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Mulch Type and NPK Fertilizer Effects on Growth and Yield of Long Bean

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Abstract: Long bean (*Vigna unguiculata*) is an important vegetable crop with high economic value; however, its productivity is strongly influenced by cultivation practices, particularly mulching and fertilization. This study aimed to evaluate the effects of different mulch types and NPK fertilizer dosages on the growth and yield of long bean plants. The experiment was conducted from August to October 2023 in Gadudero Village, Sukolilo District, Pati Regency, Indonesia. A Randomized Complete Block Design (RCBD) with two factors and three replications was used. The first factor was mulch type, consisting of no mulch (M0), straw mulch (M1), and silver-black plastic mulch (M2). The second factor was NPK fertilizer dosage, namely 150 kg ha^{-1} (N1), 200 kg ha^{-1} (N2), and 250 kg ha^{-1} (N3). Observed parameters included plant height, flowering age, number of productive branches, number of pods per plant, fresh pod weight, fresh biomass weight, and dry biomass weight. Data were analyzed using analysis of variance (ANOVA), followed by the Least Significant Difference (LSD) test at the 5% level when significant differences were detected. The results showed that mulch type significantly affected the number of pods per plant, whereas NPK fertilizer dosage had no significant effect on all observed parameters. Silver-black plastic mulch produced the highest number of pods per plant (14.72 pods), significantly higher than straw mulch and the control. No significant interaction between mulch type and NPK dosage was observed for all growth and yield parameters. The absence of NPK fertilizer effects was presumably due to residual soil fertility from previous intensive fertilization. In conclusion, the use of silver-black plastic mulch effectively increased long bean yield, while the lowest NPK dosage (150 kg ha^{-1}) was sufficient under the experimental soil conditions. These findings suggest that optimizing mulch application can enhance yield efficiency while reducing excessive fertilizer use.

Keywords: Long bean, mulch type, NPK fertilizer yield components, sustainable cultivation

1. Introduction

L ong bean (Vigna sinensis L.) is a vital vegetable crop. It has high commercial value and recreates a significant role in meeting the food and nutritional needs of the community (Islam et al., 2024). Efforts to fulfill these demands require proper cultivation practices for long bean production. One important cultivation technique for long beans is the use of organic and inorganic mulches (Naisanu et al., 2025). Plastic mulch is used to regulate soil temperature and hold soil moisture, thereby reducing pathogens (Bahadur et al., 2018). The use of black plastic on the lower layer and silver plastic on the upper layer is particularly important during the rainy season.

Mulching aims to reduce water loss from the soil by reducing soil temperature and moisture (Kader et al., 2019). Mulch application is an approach to suppress weed growth, modify soil water balance, temperature, and humidity, and create favorable conditions for plant growth. One advantage of using silver-colored mulch is its ability to reflect sunlight, which reduces soil water evaporation and discourages pests due to light reflection (Yadav et al., 2023). Ultraviolet light reflected to the lower leaf surface can deter pests such as aphids, thrips, mites, caterpillars, and fungal pathogens (Akter, 2017). The use of inorganic mulch improves water-use efficiency and reduces erosion, pests, and diseases (Prem et al., 2020). Therefore, it is necessary to evaluate the cultivation of long beans through a comparison of organic and inorganic mulches.

Factors were enhanced production, including the selection of high-quality seed varieties, cultivation techniques, pest and disease management, and proper post-harvest handling. In addition to mulch application, fertilization supports growth and yield (Purnamawati & Lubis, 2025; Riry et al., 2020). Fertilization provides balanced nutrient availability in the growing medium. NPK fertilizer supplies essential nutrients as nitrogen, phosphorus, and potassium required by

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plants (Galembeck et al., 2019). Previous research indicated that an NPK fertilizer dose of 225 kg ha^{-1} and cow manure dose at 30 ton ha-1 was optimal for long bean growth and yield (Riry et al., 2020).
Based on the above considerations, it is necessary to evaluate and improve long bean productivity to meet future demand. Therefore, this study aimed to compare the effects of organic and inorganic mulches on long bean growth and to determine the optimal NPK fertilizer rate for long bean cultivation.

