interaction between the treatment of biological fertilizers and alkaline complementary fertilizers on the number of flowers and fruits (Table 3.) This indicates that curly red chili plants responded well to the treatment of biological fertilizers and alkaline complementary fertilizers. There is a

mutually beneficial interaction between microbial agents that live around the root rhizosphere layer and plants in the utilization and transportation of nutrients which can ultimately increase chili production.

Table 3. The interaction effect of the application of biological fertilizers and alkaline complementary fertilizers on the number of flowers and fruits

Alkaline Fertilizer	Biological Fertilizer		
	0 ml/plant	4 ml/plant	8 ml/plant
Flower number			
0 ml/plant	151,55 (b) B	170,52 (b) AB	182,89 (a) A
0.05 ml/plant	178,56 (a) A	165,65 (b) A	171,78 (a) A
0.1 ml/plant	169,59 (ab) B	195,30 (a) A	186,06 (a) AB
BNT	20.66		
Fruit number			
0 ml/plant	151,55 (b) B	170,52 (b) AB	182,89 (a) A
0.05 ml/plant	178,56 (a) A	165,65 (b) A	171,78 (a) A
0.1 ml/plant	169,59 (ab) B	195,30 (a) A	186,06 (a) AB
BNT	20.89		

Note: The average number followed by different lowercase letters in the column and different capital letters in the rows at an error rate of 5%

Without the provision of biological fertilizers (0 ml/plant) with a dose of alkaline complementary fertilizer 0 grams/plant can produce the number of flowers up to 151.55 flowers. The application of biological fertilizers at a dose of 4-8 grams/plant increased the number of flowers. Application of biological fertilizer 4 ml/plant without alkaline complementary fertilizer (0 gram/plant) increased the number of flowers up to 170.52. At a dose of 8 grams/plant the number of flowers increased again until it reached 195.30. The application of 8 ml/plant of biological fertilizer without alkaline complementary fertilizer also increased up to 182.89. However, there was a decrease at the dose of 0.05 gram/plant, but statistically it was not significantly different. The number of flowers is very crucial for chili plants. The high yield of chili plants is strongly influenced by the number of flowers that develop to form fruit. The higher the number of flowers formed, the greater the potential for fruit formation.

In this study, the data showed that without the application of biological fertilizers (0 ml/plant) and without complementary alkaline fertilizers (0 grams/plant) they could still produce up to 127.67 fruits. In the application of alkaline fertilizer at a dose of 4-8 grams/plant, the number of fruits increased. The application of 4 ml biological

fertilizer/plant without alkaline complementary fertilizer was able to increase chili fruit up to 144.33 pieces, and at a dose of 8 grams/plant it increased fruit up to 156.00. The application of 8 ml biological fertilizer/plant without alkaline complementary fertilizer increased chili fruit up to 150.67, and reached the highest number of fruit at a dose of 0.1 gram alkaline complementary fertilizer/plant.

The formation of flowers and fruit is influenced by the availability of nutrients, especially phosphorus and potassium (Olaniyi, 2010). Biological fertilizers contain phosphate solubilizing microbes, namely *Pseudomonas* sp. and *Lactobacillus* sp. Both bacteria are phosphate solubilizing bacteria that can dissolve phosphate bound to other elements, such as Al, Mg, Fe, and Ca. The process of dissolving phosphate from these elements is carried out by secreting organic acids (citric, glutamate, glyoxalate and succinate) so that P elements become available and meet the needs of plants (Boraste *et al.*, 2009). Then, it is also added to alkaline complementary fertilizer which has the availability of phosphorus which comes from the P₂O₅ nutrient content in it, so that phosphorus is easily available to plants. In addition to macro nutrients, phosphorus and potassium, the process of flowering and fruiting is also influenced by micro nutrients Ca and B. Ca elements play a role in apical growth and flower formation while B affects pollination results and seed development in formed fruit and normal fruit development (Surtinah, 2006). In the research of Hada *et al.* (2014) stated that nutrient B was able to reduce flower/fruit loss by 42.86%. The fulfillment of nutrients at the stage of flowering and fruit formation can be seen in the application of 8 ml biological fertilizer/plant and 0.1 gram alkaline complementary fertilizer/plant with a fruit set percentage of 86.53%.

3.3. Fruit Length and Fruit Weight

The results showed that the treatment of biological fertilizers and alkaline complementary fertilizers significantly affected fruit length, but the interaction between the two factors was not significant. There is a tendency to increase fruit length with increasing doses of biological fertilizer treatment and complementary fertilizer treatment. The application of 8 ml of biological fertilizer/plant was able to produce the best fruit length with a yield of 14.09 cm while the addition of 0.1 gram of alkaline complementary fertilizer/plant was able to produce fruit lengths of up to 15.01 cm.

