INTEGRATED FERTILIZATION FORMULATION: EFFECT OF GOAT MANURE AND PEARL NPK ON BIOMASS AND YIELD OF STRING BEANS (*Vigna Sinensis* L.)

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Abstract

This study aims to evaluate the effect of goat manure and Mutiara NPK inorganic fertilizer on the vegetative growth, biomass, and yield of long bean (Vigna sinensis L.). The research was conducted using a factorial Randomized Group Design (RAK) consisting of two main factors. The first factor was the dose of goat manure with three levels: J1 (2 kg/plot), J2 (3 kg/plot), and J3 (4 kg/plot). The second factor was the application of NPK Mutiara fertilizer with four levels: P0 (control/no treatment), P1 (100 kg/ha or 24 g/plot), P2 (150 kg/ha or 36 g/plot), and P3 (200 kg/ha or 49 g/plot). Each experimental unit consisted of a uniform number of long bean plants to ensure reliable observations. The results indicated that both goat manure and NPK fertilizer significantly influenced vegetative growth parameters, including plant height, leaf number, and stem diameter, as well as yield components such as pod number, pod length, and total biomass. Furthermore, there was a significant interaction between goat manure and NPK application, where the optimal combination resulted in the highest biomass accumulation and pod yield. Specifically, the combination of the highest goat manure dose (J3) and moderate NPK dose (P2) provided the most favorable effect on long bean growth and productivity. These findings suggest that integrating organic and inorganic fertilizers can optimize nutrient availability, support sustainable crop production, and improve long bean yields. The study provides practical guidance for farmers seeking environmentally friendly fertilization strategies to enhance legume crop performance, while promoting soil fertility and sustainable agricultural practices.

Keywords: *Goat Manure; NPK Pearl; Biomass; Yield; String Beans*

A. Introduction

String beans *(Vigna sinensis L.)* are an important horticultural commodity in Indonesia. This plant is known as long bean, string bean, or yardlong bean in various countries. In addition to its crunchy and sweet taste, long beans also contain various important nutrients such as fiber, vitamins C and K, magnesium, and antioxidants (Saparinto, 2013). The nutritional content

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makes long beans an important part of food diversification and improving community food security. Market demand for broad beans continues to increase along with public awareness of a healthy diet.

Despite its high potential, the productivity of long beans in some areas has decreased. Data from the Gorontalo Provincial Agriculture Office (2024) shows that the yield of long beans decreased by 10.89% from 2022 to 2023. One of the contributing factors is the decline in soil fertility due to inappropriate cultivation practices. Therefore, efforts to improve productivity through an appropriate fertilization approach are crucial, especially on land with low fertility or acidic soils. Balanced fertilization that meets crop needs can significantly increase yields.

Goat manure is a source of organic nutrients that is rich in nitrogen, phosphorus and potassium. In addition, it can improve soil physical and biological properties, such as increasing cation exchange capacity and soil microbial activity. The nitrogen content in goat manure ranges from 1.2-2.1%, which is higher than other types of manure (Balai Penelitian Ternak, 2010). The use of goat manure can significantly increase the growth and yield of long bean plants (Hermawan et al., 2023). Therefore, goat manure is a good choice to improve soil fertility naturally. On the other hand, Mutiara NPK fertilizer as an inorganic compound fertilizer provides macro nutrients that are quickly available to plants. Nitrogen, phosphorus, and potassium elements are needed by plants in large quantities during the vegetative and generative growth phases. The use of NPK fertilizers can significantly increase the growth and yield of long bean plants (Sulaiman et al., 2024). However, excessive use of inorganic fertilizers can cause long-term degradation of soil quality. Therefore, a balanced fertilization strategy between organic and inorganic fertilizers is needed.