2. Material and Methods

2.1 Time and Location of Study

The study was from August to October 2023 on agricultural land located in Gadudero Village, Sukolilo District, Pati Regency, Central Java, Indonesia. The experimental site is situated at an altitude of approximately 12 m above sea level.

2.2 Materials and Equipment

The materials used were long bean seeds of the Kanton Kavi variety, NPK compound fertilizer, silver–black plastic mulch as inorganic mulch, and rice straw as organic mulch. The equipment used consisted of a measuring ruler, stationery, labels, a digital camera, wooden stakes, a hoe, scissors, an oven, and a digital balance.

2.3 Experimental Design

The experiment was arranged using a Randomized Complete Block Design (RCBD) with a two-factor factorial arrangement and three replications. The first factor was mulch type (M), consisting of three levels: M0: no mulch (control); M1: rice straw mulch; M2: silver–black plastic mulch. The second factor was NPK fertilizer rate (N), consisting of three levels: N1: 150 kg ha^{-1}; N2: 200 kg ha^{-1}; N3: 250 kg ha^{-1}. This resulted in nine treatment combinations. Each treatment was replicated three times, resulting in 27 experimental units (beds). Each bed consisted of five plants, giving a total of 135 experimental plants. Data were analyzed using analysis of variance (ANOVA) at a 5% significance level. When significant differences were detected, mean separation was performed using the Least Significant Difference (LSD) test at 5%.

2.4 Experimental Prosedure

The experiment was initiated by clearing the land of weeds and loosening the soil to improve soil structure. Raised beds measuring 250 cm in length were prepared with a planting spacing of 50 × 50 cm, and farmyard manure was applied before planting. Plastic mulch was installed before planting, while rice straw mulch was applied at 7 days after planting (DAP) at a rate of 6 t ha^{-1} using air-dried straw. Seeds were planted directly in the field, with two seeds per planting hole. Gap filling and thinning were at 7–14 DAP to ensure a uniform plant population. Irrigation was every four days in the morning using a flooding system. NPK fertilizer was at 14 and 28 DAP according to the designated treatment rates. Pest and disease control were using physical removal of infected plants and chemical control when necessary. Harvesting was at 35–43 DAP based on pod maturity indicators and performed five times at one-day intervals.

2.5 Observed Parameters

Observed parameters included plant height, flowering time, and yield components of long bean. Plant height was measured weekly from 7 to 42 days after planting (DAP) from the base of the stem to the tip of the longest leaf (Abebe & Workayehu, 2015). Flowering time was recorded as the number of days from planting until more than 70% of the plant population produced flowers. Yield components were the number of productive branches, the number of pods per plant, fresh pod weight per plant, fresh biomass weight, and dry biomass weight. Fresh biomass was weighed immediately after harvest, while dry biomass was weighed after oven-drying the plant samples to constant weight.

3. Results

Table 1 shows that plant height of long bean from 1 to 5 weeks after planting (WAP) was not significantly affected by mulch type, NPK fertilizer rate, or their interaction. Although plants grown under silver–black plastic mulch and higher NPK rates tended to exhibit slightly greater height values, these differences were not statistically significant. This indicates that under the experimental conditions, variation in mulch application and NPK fertilizer dosage did not markedly influence vegetative growth in terms of plant height.

Table 1: Effects of mulch type and NPK fertilizer rate on plant height of long bean (cm)

Treatment	1 WAP	2 WAP	3 WAP	4 WAP	5 WAP
Mulch Type					
Control (M0)	15.93	52.02	94.89	136.83	166.41
Straw mulch (M1)	18.78	53.00	93.11	138.89	168.63
Silver–black plastic mulch (M2)	19.33	54.02	97.69	138.61	168.33

Treatment	1 WAP	2 WAP	3 WAP	4 WAP	5 WAP
NPK Fertilizer Rate					
150 kg ha^{-1} (N1)	17.80	51.63	93.94	137.30	167.11
200 kg ha^{-1} (N2)	18.52	53.00	95.33	137.93	168.44
250 kg ha^{-1} (N3)	17.72	54.41	96.41	139.11	167.81

Table 2 indicates that mulch type and NPK fertilizer rate did not significantly affect flowering time and the number of productive branches of long bean. However, the number of pods per plant was significantly influenced by mulch type, with silver–black plastic mulch producing a higher number of pods compared to the control and straw mulch treatments. This result suggests that improved soil microclimate conditions under plastic mulch, such as better moisture conservation and temperature regulation, may enhance reproductive development and pod formation in long bean plants.

