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The Effect of NPK and Guano Fertilizer on the Growth and Yield of Bogor Peanut Plants (*Vigna subterranea* (L.) Verdc.)

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ABSTRACT

This study aimedto evaluate the effects of combined NPK fertilizer and guano application on the growth and yield of Bambara groundnut (Vigna subterranea (L.) Verdc.). The experiment employed a factorial randomized block design with two factors: NPK fertilizer dosage (25%, 50%, 75%, and 100% of recommended rates) and guano dosage (5, 10, and 15 tons/ha). Observed parameters included plant height, leaf count, number of flowers, number of pegs, and fresh/dry pod weight per plant. Results demonstrated that the combination of 25% NPK and 15 tons/ha guano significantly improved plant height (43.29 cm), flower count (47.33), and fresh pod weight (81.73 g/plant). Guano alone also exhibited a substantial effect on both vegetative and generative growth, with the highest results observed at 15 tons/ha. The combination of low NPK and high guano dosages enhances Bambara groundnut productivity sustainably.

1. INTRODUCTION

Bogor peanuts or Bambara groundnuts (*Vigna subterranea* L. Verde) is a type of legume native to Africa with high nutritional value and significant potential as an alternative food source (Jeuorobo *et al*., 2019). In addition to its high protein content, Bambara peanuts also have adaptive advantages because it is drought tolerant and can grow in low-fertility soils, making it suitable for supporting sustainable agricultural systems (Mapegau *et al*., 2025; Berchie *et al*., 2016). However, the productivity of this plant among farmers is still relatively low. According to the evaluation results of Rahmawati *et al*. (2016), the average production yield for Bogor peanuts is 1.7 tons/ha. This is largely due to less than optimal soil conditions and suboptimal cultivation techniques, particularly in terms of fertilization.

Fertilization is a vital component of the cultivation process because it plays a direct role in supporting plant growth and yields. Inorganic fertilizers such as NPK are known to be effective in supplying macronutrients quickly. However, excessive use of chemical fertilizers can trigger long-term soil quality decline (Gulo & Waruwu, 2024). In contrast, organic fertilizers like guano have the advantage of improving soil structure, increasing biological activity, and gradually providing nutrients. Guano contains essential nutrients, including nitrogen (N), phosphorus (P), and potassium (K), as well as microelements such as calcium (Ca), magnesium (Mg), and zinc (Zn), which play a vital role in supporting both the vegetative and generative phases of plant growth (Putri *et al*., 2022). Several studies demonstrated a positive effect of bat guano in improving soil properties and crop yields (Karagöz & Hanay, 2017; Syofiani & Oktabriana, 2017; Ünal *et al*., 2018; Ojobor & Omovie-Stephen, 2022; Wibowo *et al*., 2022).

Combining organic and inorganic fertilizers is considered a more balanced and environmentally friendly approach to fertilization. NPK provides a nutrient supply that is quickly absorbed by plants. Meanwhile, guano maintains the sustainability of long-term nutrient availability. Applying the right fertilizer combination is expected to have a positive

impact on optimal growth and productivity of Bogor peanut plants because NPK fertilizer and guano contain elements that complement each other's needs. This is because the organic matter from guano can improve soil structure and aeration, which can facilitate the absorption of NPK fertilizer by Bogor peanut roots. Furthermore, this plant also requires a lot of phosphorus for root nodule formation, so when the P content in NPK is high, guano can strengthen its effect on pod formation and seed quality (Adeyeye *et al*., 2019). Aaccording to Mukhtaruddin *et al*. (2014), it was proven that the combination of the two fertilizers had an effect on the properties of subsoil soil, as well as increasing the P element. In the context of plant cultivation, selecting the appropriate type and dosage of fertilizer plays a very important role in supporting the morphological development of plants, such as increasing height, number of leaves, and flower formation and the final result in the form of biomass. As in the research of Utami & Saragi (2023), it was shown that there was a different growth response when caisim plants were given a combination of NPK and guano fertilizer.