The integration of organic and inorganic fertilizers in fertilizer formulations is a promising approach to improve fertilizer efficiency. This approach can improve soil conditions and increase crop yields in a sustainable manner. Research shows that the combination of goat manure and NPK can significantly increase the growth and yield of long bean plants (UPN "Veteran" Yogyakarta, 2024). In addition, this combination can reduce dependence on inorganic fertilizers and improve agricultural sustainability. Therefore, integrated fertilization formulation is an effective strategy in long bean cultivation.

Previous research showed that a dose of goat manure of 20 tons/ha gave the best results on the growth and yield of long bean plants (Hermawan et al., 2023). Meanwhile, the dose of NPK fertilizer 200 kg/ha also gave optimal results (Sulaiman et al., 2024). The combination of goat manure doses of 20 tons/ha and NPK 200 kg/ha can significantly increase the growth and yield of long bean plants. Therefore, this study aims to evaluate the effect of a combination of goat manure and Pearl NPK fertilizer on the biomass and yield of long beans. This approach is expected to produce an efficient and applicable integrated fertilization formulation to increase crop productivity in tropical agroecosystem conditions.

The results of the study are expected to provide useful information for farmers in determining the right fertilization strategy. In addition, the results of this study can also serve as a reference for agricultural researchers and practitioners in developing sustainable long bean cultivation technology. Thus, this research has a significant contribution in improving the productivity and sustainability of agriculture in Indonesia. Therefore, it is important to continue developing and applying integrated fertilization technology in broad bean cultivation. This research is expected to be the first step in realizing sustainable and environmentally friendly agriculture.

B. Materials And Methods

Research Site

This research was conducted at the Experimental Field of UPT BBI (Balai Benih Induk) Tanjung Selamat, Deli Serdang Regency, North Sumatra Province, located at an altitude of approximately 30 meters above sea level. The study took place from February to April 2022, under field conditions representative of lowland tropical climates.

Research Procedure

This study was conducted using a factorial experiment arranged in a Randomized Block Design (RBD) with three replications to minimize experimental error due to environmental variability in the field. The experimental treatments consisted of two factors. The first factor was goat manure dosage (denoted as factor J), which included three levels: J1 = 2 kg per plot (equivalent to 8 tons/ha), J2 = 3 kg per plot (12 tons/ha), and J3 = 4 kg per plot (16 tons/ha). The second factor was Pearl NPK fertilizer dosage (denoted as factor P), with four levels: P0 = control (no fertilizer), P1 = 24 g per plot (100 kg/ha), P2 = 36 g per plot (150 kg/ha), and P3 = 49 g per plot (200 kg/ha). This combination yielded 12 treatment interactions (3 × 4), namely J1P0 to J3P3.

Each treatment combination was randomly assigned to three plots (replicates), resulting in a total of 36 experimental units. Each plot measured 150 cm × 150 cm and was planted with 12 string bean (*Vigna sinensis* L.) plants using a spacing of 30 cm × 40 cm. The experimental site was prepared through standard land preparation procedures, including plowing, harrowing, and bed shaping. Goat manure was applied one week before transplanting and thoroughly incorporated into the soil, while NPK fertilizer was applied according to treatment levels in split applications half at planting and the rest at flowering.

Each plot was weeded manually and irrigated regularly to maintain optimum soil moisture. Pest and disease control was conducted preventively and curatively using recommended biological or chemical methods when necessary. Five plants were randomly selected from each plot (excluding border plants) to serve as the sample plants for observation. Spacing between individual plots was maintained at 30 cm, while a 50 cm distance was provided between blocks to prevent cross-treatment influence and ensure ease of access. All field management practices including fertilization, watering, pest control, and data collection followed standard agronomic practices to ensure uniformity and validity of the research outcomes.