Table 2: Effects of mulch type and NPK fertilizer rate on flowering time, number of productive branches, and pods per plant

Treatment	Days to flowering (days)	Number of productive branches	Number of pods per plant
Mulch Type			
Control (M0)	29.04	14.33	9.93a
Straw mulch (M1)	30.04	14.67	10.78a
Silver–black plastic mulch (M2)	31.04	15.30	14.72b
NPK Fertilizer Rate			
150 kg ha^{-1}	28.69	14.80	12.96d
200 kg ha^{-1}	29.69	14.96	11.91d
250 kg ha^{-1}	30.69	14.54	10.56d

Note: Means followed by the same letter within a column are not significantly different at LSD (5%).

Table 3 shows that mulch type and NPK fertilizer rate did not have a significant effect on fresh pod weight, fresh biomass weight, and dry biomass weight of long bean. Although numerical differences were observed among treatments, these variations were not statistically significant, indicating that changes in mulch application and NPK dosage were insufficient to markedly alter biomass accumulation under the conditions of this study. This suggests that biomass production of long bean was more strongly influenced by inherent plant growth characteristics and environmental conditions than by the applied treatments.

Table 3: Effects of mulch type and NPK fertilizer rate on fresh pod weight, fresh biomass weight, and dry biomass weight

Treatment	Fresh pod weight (g)	Fresh biomass weight (g)	Dry biomass weight (g)
Mulch Type			
Control (M0)	334.91	716.54	253.35
Straw mulch (M1)	249.26	765.65	282.85
Silver–black plastic mulch (M2)	276.11	859.11	300.54
NPK Fertilizer Rate			
150 kg ha^{-1}	367.50	766.22	275.81
200 kg ha^{-1}	359.44	808.07	286.11
250 kg ha^{-1}	276.11	767.00	274.81

4. Discussion

This study provides evidence that variations in mulch type and NPK fertilizer rate had limited influence on the vegetative growth and biomass production of long bean under the experimental conditions. The absence of significant effects on plant height, flowering time, productive branches, and biomass-related variables suggests that the growth response of long bean was relatively stable across the tested treatments (Erves, 2025). This stability may indicate that the soil and environmental conditions at the study site were already sufficient to support optimal vegetative development, thereby reducing the observable impact of additional agronomic inputs (Shah and Wu, 2019).

In contrast, the number of pods per plant was significantly affected, indicating that yield formation in long bean is more sensitive to management practices than vegetative growth parameters. The higher pod number observed under silver–black plastic mulch suggests improved microclimatic conditions around the root zone, such as better soil moisture retention and temperature regulation, which may enhance reproductive efficiency (Amare & Desta 2021). This finding highlights that yield components can respond independently of overall biomass accumulation.

The lack of significant response to increasing NPK fertilizer rates further suggests that nutrient availability was not a limiting factor within the tested range (Kihara et al., 2016). Therefore, higher fertilizer inputs did not translate into proportional yield or biomass gains, implying that excessive fertilization may be unnecessary and inefficient under similar agroecological conditions. Overall, these results emphasize the importance of optimizing cultivation practices based on yield-relevant responses rather than solely increasing input levels.

5. Conclusions

This study demonstrates that the combined evaluation of mulch type and NPK fertilizer rate provides new insight into their roles in long bean cultivation under lowland tropical conditions. The results show that variations in mulch application and NPK dosage did not significantly affect most vegetative growth and biomass parameters, indicating that long bean growth is relatively resilient to changes in these inputs. However, the number of pods per plant was significantly influenced, highlighting that reproductive performance is more responsive to mulch management than to increased fertilizer rates. These findings align with the study objectives and underscore the originality of this work in identifying mulch selection particularly silver–black plastic mulch as a more effective strategy for improving yield efficiency than increasing NPK fertilizer input under the tested conditions.

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Conflict of Interest

The authors declare no conflicts of interest.

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