AGRIWAR JOURNAL
MASTER OF AGRICULTURAL SCIENCE WARMADEWA UNIVERSITY
E-ISSN: 2808-1137, **P-ISSN**: 2808-1323

Vol. 3, **No.** 2, **Dec 2023**, **Page** 73-79
DOI: https://doi.org/10.22225/aj.3.2.8786.73-79

Fertilizing NPK and Compost from Coffee Skins on Long Bean Plants

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Abstract
This research aims to examine the influence of NPK fertilizer and coffee husk compost and their combined influence on the growth and yield of long bean plants. The research was carried out in the Greenhouse of the Faculty of Agriculture, Warmadewa University from March to June 2022 using a two-factor randomized block design which was repeated three times. The first factor, NPK fertilizer (M), has four levels, namely M0 = 0 kg ha-1, M1 = 100 kg ha-1, M2 = 200 kg ha-1, M3 = 300 kg ha-1. The second factor, Coffee Skin Compost (K) treatment, consists of four levels: K0 = 0 ton ha-1, K1 = 15 ton ha-1, K2 = 30 ton ha-1, and K3 = 45 ton ha-1. Application of NPK fertilizer at a dose of 300 kg ha-1 resulted in the highest fruit weight of 136.29 g, an increase of 63.36% compared to the lowest fruit weight (83.43 g) in the 0 kg ha-1 NPK fertilizer treatment. Apart from that, the 45-ton ha-1 coffee skin compost treatment produced the highest fruit weight, namely 117.53 g, an increase of 27.58% compared to the lowest fruit weight (92.12 g) in the 0 kg ha-1 coffee skin compost treatment. In particular, the combination of 300 kg ha-1 of NPK fertilizer and 45 tons ha-1 of coffee husk compost produced the highest oven-dry weight, reaching 95.28 g.

Keywords*: Coffee husk waste, compost, NPK fertilizer, long bean*

1. Introduction

Long beans (*Vigna sinensis* L.) are a legume vegetable plant that is widely grown in Indonesia, although they originally come from India and Central Africa and have been cultivated in Indonesia for centuries [1]. This vegetable is very popular, used in various culinary dishes or as medicine. Long beans are loved because they taste delicious and are rich in nutrients such as protein, fat, carbohydrates, vitamins A, B, and C, as well as minerals such as calcium, phosphorus, and iron. They contain plant protein ranging from 17 to 21%. In addition, long beans are believed to have medicinal properties, helping treat diabetes, rheumatism, arthritis, and urinary tract disorders [2].

Even though it is popular, long bean production has decreased from 63,177 tonnes/ha in 2017 to 51,359 tonnes/ha in 2019 [3]. To bridge this gap and ensure consistent income for farmers, efforts must focus on increasing string bean production while maintaining soil health. Currently, chemical fertilizers dominate the market, but long-term use can damage the soil ecosystem, causing increased acidity and a decrease in soil microorganisms. The reduction in the number of microorganisms results in a reduction in the supply of nutrients to the plants so that the plants become infertile causing a decrease in production.

To overcome these challenges, fertilization has emerged as an important strategy to increase long bean production and soil capacity without causing losses [4]. Fertilization can be organic, inorganic, or a combination of both. Effective fertilization considers quantitative factors, such as fertilizer dosage, and qualitative aspects, including the provision of nutrients that are relevant to existing nutritional problems. The correct timing and placement of fertilizer ensures the absorption of nutrients by plants, thereby encouraging increased production and quality. Organic fertilizers in particular aim to improve the physical and biological properties of soil [5].

Considering the high nutrient requirements of long beans, NPK fertilizer has proven to be effective in encouraging leaf growth, especially if accompanied by optimal environmental conditions in the vegetative phase. NPK compound fertilizer gradually releases nutrients so that plants can absorb them as needed. Because long beans require large amounts of nitrogen, phosphorus, and potassium, obtaining these three nutrients according to plant needs is very important [6]. Previous research shows that the use of NPK fertilizer at a rate of 200 kg ha^{-1} on long bean plants provides optimal results on various variables including plant length, number of leaves, leaf area, number of pods per plant, length of pods per plant, weight of pods per plant, and production per hectare [7].

