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The Effect of Bio-Slurry and NPK On Growth and Yield Cayenne Pepper (*Capsicum frutescens* L.)

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Abstract: Cayenne pepper (*Capsicum frutescens* L.) is an important horticultural commodity in Indonesia with increasing demand, so cultivation efforts are needed to increase its productivity. One way is through fertilization with a combination of organic and inorganic fertilizers. Bio-slurry, a byproduct of the biogas process, contains macro and micro nutrients that can improve soil structure and fertility, while NPK fertilizer plays a role in providing key nutrients quickly. This study investigated the effect of bio-slurry and NPK fertilizer on Kaliber chili pepper using a factorial RBD in Tulungagung, Indonesia. Growth and yield parameters—plant height, stem diameter, fruit number, and fruit weight—were measured. The combination of bio-slurry and NPK significantly improved all parameters evaluated. The best treatment was the B2N2 combination (30 ml bio-slurry and 20 g NPK), which resulted in optimal plant height, stem diameter, fruit number, and fruit weight compared to other treatments. Thus, the combination of bio-slurry and NPK can be an effective fertilization strategy for increasing cayenne pepper productivity.

INTRODUCTION

As a horticultural crop, Cayenne pepper (*Capsicum frutescens L.*) holds substantial economic significance. This plant contains vitamin A, vitamin C, protein, calcium, as well as capsaicin, which acts as an antioxidant and serves as an active compound widely utilized in the pharmaceutical industry.(Andani et al., 2020). According to data from the Ministry of Agriculture (2024), national chili production has experienced fluctuations but showed an increase in 2023, with a positive projection in 2024 expected to reach 3 million tons. This indicates a significant opportunity for the development of chili agribusiness to support food security and strengthen the national economy.

One of the key aspects in improving chili productivity is the availability of sufficient soil nutrients. Fertilization serves as a strategic approach to overcome such limitations.

Bio-slurry, produced as a residual material from biogas processing of livestock manure, serves as a liquid organic fertilizer enriched with key macronutrients, nitrogen (N), phosphorus (P), and potassium (K),along with micronutrients such as magnesium (Mg), calcium (Ca), and sulfur (S), which collectively contribute to enhancing plant growth. (Biru, 2021). The application of bio-slurry has been demonstrated to enhance soil structure, stimulate microbial activity, and improve the soil's water-holding capacity. (Novianto, 2022)

However, the nutrients contained in organic fertilizers such as bio-slurry alone are not sufficient to fully meet the plant's requirements. Therefore, a combination with inorganic fertilizers such as NPK is necessary to provide nutrients that are readily available for plants. NPK Mutiara 16-16-16 contains a balanced composition of macronutrients, which supports both vegetative and generative growth, including in chili plants. (Chairiyah et al., 2022). According to the study conducted by (Azwir et al., 2020), NPK fertilization plays a crucial role in enhancing the reproductive growth of Cayenne pepper plants. Its application not only increases the number of productive branches but also stimulates more optimal flower formation, which consequently leads to an increase in fruit yield. Thus, the application of NPK fertilizer can be considered essential in supporting the productivity of Cayenne pepper through the improvement of both vegetative and generative growth quality.

This study examined how the combined application of bio-slurry and NPK fertilizer affects the growth and yield of Kaliber Cayenne pepper (*Capsicum frutescens L.*).

RESEARCH METHODS

This research was conducted in Kedungcangkring Village, Pagerwojo District, Tulungagung Regency, East Java, at an altitude of approximately 83 meters above sea level (masl), from November 2024 to March 2025. The materials used included Cayenne pepper (*Capsicum frutescens L.*) cultivar Kaliber seeds, NPK Mutiara 16-16-16 fertilizer, liquid bio-slurry, manure, rice husk charcoal, and pesticides. The tools employed consisted of polybags, shovels,

buckets, measuring cups, hoses, calipers, rulers, measuring tapes, and scales. A factorial Randomized Block Design (RBD) with two factors was implemented in this experiment: bio-slurry dosage (0 ml, 15 ml, 30 ml) and NPK dosage (0 g, 10 g, 20 g), resulting in nine treatment combinations replicated three times with a total of 81 plant samples. The experimental procedures included preparation of planting media (soil, rice husk charcoal, and manure), seedling cultivation until the seedlings reached approximately 50 days old, fertilization according to the treatments, and maintenance consisting of watering, replanting, weeding, soil loosening, and pest and disease control. Parameters assessed were plant height, stem diameter, fruit count, and fruit weight. Data collection was carried out from 14 to 126 DAT with a total of five harvests. Statistical analysis was performed using ANOVA, and when significant differences occurred, means were separated with DMRT at the 5% significance level.

