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Improving Growth and Nutrient Uptake in Cayenne Pepper (*Capsicum frutescens* L.) using Coffee Husk Compost and Inorganic Fertilizer

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ABSTRACT: The continuous increase in chili demand prompts farmers to rely on inorganic fertilizers to achieve optimal yields. However, excessive application of inorganic fertilizers without adequate organic fertilizer supplementation can lead to a decline in soil quality and crop productivity. Utilizing organic waste, such as coffee husks, as a composting material offers an environmentally friendly solution. Coffee husk compost not only serves as a potential nutrient source but also contributes to maintaining environmental cleanliness. This study aimed to analyze the effect of combining coffee husk compost and inorganic fertilizers on the growth and nutrient uptake of cayenne pepper. The research was conducted at the Experimental Farden of the Faculty of Agriculture, Udayana University and the Soil Chemistry and Fertility Laboratory, from May to September 2024. A Randomized Block Design (RBD) with 9 treatments and 3 replications was employed. Observed parameters included plant height, leaf count, fruits count, fruit weight and the uptake of nitrogen (N), phosphorus (P) and potassium (K). The results showed that the treatment of 125 g polybag^{-1} with 0,87 g polybag^{-1} inorganic fertilizer (P7) yielded the best results.

KEYWORDS: coffee husk compost, inorganic fertilizer, cayenne pepper, nutrient uptake

I. INTRODUCTION

Chili plants (*Capsicum* spp.) exhibit significant variations in growth habit, fruit shape, and color. Among these, cayenne pepper (*Capsicum frutescens*) is a widely utilized variety in many communities. Beyond its nutritional value, attributed to its vitamin content, cayenne pepper cultivation is also economically appealing due to its marketability. The increasing market demand has driven chili farmers to intensify the use of inorganic fertilizers to achieve higher yields. According to Ghaisani *et al*. (2020), the application of inorganic fertilizers, such as TSP, is one method to enhance chili production.

Inorganic fertilizers, also known as chemical fertilizers, play a crucial role in providing essential macronutrients to support plant growth. In agricultural production systems, especially in practices that do not integrate organic matter, inorganic fertilizers are central to achieving high productivity (Siwanto et al.). However, the lack of organic matter integration in crop cultivation can lead to continuous degradation of agricultural land, ultimately resulting in reduced yields. Inorganic fertilizers, also known as chemical fertilizers, play a crucial role in providing essential macronutrients to support plant growth. In agricultural production systems, especially in practices that do not integrate organic matter, inorganic fertilizers are central to achieving high productivity (Siwanto et al.). However, the lack of organic matter integration in crop cultivation can lead to continuous degradation of agricultural land, ultimately resulting in reduced yields. To address these issues, one effective strategy is to apply organic matter to the soil. According to the Regulation of the Minister of Agriculture No. 70/Permentan/SR.140/10/2011, the use of organic fertilizers and soil amendments is encouraged to improve the physical, chemical, and biological properties of the soil. Additionally, combining organic and inorganic fertilization is recommended as a balanced fertilization approach.

Efforts to maintain soil quality involve returning organic matter to the soil through the application of organic fertilizers, biofertilizers, or soil conditioners (Law No. 22 of 2019). Coffee husk compost is one type of organic fertilizer derived from organic waste. Nuryana et al. (2016) stated that coffee waste, comprising husks and pulp, constitutes 48% of the total weight of coffee cherries. Utilizing coffee husk waste represents an environmentally friendly endeavor to replenish organic matter in the soil. An approach combining coffee husk compost with inorganic fertilizers has the potential to reduce reliance on inorganic fertilizers in cayenne pepper cultivation. This is expected to support plant growth and enhance nutrient uptake efficiency. Therefore, this study aims to analyze the effect of combining coffee husk compost and inorganic fertilizers on the growth and nutrient uptake of cayenne pepper.