Observation Variables

Observations in this study focused on key yield components of string bean (Vigna sinensis L.) to assess the effects of the applied treatments. The observed variables included number of fruits per sample, number of fruits per plot, fruit weight per sample, fruit weight per plot, and fruit length per sample. The number and weight of fruits per sample were recorded from five randomly selected plants in each plot, excluding border plants, to ensure representative sampling. Total fruit number and fruit weight per plot were measured from all harvested plants within each experimental unit. Fruit length was measured using a ruler on each sampled fruit to assess treatment impact on morphological development. These parameters were chosen to reflect both individual plant performance and overall plot productivity.

Data Analysis

The data collected from each observed variable were analyzed using Analysis of Variance (ANOVA) to determine the significance of the main effects of goat manure and NPK fertilizer applications, as well as their interaction. The statistical model used followed a factorial randomized block design. If the ANOVA indicated significant differences among treatment means, further analysis was performed using post hoc mean comparison tests, such as the Honest Significant Difference (HSD) or Tukey's test, at a 5% level of significance to identify specific treatment effects. All statistical computations were carried out using appropriate statistical software such as SPSS or SAS to ensure accuracy and reproducibility of the analysis

C. Results And Discussion

Number of fruits per sample

The use of NPK fertilizer has a significant effect on the number of fruits in each sample, as shown by the results of the analysis of variance. Meanwhile, the use of goat fertilizer and the interaction between the two influenced the limits of the number of organic products test.

The Table 1. Shows The Average Number Of Fruits Per Sample When Goat Manure And NPK Fertilizer Were

Goat Manure	NPK Fertilizer				Average
	P0	P1	P2	P3	
	... ... Fruit				
J1	2,53	2,98	3,22	2,84	2,89
J2	2,89	3,10	3,40	3,02	3,10
J3	2,98	3,00	3,32	3,36	3,16
Average	2,80 c	3,03 b	3,31 a	3,07 b	

Notes: Duncan's test at 5% and 1% level indicates significant differences when numbers followed by unequal letters in columns.

The table shows that the NPK compost treatment strongly influenced the number of natural products per test. The largest number of natural products per test was obtained in the P2 treatment followed by P3, P1 and P0. J3 had the highest number of fruits per sample when treated with goat manure, followed by J2 and J1. The cooperation between the two treatments

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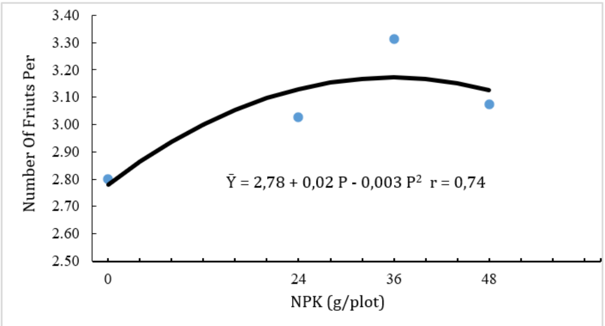
was most prominent in J2 P2 and least in J1 P0.

The Response Curve Of The Number Of Fruits Per Sample To The Application Of NPK Fertilizer Can Be Seen In Figure 1

The Figure 1. Curve Of The Number Of Fruits Per Sample To NPK Fertilizer.



The response of the number of fruits per sample to NPK fertilizer is positive quadratic. This means that NPK fertilizer causes a positive effect on the number of fruits per sample, where the higher the fertilizer applied, the number of fruits per sample increases.

Number of Fruits per Plot

The consequence of the change investigation showed that the use of goat manure compost affected the quantity of natural products per plot. While the utilization of NPK compost and the collaboration of the two affected the quantity of natural products per plot.

The quantity of natural products per plot for the use of goat manure and manure can be seen in Table 2.

Table 2. Number Of Long Bean Fruits Per Plot With Various NPK Fertilizers And Goat Manure.