RESULTS AND DISCUSSION

Plant Height

Table 1. Mean plant height (cm) of Cayenne pepper under various combinations of bio-slurry (B) and NPK (N) treatments at 14, 28, 42, 56, 70, and 84 days after transplanting (DAT).

Treatment combinations	Plant Height (cm)					
	14 DAT	28 DAT	42 DAT	56 DAT	70 DAT	84 DAT
B0N0	70a	81,43ab	88,67a	99,33a	109,43a	120,67a
BON1	70,67ab	81,33a	89,23ab	102,23b	111,43b	121,77ab
B0N2	71bc	81,33ab	89,89ab	102,43b	112,11b	123bc
B1N0	70,53ab	81,23a	89,23ab	102,43b	111,47b	112,67bc
B1N1	70,67ab	81,57ab	89,57ab	102,87b	112,53bc	123bc
B1N2	70,77ab	81,57ab	90,11ab	102,33b	113,23cd	122,13ab
B2N0	71,33bc	81,67ab	90,57b	102,47b	113,53cd	122,67bc
B2N1	71,67c	81,67ab	90,67b	103,37b	113,47cd	123,89cd
B2N2	71,67c	82b	94,11c	103,33b	114d	125,23d

Note: Means sharing the same letter in a column indicate no significant difference according to Duncan's Multiple Range Test (DMRT) at the 5% probability level.

The combination of bio-slurry and NPK was proven to increase the plant height of Cayenne pepper during the late vegetative phase (84 DAT), particularly with the combination of 30 ml bio-slurry and 20 g NPK (Table 1). Bio-slurry

improves soil structure, making it looser and more porous, which allows the roots to develop more optimally and enhances nutrient absorption (Edy et al., 2021). Bio-slurry supplies essential nutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) that support vegetative development, while its active microorganisms enhance soil fertility (Tirta Salim. S & , Razean Haireen, 2025). Bio-slurry organic matter enhances cation exchange capacity (CEC) and soil water-holding ability, while its nitrogen (N) content is essential for promoting rapid stem and leaf development (Lingga, 2021).

Meanwhile, NPK fertilizer functions as a source of macronutrients that are readily available for plants, thereby supporting vegetative growth. Previous studies have shown that higher doses of NPK tend to promote the growth of red chili plants (Sitorus et al., 2023). Other studies have also reported that increasing NPK application is directly proportional to the vegetative growth of chili plants (Chairiyah et al., 2022). The phosphorus element in NPK plays an important role in the photosynthesis process through the formation of ATP, which supports cell division (Wulandari et al., 2018). Potassium functions to enhance meristematic tissue activity, thereby promoting more optimal stem growth (Azlansyah et al., 2014).

Stem Diameter

Table 2. Mean stem diameter of chili pepper plants (cm) under different combinations of bio-slurry (B) and NPK (N) treatments at 14, 28, 42, 56, 70, and 84 days after transplanting (DAT).

Treatment combinations	Stem Diameter (cm)					
	14 DAT	28 DAT	42 DAT	56 DAT	70 DAT	84 DAT
B0N0	0,59a	0,8a	0,89ab	0,99a	1,07a	1,17a
B0N1	0,51a	0,8a	0,87a	0,99a	1,09ab	1,23ab
B0B2	0,59a	0,88bc	0,94ab	1,07b	1,12bc	1,21ab
B1N0	0,6a	0,82a	0,92ab	1,01ab	1,09ab	1,19ab
B1N1	0,58a	0,8a	0,93ab	1,14b	1,13c	1,23ab
B1N2	0,6a	0,9c	0,95ab	1,03ab	1,12bc	1,23ab
B2N0	0,57a	0,83abc	0,94ab	1a	1,14c	1,22ab
B2N1	0,6a	0,87abc	0,95ab	1,03ab	1,12bc	1,23b
B2N2	0,61a	0,88bc	1b	1,12c	1,2d	1,34c

Note: Means sharing the same letter in a column indicate no significant difference according to Duncan's Multiple Range Test (DMRT) at the 5% probability level.