II. RESEARCH METHODS

This study was conducted at the Experimental Garden of the Faculty of Agriculture, Udayana University, followed by nutrient uptake analysis at the Soil Chemistry and Fertility Laboratory, Faculty of Agriculture, Udayana University. The research spanned from May to September 2024. A Randomized Block Design (RBD) was employed, consisting of 9 treatments replicated 3 times, resulting in a total of 27 experimental units. The specific treatments applied are presented in Table 1.

Table 1. Experimental Treatments

Treatment	Coffee husk compost (g polybag^{-1})	Inorganic fertilizers (g polybag$^{-1)}$
P0	0	0
P1	0	1,75 Phonska
P2	25	0,44 Phonska
P3	25	0,87 Phonska
P4	75	0,44 Phonska
P5	75	0,87 Phonska
P6	125	0,44 Phonska
P7	125	0,87 Phonska
P8	175	0

Note: The application of inorganic fertilizers adhered to the fertilization recommendations for horticultural crops (2021).

The parameters observed in this study included plant height and number of leaves during the vegetative phase, as well as fruit count and fruit weight during the early generative phase. Additionally, plant nutrient uptake (N, P, and K) was analyzed. Plant growth observations in the field were conducted weekly, with height measured using a measuring tape and leaf count performed manually. Plant nutrient uptake was analyzed in the laboratory after harvest, utilizing the wet digestion method with H_2SO_4 and H_2O_2 as extractants.

III. RESULTS AND DISCUSSION

A Vegetative Phase

Based on the results of statistical analysis (Table 2), the combined treatment of coffee husk compost and inorganic fertilizers significantly influenced plant growth at 2 weeks after planting (WAP). The highest leaf count was observed in the treatment with 125 g polybag^{-1} coffee husk compost and 0.87 g/polybag inorganic fertilizer (P7), totaling 9 leaves. Conversely, the treatment with 1.75 g polybag^{-1} inorganic fertilizer (P1) and the control (P0) exhibited the lowest leaf counts. These findings suggest that a balanced ratio of coffee husk compost and inorganic fertilizers applied during the initial growth phase is crucial in supporting early plant development. The combination of coffee husk waste-based compost and NPK fertilizer significantly impacts leaf count growth (Prayoga et al.). Furthermore, Pratama et al. (2022) reported that the decomposition of cattle manure fertilizer for 2 weeks was already sufficient to enhance plant growth.

In contrast to the results at 2 WAP, the number of leaves at 3, 4, and 5 WAP did not show a significant treatment effect. This can be attributed to plant adaptation to environmental conditions, including the gradual availability of nutrients from slowly decomposing compost, leading to a more uniform treatment effect. Nevertheless, the treatment of 125 g polybag^{-1} coffee husk compost + 0.87 g polybag^{-1} inorganic fertilizer (P7) consistently produced the highest leaf count each week: 13.67 leaves at 3 WAP, 23 leaves at 4 WAP, and 23.33 leaves at 5 WAP. These findings align with Pratama et al. (2022) who stated that ample availability of N, P, and K nutrients is crucial for optimal plant growth; the addition of 30 t/ha of organic fertilizer from cattle manure can result in the highest leaf count. Specifically, treatment P7 significantly increased leaf count compared to the standard treatment of 1.75 g polybag^{-1} inorganic fertilizer (P1), showing increases of 34.96% at 2 WAP, 14.36% at 3 WAP, 64.29% at 4 WAP, and 24.97% at 5 WAP (Figure 1).

Table 2. Effect of Coffee Husk Compost and Inorganic Fertilizer Application on Cayenne Pepper Leaf Count

Treatment	Leaf count (leaves)			
	2 WAP	3 WAP	4 WAP	5 WAP
P0	7,33 b	8,67 a	14,33 a	17,33 a
P1	6,67 b	9,33 a	14,00 a	18,67 a
P2	6,67 b	9,67 a	14,00 a	16,67 a
P3	7,33 b	10,67 a	16,00 a	17,33 a
P4	8,00 ab	10,00 a	16,00 a	17,67 a
P5	7,33 b	11,00 a	14,33 a	17,67 a
P6	7,67 ab	9,00 a	15,00 a	15,67 a
P7	9,00 a	13,67 a	23,00 a	23,33 a
P8	7,33 b	10,00 a	13,00 a	14,67 a

Note: Numbers within a Column Followed by the Same Letter do Not Differ Significantly According to DMRT at the 5% Level. WAP: Weeks After Planting.