This study was designed to examine in depth the effect of administering NPK and guano fertilizer in various dose combinations on a number of important indicators of growth and yield Bogor peanuts. The parameters observed include plant height, number of leaves, number of flowers, as well as wet weight and dry weight of plants per plant. Through this approach, it is hoped that comprehensive information can be obtained regarding the effectiveness of the fertilizer combination in supporting vegetative and generative growth Bogor peanuts, so that it can be used as a basis for a more efficient and sustainable fertilization strategy.

1.1. Research Objectives

This research implemented with the aim of evaluating the effect of various combinations of NPK and guano fertilizer doses on the growth and yield of Bogor peanuts. The focus of the observations covered five main parameters: stem height increase, number of leaves, number of flowers formed, and biomass accumulation in the form of fresh and dry weight per plant. The findings of this study are expected to determine the most effective fertilizer combination to increase productivity Bogor peanuts in a sustainable manner.

2. RESEARCH METHODOLOGY

2.1. Time and Place

This research was conducted in Mojoroto, Pacet District, Mojokerto Regency, East Java, between February and May 2025.With an average altitude of 500 meters above sea level, this area experiences temperatures between 23 ℃ and 31 ℃ and rainfall between 1,500 and 3,000 mm/year.

2.2. Tools and Materials

The tools used in this study were shovels, bars, digital scales, measuring tapes, sprayers, and digital hygrometer. The materials used in this study were Bogor bean seeds, NPK fertilizer, guano fertilizer, Deltamethrin, 3% carbofuran, and Dithane M-45.

2.3. Research Methods

The approach used was a factorial experimental design involving two main factors studied simultaneously. These two factors were arranged within a Randomized Block Design (RBD) framework to ensure more accurate and statistically reliable results. The first factor was the level or variation of the dosage of inorganic NPK fertilizer, which plays a crucial role in supplying macronutrients to plants.

P1: 25% of the standard dose (equivalent to 50 kg/ha Urea, 37.5 kg/ha SP36, and 30 kg/ha KCl)
P2: 50% of the standard dose (100 kg/ha Urea, 75 kg/ha SP36, and 60 kg/ha KCl)
P3: 75% of the standard dose (150 kg/ha Urea, 112 kg/ha SP36, and 90 kg/ha KCl)
P4: 100% of the standard dose (200 kg/ha Urea, 150 kg/ha SP36, and 120 kg/ha KCl)

The second factor was guano fertilizer (G), which has the potential to improve soil structure and provide additional nutrients that support plant growth. There were three levels of guano application, namely G1 (5 ton/ha), G2 (10

ton/ha), and G3 (15 ton/ha). The combination of these two factors is expected to provide more comprehensive information regarding the interaction between chemical and organic fertilizers in influencing the growth and yield of Bogor peanut plants. A total of 12 different treatment combinations were replicated three times to get 36 of experimental units. This design allows for a more in-depth analysis of the influence of each factor separately and their interactions on the growth parameters and yield of Bogor peanut plants.

2.4. Research Layout

The following is a layout of the Bogor peanut experiment, there were 3 replications and in each replication unit there are 12 treatment combinations so that 36 experimental units are obtained (Figure1). The experimental plan shows increasing fertility from west to east, starting from the irrigation canal. The slope of the land causes irrigation water to flow, carrying sediment and nutrients to the east, resulting in the accumulation of organic material that enriches the soil. Furthermore, the eastern part tends to have higher soil moisture because water tends to pool in lower areas.

2.5. Experimental Implementation

The first research implementation was land preparation by turning the soil, loosening, and compacting the surface. In addition, 36 plots were created with a bed height of approximately 30 cm and a distance between beds of 60 cm. Each plot had 15 plants with only three samples taken at a planting distance of 40 x 40 cm and a plot area of 3.75 m². The sample taken was the center of the plot. This planting was planted to a depth of approximately 5 cm per plot measuring 250 x 40 cm and made 15 holes.