Goat Manure	NPK Fertilizer		
	P0	P1	P2
	... ... Fruit		
J1	34,00	33,78	37,00
J2	33,89	36,11	37,78
J3	39,89	37,44	37,44
Average	35,93	35,78	37,41

Notes: Duncan's test at 5% and 1% level indicates significant differences when n

The table above shows that goat manure treatment significantly affects the quantity of organic products per plot. Treatment J3 produced the most fruit per plot, followed by treatments J2 and J1. The highest concentration of NPK fertilizer was found in P3, followed by P2, P1, and P2. J3P3 had the highest interaction between the two treatments, while J1 P1 had the lowest interaction.

The table above shows that goat manure treatment significantly affects the quantity of organic products per plot. Treatment J3 produced the most fruit per plot, followed by treatments J2 and J1. The highest concentration of NPK fertilizer was found in P3, followed by P2, P1, and P2. J3P3 had the highest interaction between the two treatments, while J1 P1 had the lowest interaction.

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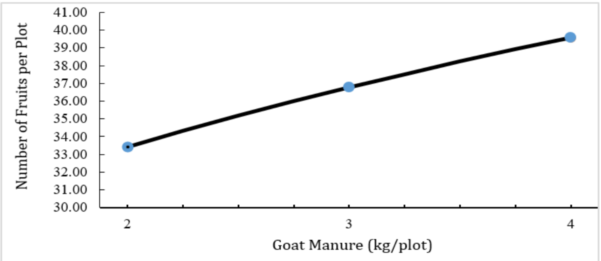
The figure 2. illustrates the relationship between goat manure application and the number of fruits per plot. PUKA (kg/plot).

Figure 2. Response Curve of Number of Fruits per Plot to Goat Manure Application.



The response of number of fruits per plot to goat manure was positive linear. This means that goat manure causes a positive influence on the number of fruits per plot, where the higher the fertilizer applied, the number of fruits per plot increases.

Fruit Weight per Sample

The application of and the combination of the two treatments had no significant effect on the weight of fruit produced by each sample plant, according to the results of the analysis of variance. However, the parameter of fruit weight per sample plant was strongly influenced by the use of NPK fertilizer, the table shows the average fruit weight per sample plant after the application of NPK fertilizer and goat manure.

Table 3. Fruit weight per plant for broad bean samples grown with different NPK fertilizers and goat manure.

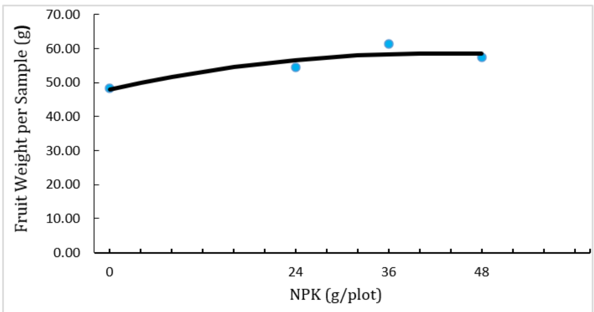
Goat Manure	NPK Fertilizer		
	P0	P1	
	... ... Gram		
J1	41,32	53,20	5
J2	49,90	53,07	6
J3	53,88	57,26	6
Average	48,36 c	54,51 b	61

Notes: At the 5% and 1% test levels, numbers in columns followed by unequal le
Duncan's test.

The table above shows that J3 has the highest goat manure treatment, followed by J2 and J1. Fruit weight on each sample plant is strongly influenced by the application of NPK fertilizer. P2 has the most fruit weight per sample plant, followed by P3, P1, and P0. J2P2 had the most interaction between the two treatments, while J1P0 was the lowest.

The response curve of fruit weight per sample plant to the application of NPK fertilizer can be seen in Figure 3.

Figure 3. Response Curve of Fruit Weight per Sample to NPK Fertilizer Application.



Fruit weight per sample responded positively quadratically to NPK fertilizer, i.e. NPK fertilizer had a positive influence on fruit weight per sample; with increasing fertilizer concentration, fruit weight per sample increased.

Fruit Weight per Plot

Fruit weight per plot was not significantly affected by the use of NPK fertilizer, goat manure, or a combination of the two treatments, according to the results of the analysis of variance, Table 4 shows the average fruit weight per plot for NPK fertilizer and goat manure.