The increased percentage of leaf count indicates that the combination of 125 g polybag^{-1} coffee husk compost and 0.87 g polybag^{-1} inorganic fertilizer (P7) possesses superior potential in supporting the vegetative growth of cayenne pepper plants. Coffee husk compost provides essential macro and micronutrients required by the plant, along with organic matter that improves soil structure. Concurrently, inorganic fertilizers supply nutrients rapidly and in larger quantities, particularly nitrogen, which is crucial for leaf formation. According to Itawari et al. (2022) coffee husk compost contains 40.21% organic carbon, 2.22% total nitrogen, 0.09% total phosphorus, and 1.21 mg 100g^{-1} total potassium.

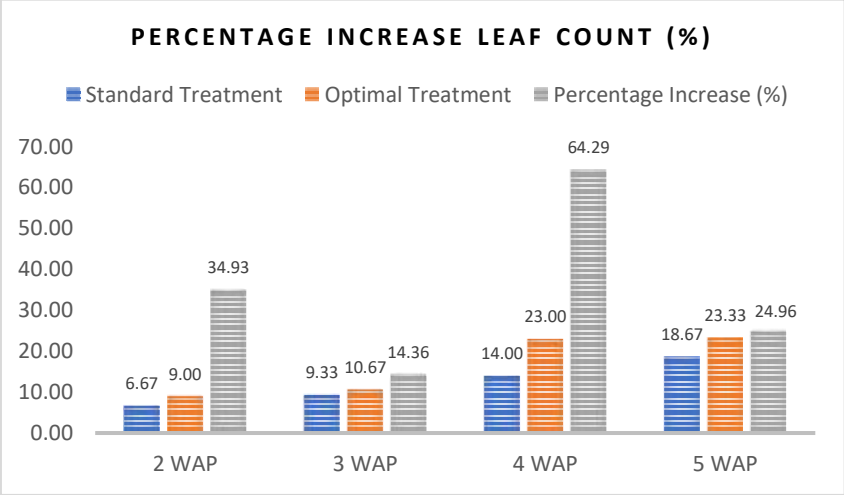

Figure 1. Percentage Increase in Leaf Count for Combined Coffee Husk Compost and Inorganic Fertilizer Treatment (P7) Compared to Standard Treatment (P1: 1.75 g/polybag Inorganic Fertilizer). WAP: Weeks After Planting

Based on the results of statistical analysis (Table 3), the combined application of coffee husk compost and inorganic fertilizers significantly influenced plant height at 3 weeks after planting (WAP). This suggests that the plant height response to treatments became evident at 3 WAP, or that the nutrient balance from the combination of coffee husk compost and inorganic fertilizers was optimally utilized for plant height during this period. The highest plant height was observed in the 175 g polybag^{-1} coffee husk compost treatment (P8) at 25.33 cm, which did not significantly differ from the 125 g polybag^{-1} coffee husk compost + 0.87 g polybag^{-1} inorganic fertilizer treatment (P7) at 25 cm. Conversely, the control treatment (P0) showed the lowest plant height at 22 cm. Although there were no statistically significant differences in plant height at 2, 4, and 5 WAP, observations consistently showed an increase in plant height each week. At 2 WAP, the highest plant height was 9 cm, recorded in the 175 g polybag^{-1} coffee husk compost treatment (P8) and 25 g polybag^{-1} coffee husk compost + 0.44 g polybag^{-1} inorganic fertilizer treatment (P2). At 4 WAP, the highest plant height was 47.67 cm in the 75 g polybag^{-1} coffee husk compost + 0.44 g polybag^{-1} inorganic fertilizer treatment (P4), and at 5 WAP, the 125 g/polybag coffee husk compost + 0.44 g/polybag inorganic fertilizer treatment (P6) reached 60.33 cm. The percentage increase in plant height (Figure 2) showed an 8.04% increase at 2 WAP, 8.70% at 3 WAP, 7.61% at 4