2.6. Data Analysis

Data obtained from observations during the study were analyzed using the analysis of variance (ANOVA) method with the application of a linear model, referring to the procedure developed by Gomez & Gomez (1995). The mathematical equations used in the analysis process are described as follows:

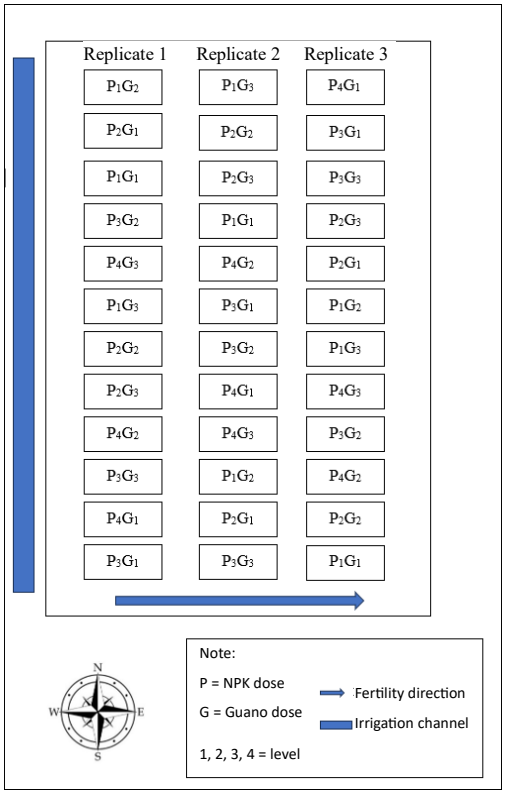

Figure 1. Layout for experimental treatment

$$\mathbf{Y_{ijk} = \mu + \delta_{ik} + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ij}} \quad (1)$$

where Y_{ijk} is observation value for the experimental unit receiving the i^{-th} level of NPK fertilizer and the j^{-th} level of guano fertilizer within the k^{-th} group; i = 1, 2, 3, 4 is number of treatment levels of NPK fertilizer dosage; j = 1, 2, 3 is number of treatment levels of guano fertilizer dosage; k is block (replication) effect; μ is overall mean (grand mean); α_i is effect of the i^{-th} level of NPK fertilizer dosage (subplot factor); β_j is effect of the j^{-th} level of guano fertilizer dosage (main plot factor); $(\alpha\beta)_{ij}$ is interaction effect between the i^{-th} level of NPK fertilizer and the j^{-th} level of guano fertilizer; δ_{ik} is random effect associated with the main plot; ε_{ijk} is random error associated with the subplot.

If the analysis results indicate a significant effect, a further Honestly Significant Difference (HSD) test was carried out using SPSS software at a significance level of 5% to identify statistically significant differences between treatments.

3. RESULTS AND DISCUSSION

3.1. Plant Height

The results of the study revealed that the provision of a combination of NPK and guano fertilizers have a significant impact with a HSD value of 5% of 6.97 on increasing plant height Bogor peanuts at the age7 weeks after planting (WAP). The combined application of 25% NPK fertilizer and 15 tons/ha of guano fertilizer proved more effective in stimulating plant growth than either fertilizer alone or without fertilization. This positive growth response indicates that the availability of nutrients from the rapidly available NPK fertilizer, combined with the organic content and microelements from the guano fertilizer, creates an environment that supports optimal plant development in the vegetative growth phase, as listed in Table 1.The treatment combination that yielded the highest yield was 25% NPK combined with 15 tons/ha of guano, with an average plant height of 43.29 cm. This value was statistically significantly different from the 25% NPK + 5 tons/ha guano treatment, which only produced an average plant height of 37.00 cm.

When viewed separately, the application of guano fertilizer at a dose of 15 tons/ha showed the highest average yield, namely 40.09 cm significant with a HSD value of 5%, namely 0.43 because the soil receives sufficient amounts of organic matter with optimal improvement of the physical, chemical and biological properties of the soil, compared to other guano doses. Meanwhile, 100% NPK treatment showed effectiveness with a 5% HSD value of 0.64 the best in increasing plant height in the early stages of plant development, which is indicated by observations at the age of 3, 5, and 6 Weeks After Planting (MST) with a height of 24.98 cm, 34.01 cm, and 37.89 cm.