Although string beans are commercially valuable, the limited availability of organic fertilizer requires the exploration of effective, safe, and affordable alternatives. One alternative is to use coffee skin waste to make compost [8]. Bali coffee production experienced a slight increase from 2017 to 2021, reaching 15,759 tons ha^{-1} [9]. As the fourth largest coffee exporter in the world with a market share of 11% [10], Indonesian coffee plantations produce large amounts of solid waste in the form of coffee fruit skins. Unfortunately, coffee cherries often pile up around processing locations, causing environmental pollution. However, coffee skin waste has considerable potential as a plant growth medium.

Research shows that providing coffee husk compost has a significant effect on soybean plant height, number of branches, number of pods, weight of 100 seeds, and dryness of seeds per plot. The best results involve coffee husk compost at a dose of 30 tons ha^{-1} or 3 kg $plot^{-1}$ [11]. Furthermore, research that applied 15 tons ha^{-1} of coffee husk biochar produced the highest total fresh weight per plant in the growth of Arabica coffee plants [12]. Considering the above, it is necessary to research to understand the impact of providing coffee husk compost and NPK doses on the growth and production of long bean plants.

2. Materials and Methods

2.1. Research site

This research was conducted at the Green House of the Faculty of Agriculture, Warmadewa University, Jalan Terompong No.24, Sumerta Kelod, East Denpasar District, Denpasar City, with an altitude of 20 meters above sea level, with an average temperature of 30-37 ºC. This research was conducted in March-June 2022.

2.2. Materials and tools

The tools and materials used are a hoe, polybag measuring 40x40 cm, measuring instruments, bamboo stake, stationery, scissors, analytical balance, digital camera, NPK fertilizer (16:16:16), compost from coffee skins, and bean seeds long.

2.3. Design Experiment

The research employed a randomized block design (RBD) with a factorial arrangement of two factors, repeated three times. The first factor, denoted as "M," represented the dosage of NPK fertilizer and included four treatment levels:

M0: 0 kg ha^{-1} (0 g $polybag^{-1}$)
M1: 100 kg ha^{-1} (0.5 g $polybag^{-1}$)
M2: 200 kg ha^{-1} (1 g $polybag^{-1}$)
M3: 300 kg ha^{-1} (1.5 g $polybag^{-1}$)

The second factor, denoted as "C," represented the dosage of coffee skin compost and included four treatment levels:

C0: 0 ton ha^{-1} (0 g $polybag^{-1}$)
C1: 15 ton ha^{-1} coffee husk compost (75 g $polybag^{-1}$)
C2: 30 ton ha^{-1} coffee husk compost (150 g $polybag^{-1}$)
C3: 45 ton ha^{-1} coffee husk compost (225 g $polybag^{-1}$)

2.4. Data from analysis of research soil and compost from coffee skins

Data from laboratory analysis of soil properties and compost before the research are presented in Tables 1 and 2.

2.5. Observed Variables

The variables observed in this study were plant height, number of leaves, fresh weight of stover, dry weight of stover, fruit weight, number of fruit, and fruit length.

Table 1. Results of the Experimental Soil Analysis

No	Analysis Type	Mark	Information
1	Water content (%)	5.74	Very low
2	pH	6.37	Neutral
3	C-organic (%)	0.30	Very low
4	N-total (%)	0.11	Very low
5	P-available (ppm)	53.68	Very low
6	K-available (ppm)	0.41	Very low
7	C/N Ratio	2.80	Very low
8	Texture (%)		
	- sand	53.2	
	- dust	24.0	Sandy clay loam
	- clay	22.8	

Source: Results of Analysis at the Soil Physics and Chemistry Laboratory of the Sukosari Research Center 2022

Table 2. The results of the analysis of coffee husk compost

No	Analysis Type	Mark	Information
1	pH	8.3	Slightly alkaline
2	DHL (mmhos/cm)	14.44	Very high
3	C-organic (%)	36.59	Very high
4	N total (%)	0.43	Very low
5	P-available (ppm)	619.07	Very high
6	K-available (ppm)	611.71	Very high
7	C/N ratio	85.09	Very high
8	Water content	17.41	

Source: Bismantara. 2021

2.6. Data analysis

Research data was analyzed using statistical analysis of variance (ANOVA) according to the research design. For single treatments that provide significant to very significant effects, continue with the LSD test at the 5% level. To determine the closeness of the relationship between the observed variables, correlation analysis was carried out.