WAP, and 8.37% at 5 WAP. This increase indicates that the combination of coffee husk compost and inorganic fertilizers had a more pronounced effect on leaf number growth compared to plant height. This aligns with the statements by Napitupulu et al. (2023); Polta & Subagiono (2018) that adequate nutrient availability and good soil structure promote plant growth, and that the application of 90 g of coffee husk compost can enhance the growth of red chilies.

Table 3. Effect of Coffee Husk Compost and Inorganic Fertilizer Application on Cayenne Pepper Plant Height

Treatmen	Plant Height (cm)			
	2 WAP	3 WAP	4 WAP	5 WAP
P0	8,33 a	22,00 c	43,00 a	60,00 a
P1	8,33 a	23,00 bc	44,33 a	55,67 a
P2	8,67 a	23,00 bc	39,67 a	55,33 a
P3	9,00 a	22,33 bc	42,33 a	53,00 a
P4	7,67 a	24,00 ab	47,67 a	59,67 a
P5	8,67 a	23,33 bc	46,67 a	59,33 a
P6	8,00 a	24,67 ab	47,00 a	60,33 a
P7	8,67 a	25,00 a	46,67 a	55,67 a
P8	9,00 a	25,33 a	43,67 a	57,00 a

Note: Numbers within a Column Followed by the Same Letter do Not Differ Significantly According to DMRT at the 5% Level. WAP: Weeks After Planting.

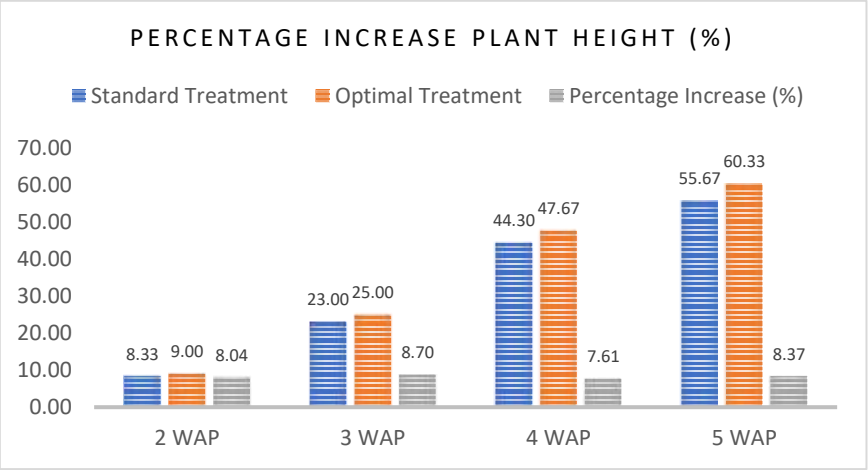

Figure 2. Percentage Increase in Plant Height for Optimal Treatments Each Week Compared to Standard Treatment (P1: 1.75 g/polybag Inorganic Fertilizer). WAP: Weeks After Planting