The increase in plant height that occurs in the combination of low-dose NPK fertilizer with high-dose guano is most likely due to guano's ability to improve soil structure and increase the availability of key plant nutrients, including macronutrients such as nitrogen, phosphorus, and potassium, as well as supporting nutrients in the form of micronutrients such as iron, manganese, zinc, copper, boron, and others. These elements play an important role in the cell elongation process, which directly affects plant growth. On the other hand, application of NPK fertilizer at full dose (100%) tends to be more effective in the early stages of vegetative growth due to easily absorbed by plants.

The role of NPK in this combination is crucial because it complements and accelerates the nutrient availability of the guano fertilizer. Nitrogen, for example, plays a role in vegetative growth, root nodules, and provides a faster effect. Furthermore, the phosphorus in NPK fertilizer forms roots, flowers, and seeds, accelerating the growth of early roots and pods (Nugroho *et al*., 2021). Meanwhile, the potassium content in NPK fertilizer regulates the translocation of photosynthesis products, stomatal opening, and resistance to abiotic stresses and diseases.

Table 1. Average plant height (cm) at 7 weeks after planting in the combination treatment of NPK and guano fertilizers

NPK Fertilizer Dosage (%)	Guano Fertilizer Dosage (ton/ha)		
	5	10	15
P1 (25% standard)	37.00 a	37.07 a	43.29 a
P2 (50% standard)	38.17 a	37.87 a	40.77 a
P3 (75% standard)	37.67 a	39.33 a	38.13 a
P4 (100% standard)	39.00 a	38.80 a	38.17 a
HSD 5%		6.97	

Note: mean values given with same letter indicate no significant difference according to the HSD test with a 95% confidence level.

Effectiveness decreases in subsequent growth stages if not supported by additional organic components that can strengthen the soil's ability to bind and retain nutrients. The data obtained supports the results reported by Sari (2020) research, which showed that a combination of organic guano fertilizer and inorganic NPK fertilizer was the best treatment, with the highest plant height of 62.66 cm compared to the single treatment on soybean plants.

3.2. Number of Leaves

Based on the ANOVA analysis, the interaction between various doses of NPK fertilizer and guano fertilizer did not have a significant effect on the number of leaves Bogor peanut plants at all observed age stages. In addition, when each factor was analyzed separately, the application of NPK fertilizer also in significant on the number of leaves of the plant at each observation time. On the other hand, the single effect of guano fertilizer showed a very significant difference in the number of leaves at all observed plant ages, namely with a HSD value of 5% at 2 MST of 0.18, at 3 MST of 0.20, at 4 MST of 0.26, at 5 MST of 0.43, at 6 MST of 0.88 and at 7 MST of 0.51.The average value of the further test results for each single factor can be seen in detail in Table 2.

Figure 2. Bogor peanut plants from different treatment of NPK and guano fertilizers

Table 2. Effect of combination treatment NPK and guano fertilizer on the average number of leaves of Bogor peanuts

NPK Fertilizer Dosage (%)	MST					
	2	3	4	5	6	7
P1 (25% standard)	3.33	5.11	7.56	11.44	20.56	24.33
P2 (50% standard)	3.44	5.33	7.89	11.67	22.00	24.44
P3 (75% standard)	3.44	5.22	7.67	12.67	23.00	24.67
P4 (100% standard)	3.33	5.22	7.33	11.22	20.33	25.33
HSD 5%	tn	tn	tn	tn	tn	tn
Guano Fertilizer Dosage						
G1 (5 ton/ha)	2.83 a	4.58 a	6.75 a	10.33 a	19.75 a	23.67 a
G2 (10 ton/ha)	3.58 b	5.50 b	7.83 b	11.92 b	21.42 b	24.33 b
G3 (15 ton/ha)	3.75 b	5.58 b	8.25 c	13.00 c	23.25 c	26.08 c
HSD 5%	0.18	0.20	0.26	0.43	0.88	0.51

Note: mean values given with same letter indicate no significant difference according to the HSD test with a 95% confidence level.; tn = no significant difference.