3. Results and Discussion

3.1. Results

3.1.1. Significance of the influence of NPK fertilizer and compost

The results of the statistical analysis of the several variables observed in this study significantly influence the doses of NPK fertilizer and compost from coffee husks and their interactions with the observed variables are presented in Table 3.

According to Table 3, the application of NPK fertilizer (M) and compost from coffee husks (C) demonstrates a statistically very significant influence ($P<0.01$) on all observed variables. However, the interaction between NPK fertilizer and compost (MxC) does not show a significant effect ($P>0.05$) on all observed variables, except for the variable 'dry weight of stover,' where a significant effect is observed ($P<0.01$).

Table 3. Illustrates the significant effects of NPK fertilizer dose (M) and compost (C) from coffee husks, as well as their interaction, on the observed variables

No	Variable	Treatment		
		M	C	MxC
1	Plant height (cm)	**	**	ns
2	Number of leaves (pieces)	**	**	ns
3	Fresh weight of stover (g)	**	**	ns
4	Dry weight of stover (g)	**	**	**
5	Fruit weight (g)	**	**	ns
6	Number of fruits (fruit)	**	**	ns

Note: ns= not significant (P>0.05); *= significant (P<0,05), **= very significant (P<0.01)

Table 4. The average yield of variables observed in the treatment of NPK fertilizer and coffee husk compost

Treatment	Plant Height (cm)	Number of Leaves (strands)	Fresh Weight Stover (g)	Dry Weight Stover (g)	Fruit Weight (g)	Number of Fruits (Fruit)	Fruit Length (cm)
NPK (M)							
M0 (Control)	138.54 d	19.75 d	264.12 d	26,20 d	83.43c	7,92 d	46.79a
M1 (100 kg ha^{-1})	153.49 c	23.25 c	328.69 c	32.04c	94.89 bc	9.25c	46.99a
M2 (200 kg ha^{-1})	165.49 b	25.25 b	363.80 b	44.41 b	106.81b	10.58 b	46.76 a
M3 (300 kg ha^{-1})	172.74 a	28.83 a	426.28 a	73.51 a	136.29a	12.50a	48.53 a
LSD 5 %	6.01	0.87	24.85	4.32	12.82	0.93	2.78
Compost (C)							
C0 (control)	153.53 b	22.83 c	315.60 b	36.70c	92.12 b	8.67c	46.07a
C1 (15 ton ha^{-1})	155.56 b	24.08 b	338.55 b	41.69b	105.76a	9.67 b	47.62 a
C2 (30 ton ha^{-1})	158.50 ab	24.83 ab	359.84 ab	45.6b	106.03a	10.42 b	47.18 a
C3 (45 ton ha^{-1})	164.42 a	25.33 a	368.90 a	52.22 a	117.53 a	11.50 a	48.19 a
LSD 5 %	6.01	0.87	24.85	4.32	12.82	0.93	2.78

Note: The mean value followed by the same letter in the same treatment and column is not significantly different at the 5% LSD test level.

3.1.2. Plant height

Table 4 shows that increasing the dose of NPK fertilizer from M0 to M3 affects plant height, with the highest value recorded at M3 at 172.74 cm, which is significantly different from M0, M1, and M2. Likewise, the application of coffee husk compost from C0 to C3 increased plant height, where the highest value was achieved at C3, namely 164.42 cm, and was significantly different from C0 and C1. However, there is no significant difference between C3 and C2.