B Generative Phase Response and Nutrient Uptake

The assessment of plant growth response is also supported by the acceleration of generative phase initiation, measured by fruit count and weight at the first harvest when physiological maturity (red color) is reached. This parameter aims to identify treatments that can promote earlier fruit production. Based on statistical analysis, the combination of coffee husk compost and inorganic fertilizers significantly affected both the number and weight of cayenne pepper fruits at the first harvest. The treatment of 125 g polybag^{-1} coffee husk compost + 0.87 g polybag^{-1} inorganic fertilizer (P7) resulted in the highest fruit count and weight, with 12 fruits and a weight of 25.08 g/plant. Specifically, the application of coffee husk compost alone at a dose of 9 g polybag^{-1} could increase fruit count up to 9 fruits/plant. These results indicate that the combination of coffee husk compost and inorganic fertilizers is more optimal in supporting the growth and yield of cayenne pepper. These findings are consistent with the research by Ebigail (2020); Sulaminingsih (2024), who state that compost plays a role in improving soil properties, thereby optimizing nutrient absorption and providing complete nutrients required by plants. Meanwhile, inorganic fertilizers supply macronutrients (NPK) in high concentrations with faster availability to plants in the soil. This result is further supported by the nutrient uptake data, where treatment P7 also showed the highest nutrient uptake compared to the standard treatment (P1). Nutrient uptake in treatment P7 was 3.52 g plant^{-1} for N, 0.39 g plant^{-1} for P, and 5.01 g plant^{-1} for K (Figure 3). According to Sangkala et al. (2023) nitrogen is an essential nutrient involved in plant tissue formation and increasing plant weight through its function as a component

of cell structure, including chlorophyll. Phosphorus is necessary for fruit tissue formation during the generative phase, and potassium plays a role in plant metabolic processes (Kurnia et al., 2021). A deficiency in any of these nutrients will affect the plant growth process (Segala et al., 2022).

Table 4. Effect of Combined Coffee Husk Compost and Inorganic Fertilizer on Cayenne Pepper Fruit Count and Weight at Early Harvest

Treatment	Fruit Count (fruit)	Fruit Weight (g)
P0	5,00 ab	11,96 ab
P1	0,33 b	2,10 b
P2	5,50 ab	12,17 ab
P3	1,50 b	4,39 b
P4	7,00 ab	15,84 ab
P5	5,00 ab	9,78 b
P6	6,50 ab	14,37 ab
P7	12,00 a	25,08 a
P8	2,00 b	5,04 b

Note: Numbers within a Column Followed by the Same Letter do Not Differ Significantly According to DMRT at the 5% Level.

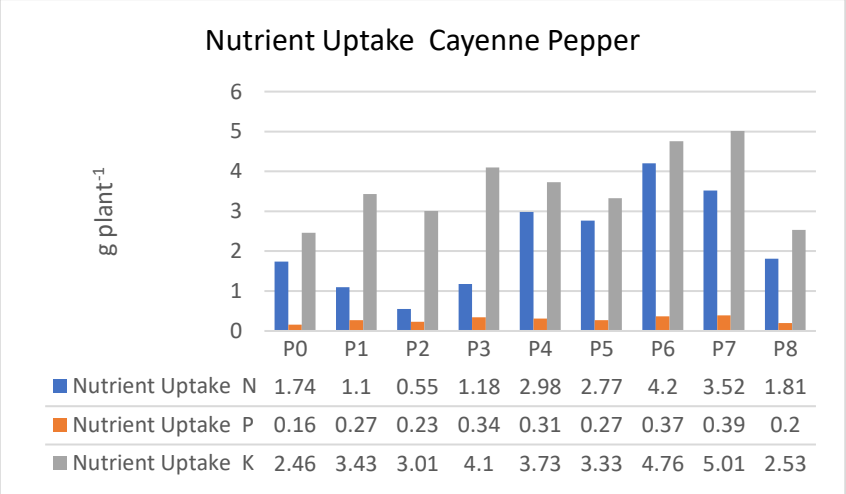

Figure 3. Diagram of nitrogen (N), phosphorus (P) and potassium (K) Nutrient Uptake in Cayenne Pepper Plants.

IV. CONCLUSIONS

The combination of coffee husk compost and inorganic fertilizer significantly enhanced the growth and nutrient uptake of cayenne pepper plants. Treatment P7 (125 g/polybag coffee husk compost + 0.87 g/polybag inorganic fertilizer) consistently yielded the best results for both vegetative growth and overall productivity of cayenne pepper.

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