The table 4 shows that J3 has the highest goat manure treatment, followed by J2 and J1. P3 had the highest yield from the NPK fertilizer treatment, followed by P2, P1, and P0. J3P3 had the highest interaction between the two treatments, while J1P0 had the lowest interaction.

Goat Manure	NPK Fertilizer				Average
	P0	P1	P2	P3	
	... ... Gram				
J1	522,22	522,22	644,44	611,11	575,00
J2	500,00	711,11	644,44	544,44	600,00
J3	677,78	622,22	633,33	811,11	686,11
Average	566,67	618,52	640,74	655,56	

Fruit Length per Sample

Information on the perception of organic product length per test and examination of its fluctuation is presented in Appendix 18 to 19. Goat manure, NPK fertilizer, and the interaction of the two treatments had no significant effect on the parameter of fruit length per sample, according to the results of variance analysis. The average fruit length per test plant on the use of goat manure and NPK fertilizer can be seen in Table below.

Table 5. Length Of Organic Product Per Plant Of Long Bean Test On Various Goat Manure And NPK Fertilizer

Goat Manure	NPK Fertilizer				Average
	P0	P1	P2	P3	
	... ... cm				
J1	45,23	46,91	46,42	48,70	46,81
J2	42,35	55,17	56,09	53,38	51,75
J3	50,51	48,52	48,37	45,85	48,31
Average	46,03	50,20	50,29	49,31	

The table above shows that the best goat compost treatment is J2 followed by J3 and J1. V2, followed by V1, V3, and V0, had the longest fruit length per plant sample during the NPK fertilizer treatment. The collaboration of the two treatments was most prominent in J2P2 and least in J2 P0.

Effect of Goat Manure on Growth and Production of String Beans

The treatment of goat manure has been proven to have a significant effect on the number of fruits per plot, based on the analysis of variance. However, there was no significant effect on plant height, number of productive branches, number of fruits per sample, weight of fruits per sample, weight of fruits per plot, or length of fruits per sample. The goat fertilizer treatment generally had a significant impact on the yield per plot of long bean plants. The largest yield was obtained in treatment J3, which showed uniqueness compared to treatments J2 and J1. This indicates that the use of goat manure has provided the necessary supplements at the generative stage of the plant. The availability of potassium, which is essential for the formation of broad bean seeds, greatly affects the productivity of the plants in producing broad beans. In addition, the suggestion that goat manure can improve soil fertility allows plant roots to breathe and absorb supplements better, which is consistent with previous findings (Campbell et al., 2003). The utilization of goat manure compost, especially on soils with high porosity, has positive implications on plant growth and yield.

With permeable soil conditions, air circulation in the soil becomes large, helping the breathing of root cells, and allowing the delivery of water and minerals from the roots to other parts of the plant. The treatment of goat manure showed a significant effect on the height of long bean plants. Broad bean plant height reached its peak at the age of one and a half months after planting, seen in treatment J3, followed by J1 and J2. The reason is thought to be because goat manure is still young, has round grains so it is difficult to separate perfectly. As explained by Sutedjo (2002), this compost is suitable to be applied at the final stage of growth to stimulate flower development and organic production, as also stated by Lakitan (2004). The goat compost treatment also affected the weight of organic products of long bean plants, where the highest weight of organic products was found in treatment J3, followed by J2 and J1. This finding is consistent with the research of Subhan et al. (2005), which showed an increase in unit weight per plot, fill weight, number of stalks, and dry weight in vegetable crops with the use of compost. Research by Zavie et al. (2014) added that phosphorus-rich manure can encourage flower formation in broad bean plants, especially when supported by soil that has sufficient phosphorus content.