3.1.3. Number of leaves

Increasing the dose of NPK fertilizer from M0 to M3 had a positive impact on the number of leaves, with the highest number recorded at M3 at 28.83, which was significantly different from M0, M1, and M2 (Table 4). Likewise, applying coffee husk compost from C0 to C3 also increased the number of leaves, with the highest number recorded at C3 at 25.33, which was significantly different from C0 and C1. However, there is no significant difference between C3 and C2.

3.1.4. Fresh weight of stover

Based on Table 4, it can be seen that increasing the dose of NPK fertilizer from M0 to M3 increased the fresh weight of stover, with the highest value recorded at M3 at 426.28 g. This value is significantly different from M0, M1, and M2. Meanwhile, increasing the dose of coffee husk compost from C0 to C3 also caused an increase in the fresh weight of the stover, with the highest value achieved at C3, namely 368.90 g. This value is significantly different from C0 and C1, but not significantly different from C2.

3.1.5. Dry weight of stover (g)

Table 5 shows the effect of the interaction between NPK fertilizer and compost on the dry weight of stover. The dry weight of stover reached the highest value in the M3C3 treatment (95.28 g). There was a real difference between the dry weight of stover in the M3C3 interaction and the other interactions (M0C3, M1C3, and M2C3). In addition, the highest dry weight of stover achieved in M3C3 (95.28 g) showed a significant difference with the M3C0 interaction treatment, while there was no real difference with the M3C1 and M3C2 interactions.

Table 5. Average oven dry weight of stover due to the effect of NPK fertilizer and coffee husk compost

Treatment	Coffee Skin Compost (C) Fertilizer							
	C0		C1		C2		C3	
NPK (M)								
M0	23.46 A	c	26.02 A	c	27.18 A	c	28.15 A	c
M1	29.38 A	bc	31.25 A	c	32.56 A	c	34.95 A	c
M2	37.00 B	b	43.07 AB	b	47.09 A	b	50.49 A	b
M3	56.95 C	a	67.51 B	a	74.29 B	a	95.28 A	a
LSD 0.05	8.63							

Information :

1. Numbers followed by the same lowercase letter in the same column are not significantly different at the 5% LSD test level
2. The numbers followed by the same capital letter in the same row are not significantly different at the 5% LSD test level

3.1.6. The weight of fruit (g)

Application of NPK fertilizer doses from M0 to M3 increased fruit weight, where the highest was obtained at M3, namely 136.29 g, and was significantly different from M0, M1, and M2. Likewise, the coffee skin compost fertilizer treatment from C0 to C3 increased fruit weight, where the highest was C3, namely 117.53 g, and was significantly different from C0, but C3 was not significantly different from C1 and C2 (Table 6).

Table 6. Average fruit weight due to the influence of NPK fertilizer treatment and coffee husk compost

Treatment	Weight of fruit (g)	Number of fruit (fruit)
NPK (M)		
M0 (Control)	83.43 c	7.92 d
M1 (100 kg ha^{-1})	94.89 bc	9.25 c
M2 (200 kg ha^{-1})	106.81 b	10.58 b
M3 (300 kg ha^{-1})	136.29 a	12.50 a
LSD 5 %	12.82	0.93
Compost (C)		
C0 (control)	92.12 b	8.67 c
C1 (15 ton ha^{-1})	105.76 a	9.67 b
C2 (30 ton ha^{-1})	106.03 a	10.42 b
C3 (45 ton ha^{-1})	117.53 a	11.50 a
LSD 5 %	12.82	0.93

Note: The mean value followed by the same letter in the same treatment and column is not significantly different at the 5% LSD test level.

3.1.7. The number of fruit (fruit)

Providing doses of NPK fertilizer from M0 to M3 increased the number of fruit, where the highest was obtained at M3, namely 12.50 fruit, and was significantly different from M0, M1, and M2. Likewise, the coffee skin compost fertilizer treatment from C0 to C3 increased the number of fruit, where the highest was C3, namely 11.50 fruit, and was significantly different from C0, C1, and C2, but C1 was not significantly different from C2 (Table 6).