Results showed that bio-slurry combined with NPK promoted stem diameter growth in chili pepper, with the maximum effect observed at 84 DAT (Table 2). Bio-slurry contributed to improving soil structure, thereby increasing porosity and aeration, which facilitated optimal root system development. The nitrogen contained in bio-slurry supported the acceleration of stem tissue growth, while the phosphorus supplied through NPK directly contributed to the enlargement of stem diameter by playing a crucial role in stem cell division (Chairiyah et al., 2022).

Number and weight of chili fruits

Table 3. Average number of fruits and fruit weight of chili plants under various combinations of Bio-slurry (B) and NPK (N) treatments at the first, second, third, fourth, and fifth harvests.

Treatment combinations	Number of Fruits per Plant	Fruit Weight of Cayenne Pepper (g)
B0N0	150,33a	444,67a
B0N1	187,33b	559,33b
B0N2	226,67d	680d
B1N0	226,67d	622c
B1N1	237,33e	714e
B1N2	262,33f	788,33f
B2N0	238e	715,33e
B2N1	264.67f	796f
B2N2	300,33g	905g

Note: Means sharing the same letter in a column indicate no significant difference according to Duncan's Multiple Range Test (DMRT) at the 5% probability level.

The combination of bio-slurry and NPK was proven to increase the number of chili fruits, with the best results obtained from the B2N2 combination (Table 3). The synergy between the two creates optimal root conditions, as bio-slurry supplies nutrients gradually while NPK provides nutrients that are readily available. This environment promotes more effective flower formation and efficient pollination, thereby increasing the number of fruits produced. Potassium plays an important role in carbohydrate translocation and starch formation, which in turn influences the number of fruits produced (Novizan, 2021). Other studies have also confirmed that bio-slurry can improve fruit quality, increase the number of fruits per plant, as well as other parameters such as fruit weight and diameter (Nathalia et al., 2023). Thus, the availability of nutrients from bio-slurry supports

the flowering to fruiting phases, while the application of NPK complements the plant's macronutrient requirements. Previous studies have shown that NPK application can increase plant height, fruit weight, and the number of fruits per plant (No & L, 2021).

The combination of bio-slurry and NPK resulted in the highest fruit weight of chili at 126 days after transplanting (DAT), with the best outcome observed in the B2N2 treatment (Table 3). Bio-slurry contributed to improving fruit quality and weight due to its phosphorus and potassium content, which supports fruit formation and enlargement (Klinton et al., 2017). The macronutrient content in bio-slurry also contributes to increasing crop productivity. Liquid bio-slurry impacts fruit yield components such as weight, number, and fresh biomass, but has limited influence on plant height and fruit diameter (Rizal et al., 2022). Adequate phosphorus (P) and potassium (K) supply can improve fruit quality and yield, including fruit diameter, weight, and sugar content (Bariyyah et al., 2015). In addition to bio-slurry, NPK fertilizer plays an important role in increasing chili fruit weight due to its potassium content, which supports fruit formation and enlargement (Lathifa & Dr. Ir. Titin Sumarni, 2024). Potassium (K) from NPK enhances carbohydrate movement and sugar deposition in fruits, thereby increasing fruit weight (Ermawati et al., 2021).

CONCLUSIONS

1. Bio-slurry application significantly improved Cayenne pepper growth and yield, demonstrated by increases in plant height, stem diameter, and fruit number and weight.
2. The application of NPK fertilizer also played an important role in supporting vegetative growth, such as plant height and stem diameter, while simultaneously enhancing productivity through the increase in both fruit number and fruit weight.
3. The combination of bio-slurry and NPK showed a positive interaction, resulting in the best growth and yield of Cayenne pepper across all parameters.

RECOMMENDATIONS

This study revealed that the best growth and yield of Cayenne pepper were obtained with the combination of 30 ml bio-slurry and 20 g NPK. However, since this dosage was the highest level applied in the present study, further investigation is still required. Subsequent research is important to determine whether this combination truly represents the most optimal dosage for Cayenne pepper , or whether higher dosages may provide even better results, or conversely, pose the risk of less favorable effects.

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