The treatment of goat compost has a significant impact on the amount of organic products per test of long bean plants. The highest amount of organic product produced per test of long bean plants was recorded in treatment J3, followed by J2 and J1. The cause is thought to be related to the condition of the soil used, which is acidic soil. This was revealed from the results of soil analysis which showed a soil pH of 4.70, categorized as acidic soil. Acidic soil conditions can inhibit plant access to available nutrients, becoming one of the main obstacles in plant growth and development. According to Tedjasarwana (2012), soil pH has a significant impact on plant health and growth. In soils with acidic pH, the capacity of roots to absorb nutrients is limited, making nutrients difficult for plants to access. Thus, soil pH management is of key importance in optimizing crop production and ensuring nutrients are available in sufficient quantities. Agricultural sustainability relies on soil biodiversity, ranging from microorganisms

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to soil fauna and flora, which drive soil formation, nutrient cycles, structure, and productivity. The review also highlights the impact of post-Green Revolution chemical-extractive agricultural practices on soil biota degradation and recommends agrobiodiversity-based management and interdisciplinary soil function monitoring to maintain ecosystem services and food security (Nazara & Zega, 2025).

Effect of NPK Fertilizer on Growth and Production of String Beans

The results of the significant difference test showed that the NPK fertilizer treatment had a significant effect on plant height at one month after planting, the number of organic products per plant, and the weight of organic products per plant. However, the effect was not significant on the number of useful branches, the number of natural products per plot, the weight of natural products per plot, and the length of natural products per plant. Overall, the NPK compost treatment also affected the height of long bean plants.

Broad bean plant height reached its peak in the P2 treatment at the age of one month after planting. Although not significantly different from P0, there was no significant difference between P1, P2, and P3. This is caused by NPK compost which is an important supplement in the vegetative phase of plants for optimal growth. Fahmi (2014) explained that pearl NPK compost is an inorganic fertilizer that contains several nutrients that are important for plant development. In addition, Mulyani (2008) stated that plant height increased along with the increase in the dose of pearl NPK fertilizer. Thus, the older the plant, the plant roots will develop well to absorb the nutrients N, P, and K from the pearl fertilizer. With these supplements, plant growth and development will increase significantly. soil management and conservation, irrigation efficiency and scheduling, fertilization scheduling, water balance, and emphasizing the usefulness of this book for students and practitioners in designing input-efficient and resource-constraint-resilient farming systems (Nazara, 2025)

The NPK compost treatment basically affected the amount of organic products per test of broad bean plants. The number of organic products per test of broad bean plants reached its peak in the P2 treatment, which was significantly different from the P1, P3, and P0 treatments. This is thought to be due to the content of nitrogen, phosphorus and potassium nutrients in the NPK compost, which may stimulate the production of natural products, thus affecting the amount of products in the broad bean plants. According to Sasongko (2010), supplements such as nitrogen, phosphorus, and potassium are essential in the development of natural products. Lack of these substances can inhibit the growth

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of natural products. Protein requires nitrogen in its formation, while phosphorus is an important component for protein synthesis and the formation of new cells. This statement is also in line with Syarief's (2006) explanation that the availability of adequate supplements during the growth period can increase plant digestive activity, improve the process of cell elongation, division, and differentiation, which in turn will support overall plant growth. Jumin (2005) also states that successful plant development and creation requires adequate intake of nutrients or supplements.

The NPK fertilizer treatment basically affected the weight of organic product per test of broad bean plants. The peak organic product weight per test of broad bean plants was recorded in the P2 treatment, which was basically not different from P1 and P0, but did not show significant differences with P3. It is thought that phosphorus supplements contained in NPK fertilizers can stimulate and accelerate the process of cell division, thus affecting the weight of organic products of broad bean plants. As highlighted by Deptan (2013), the use of rainbow NPK fertilizer can accelerate the fertilization process and yield of long bean. The ability of phosphorus in rainbow NPK compost to stimulate root growth, especially in the root system that supports the development of seeds and young plants, assists in digestion, respiration, and accelerates the flowering process, leaf senescence, and increases plant resistance to disease. Gardner and colleagues (1985) also noted that plants need adequate and balanced supplements. An imbalance in supplementation or excess dosage can disrupt the photosynthesis process and reduce the amount of photosynthate produced. To achieve optimal growth and yield, the soil must be supplied with balanced nutrients.