Table 4. The independent effect of biological fertilizer and alkaline complementary fertilizer application on fruit length

Treatment	Fruit length (cm)
Biological fertilizer	
4 mL/plant	13.84ab
8 mL/plant	14.19a
Alkaline fertilizer	
0 gram/plant	12.69c
0.05 gram/plant	13.72b
0.1 gram/plant	15.01a
BNT 5%	0.59

Fruit weight is closely related to fruit length, fruit weight will increase along with fruit length. Fruit formation is influenced by the availability of nutrients N, P, and K which will be used in the photosynthesis process as a constituent of carbohydrates, fats, proteins, minerals and vitamins which will be translocated in the fruit storage section (Hafizah, 2017). The results showed that the application of biological fertilizers, alkaline complementary fertilizers, and their interactions had a significant effect on fruit weight per plant. Biological fertilizer treatment can increase fruit weight per plant as much as 48.8 grams/plant (an increase of 14.27%) and there is no difference between treatment with biological fertilizers of 4 ml/plant and 8 ml/plant. Meanwhile, the alkaline complementary fertilizer treatment increased fruit weight per plant by 35.6 grams/plant (an increase of 10.13%) and there was no difference between the alkaline complementary fertilizer treatment of 0.05 mL/plant and 0.1 mL/plant. The highest fruit weight per plant was obtained in the 8 mL/plant biological fertilizer treatment which was given an alkaline complementary fertilizer of 0.1 mL/plant, which was 436.70 grams/plant.

Microbes *Azospirillum sp.*, *Azotobacter sp.*, *Lactobacillus sp.*, *Pseudomonas sp.*, which are contained in biological fertilizers will increase soil life naturally through microbiological processes due to additional nutrients from alkaline complementary fertilizers, so as to improve physical, chemical, and biological soil properties. According to Lawenga *et al.* (2015) biological fertilizers are able to affect the value of soil porosity and permeability so as to create a more stable and stable growth environment. Microbes also play a role in the process of decomposition of organic matter so that nutrients are easily available to plants. In addition, microbes are also able to increase the fixation of nutrients in the rhizosphere, produce growth stimulants for plants, increase soil stability, provide biological control, biodegradation of substances, recycle nutrients, promote mycorrhizal symbiosis, and develop bioremediation processes in soil contaminated with toxic substances (Rivera-Cruz *et al.*, 2008). Besides being able to act as a source of nutrients and a starter for microbial growth and development, alkaline complementary fertilizers are also able to complement the needs of macro and micro nutrients for plants. The alkaline nature of complementary fertilizers acts as a catalyst to form compounds in plant cells that are useful in maximizing the availability of nutrients in the soil (Surtinah, 2006).

Biofertilizers contain microorganisms that act as auxin producers, namely *Azotobacter sp.* and *Azospirillum sp.* as nitrogen fixing microbes and growth regulators. Meanwhile, complementary alkaline fertilizers were able to supply N as much as 8.4 mg/plant, P as much as 17.78 mg/plant, and K as much as 1.23 mg/plant, and contain micro-nutrients that support plant growth and production. According to Annisava (2014), high nitrogen content increases the amount of chlorophyll in each leaf, so that the photosynthesis process goes well and produces more photosynthate to be translocated to the weight of seeds and fruit. Fruit formation is also influenced by potassium. This is because potassium plays a role in catalyzing the formation of protein and increasing the content of carbohydrates and fruit sugar. This makes the seeds denser and fuller which will improve the quality of the fruit in terms of color and shape (Wardhani, 2014).

Microbes *Pseudomonas sp.* in biological fertilizers also produce the hormone auxin which can stimulate fruit formation, while *Lactobacillus sp.* produce cytokinin hormones (Timmusk *et al.*, 1999). According to Tjondronegoro *et al.* (1989) when met with IAA (Indole Acetic Acid), cytokinins rapidly stimulate cell division so that the formation of fruit weight can be better. In a study by A'yun *et al.* (2013), the application of

Pseudomonas sp. and *Lactobacillus sp.* increase the fruit weight of chili plants by 112.74%.

The addition of biological fertilizers accompanied by complementary alkaline fertilizers can interact with each other in increasing the growth and development of soil microorganisms optimally, so that it will help increase plant growth and production. This is indicated by the highest production produced by the interaction between the treatment of biological fertilizers 4 applications and the application of complementary alkaline fertilizers 2 times/week, namely 436.70 grams of plant⁻¹ or an increase of 44.52% compared to the control. If converted, the productivity results obtained can reach 10.39 tons ha⁻¹. The potential yield of 10.39 tons ha⁻¹ is an increase compared to the chili production achieved by farmers in the Lampung area, which is 7.39 tons ha⁻¹ or the potential chili production at the national level, which is 8.54 tons ha⁻¹ (BPS, 2018).

4. CONCLUSION

Based on the results of the study, it can be concluded that the application of biological fertilizers and alkaline complementary fertilizers can increase plant height, number of flowers, number of fruits, fruit length and fruit weight per plant. To obtain good growth and yield of curly red chili plants, it is recommended to use biological fertilizer treatment at a dose of 8 ml/plant with the addition of 0.1 gram alkaline complementary fertilizer/plant.

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