3.2 Discussions

The fruit weight variable in this study showed that the use of NPK fertilizer (M) and coffee husk compost (C) had a very significant effect ($P<0.01$) but no interaction occurred. Increasing the dose of NPK fertilizer from M0 to M3 increased fruit weight, where the highest fruit weight was obtained at M3 (136.29 g) and was significantly different from M0 (83.43 g), M1 (94.89 g), and M2 (106.81 g), while In the coffee peel compost treatment from C0 to C3, the highest fruit weight was found in C3, which was 136.29 and significantly different from C0 (92.12 g), but not significantly different from C1 (105.76 g) and C2 (106.03 g).

Coffee husk compost, identified as an organic fertilizer, contains essential macro and micronutrients that enhance soil structure and provide nutrients for plant growth. According to [13], coffee husk waste possesses organic matter and nutrients, including 36.59% C-organic, 0.43% nitrogen, 619.07% phosphorus, and 611.71% potassium, along with elements like Ca, Mg, Mn, Fe, and Zn. Complementing this, the combination with NPK inorganic fertilizers further supports plant nutrient availability, as NPK fertilizer contains 16% N, 16% P_2O_5, and 16% K_2O crucial for plant growth.

An interaction effect between NPK fertilizer and coffee husk compost application on long bean plants was observed, with the highest average plant height resulting from the combination of NPK fertilizer at 300 kg ha^{-1} and coffee husk compost at 45 tons ha^{-1} (M3C3), reaching 296.23 cm. The presence of macro and micronutrients in the soil contributed to increased vegetative growth, influencing plant height through enhanced photosynthesis, as highlighted by [14]. Solar radiation, captured by chlorophyll in plants, plays a key role in this process.

The application of NPK fertilizer and coffee husk compost also influenced the number of plant leaves, with the highest average number achieved at an NPK dose of 300 kg ha^{-1} (M3) and coffee husk compost dose of 45 tons ha^{-1} (C3). The increased dose of fertilizer positively correlated with the number of leaves, emphasizing the roles of N and K elements in vegetative growth and plant resistance to diseases.

Moreover, the highest mean fresh body weight was obtained with the NPK fertilizer dose of 300 kg ha^{-1} (M3) and coffee husk compost dose of 45 tons ha^{-1} (C3). Macronutrients in NPK fertilizer and coffee husk compost played a crucial role in supporting robust weight yields, as noted by [17].

The application of NPK fertilizer and coffee husk compost also had an interaction effect on the average oven-dry weight, with the highest yield observed in the treatment with NPK fertilizer at 300 kg ha^{-1} and coffee husk compost at 45 tons ha^{-1} (M3C3), reaching 95.28 g. This increase in dry weight reflected enhanced protoplasm due to cell division, as highlighted [19].

Furthermore, the effect of NPK fertilizer and coffee husk compost on long bean fruit weight indicated the highest average yield with the NPK fertilizer dose of 300 kg ha^{-1} (M3) and coffee husk compost dose of 45 tons ha^{-1} (C3), at 136.29 g and 117.53 g, respectively. The nutrient content in plants, especially N, P, and K, influenced growth and development, contributing to optimal harvest results. Phosphorus, in particular, played a crucial role, as emphasized by [21], [22], and [23], impacting energy transfer, biochemical reactions, and photosynthetic processes.

4. Conclusion

The interaction between coffee husk compost and NPK fertilizer had minimal impact on various variables in long bean plants. Optimal results, particularly in plant height and stem oven dry weight, were observed with an NPK dose of 300 kg ha^{-1} and coffee husk compost of 45 tons ha^{-1}. This combination led to a significant increase in plant height (89.19%) and stem oven dry weight (76.62%) compared to the treatment without NPK and coffee husk compost.

The application of NPK fertilizer alone significantly influenced long bean fruit weight, with the most favorable outcomes seen at the 300 kg ha^{-1} NPK treatment, resulting in a 63.36% increase compared to the treatment without NPK (M0). Similarly, the use of coffee husk compost alone exhibited a substantial effect on long bean fruit weight, with optimal results at the 45 tons ha^{-1} coffee husk compost treatment, showing a 27.58% increase compared to the treatment without coffee husk compost.

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