Effect of Interaction of Goat and NPK Fertilizer on Growth and Production of Long Bean

Plant height, number of productive branches, number of fruits per sample, number of fruits per plot, weight of fruits per sample, and fruit length were all not affected by the interaction between goat manure and NPK fertilizer treatments, as indicated by the analysis of variance. Looking at the after-effects of the analysis outlined in the table, this confirms that the combination of different levels of NPK compost with different levels of goat manure resulted in better growth and establishment of broad bean plants than using only goat manure without NPK fertilizer. The combination of 3 kg/plot of goat manure with 24 g/plot of NPK yielded the highest fruit weight per plot, 711.11 g/plot, while the combination of 3 kg/plot of goat manure with 0 g/plot of NPK yielded the lowest fruit weight per plot, 500.00 g/plot. This shows that goat manure and

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NPK fertilizer complement each other to meet the supplement needs of long bean plants. Variations in concentration affect several parameters, including wet root weight and dry crown and root weight, while some other morphometric parameters remain unchanged; these findings emphasize the importance of determining the appropriate concentration range of AB Mix to maximize biomass accumulation without causing nutritional stress on plants (Nazara et al., 2023).

According to Sutedjo (2002), goat manure has a round grain texture and is difficult to physically decompose. Before its use, it is advisable to compost the fertilizer until it reaches a level of maturity. Mature goat compost is cool, dry, and generally odorless. The high nitrogen content in goat manure compost can enhance the vegetative growth of plants. Therefore, the application of this manure is very beneficial in the final stages of preparation to stimulate the development of flowers and natural yields of plants (Lakitan, 2004). so that cultivation practices can optimize flow duration and media selection without significant changes in growth, while paying attention to specific combinations for rooting parameters (Nazara et al., 2024).

The combined treatment of goat manure and NPK compost affects the development and growth of long bean plants because goat manure also contains supplements that can prepare the soil and plants to complement the large amounts of supplements contained in NPK fertilizers. This statement is in line with Sutoro (2003), which states that organic matter has an important role in improving soil fertility, regulating the availability of nutrients for plants, and developing various physical, organic, and other substance properties in the soil, such as soil pH, cation and anion exchange capacity, as well as soil buffering effects and the balance of elements that are toxic to plants, such as Fe, Al, Mn, and other heavy metals, including the balance of insect toxins.

In the context of this study, NPK fertilizer had a more significant impact on the growth and production of long beans compared to other types of fertilizer. Although NPK fertilizer has a slower application process, its components can be quickly utilized by the broad bean plants. This shows one of the advantages of inorganic compost that reacts faster in plants when compared to organic fertilizers. Essential supplements are of two types, namely large amounts and small amounts. Large amounts of supplements are required in large quantities by plants, while small amounts of supplements are required in small quantities by plants.

D. Conclusions

The number of fruits per plot was significantly affected by how goat manure was treated. While the limits of plant height

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at about one and a half months after planting, number of useful branches, number of natural products per test, weight of organic products per test, weight of natural products per plot and length of natural products per test were not fundamentally affected by the use of goat manure. NPK compost treatment basically had a significant effect on plant height at 1 month after planting, number of organic products per test, and weight of natural products per test. While the limitations on the number of useful branches, number of natural products per plot, weight of organic products per plot and length of organic products per test had a significant effect on the utilization of NPK fertilizer. The interaction between goat manure and NPK compost had a significant effect on all perception limits (plant height, number of useful branches, number of natural products per test, number of natural products per plot, weight of organic products per test, weight of natural products per plot and length of organic products per test).

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