The high nitrogen content and the presence of natural phytohormones such as auxins and gibberellins in guano fertilizer are thought to play a role in stimulating cell division and the formation of new leaves. Application of guano at a high dose, namely 15 tons/ha, can provide nutrients more stably and sustainably, thus supporting physiological processes related to leaf growth. On the other hand, treatment with NPK fertilizer application did not significantly affect the number of leaves formed, which is most likely influenced by the dominance of plant genetic factors and the physiological development phase that determines these parameters. This align with the findings of Palita *et al.* (2021), that fertilization with guano as soil amendment resulted in promoting effect on growth biomass and photosynthesis.

3.3. Number of Flowers

The combination treatment of 25% NPK fertilizer and 15 tons/ha of guano gave the highest results in terms of the number of flowers, with an average of 47.33 flowers, which in general significant with a HSD value of 5%, namely 6.97 different compared to other treatments (see Table 3). This is because the combination results in faster nutrient absorption with a continuous supply and optimal soil improvement, resulting in a significantly increased flower count. In addition, a single guano application at a dose of 15 tons/ha is also significantly proven with a HSD value of 5% of 1.21 increases the number of flowers but is still less effective for plants to absorb nutrients. While in the single factor treatment of fertilizer NPK also has a significant effect with a HSD value of 5% of 1.78.

Table 3. Effect of combination treatment NPK and guano fertilizer on the average number of flowers of Bogor peanuts

NPK Fertilizer Dosage (%)	Guano Fertilizer Dosage (ton/ha)		
	5	10	15
P1 (25% standard)	24.67 a	26.00 a	47.33 e
P2 (50% standard)	29.33 ab	33.67 bcd	30.33 abc
P3 (75% standard)	28.67 ab	30.00 abc	29.33 ab
P4 (100% standard)	29.00 ab	40.33 d	36.33 cd
HSD 5%		6.97	

Note: mean values given with same letter indicate no significant difference according to the HSD test with a 95% confidence level.

The phosphorus (P) contained in guano plays a crucial role in ATP synthesis and in activating genes that regulate the flowering process. Furthermore, potassium (K) supports the transfer of photosynthesis products to plant parts that play a role in the development of reproductive organs. Using a combination of low-dose NPK fertilizer and high-dose guano creates an optimal nutritional balance while avoiding excess nitrogen, which can inhibit flowering. This finding aligns with the research of Sachan & Krishna (2021), which demonstrated a positive synergy between organic and inorganic fertilizers in supporting the reproductive phase of legume plants. Meanwhile, research by Asril *et al*. (2023) demonstrated that a combination of guano and NPK fertilizers provided phosphorus for flowering, fruiting, and seed and fruit ripening in chili plants, resulting in the highest fruit weight.

3.4. Number of Pods

The combination treatment of 25% NPK fertilizer with 15 tons/ha of guano produced the highest number of pods per plant and per plot, namely 42.67 pods/plant (Table 4) and 565 pods/plot (Table 5). Apart from that, the single application of guano fertilizer on the number of pods per plant also showed a significant effect with HSD 5% of 1.44, while HSD 5% per plot was 15.76. Providing NPK fertilizer with a single factor also had a significant effect with 5% HSD amounting to 2.13 per plant, while with 5% HSD per plot it was 23.20. The increase in pod number occurs due to the availability of phosphorus, crucial for seed filling, and potassium, which supports plant biomass accumulation. Guano contains humic acid, which helps the soil retain and release nutrients better, allowing plant roots to absorb them more efficiently. This increased nutrient absorption efficiency allows plants to grow optimally. Syofiani & Oktabriana (2017) reported similar findings, where application of bat guano increase nutrients N, P, K and increase the growth of soybean in the gold mine tailings.

Table 4. Effect of combination treatment NPK and guano fertilizer on the average number of pods per plant of Bogor peanuts

NPK Fertilizer Dosage (%)	Guano Fertilizer Dosage (ton/ha)		
	5	10	15
P1 (25% standard)	17.33 a	18.33 a	42.67 d
P2 (50% standard)	22.33 ab	25.00 ab	24.33 ab
P3 (75% standard)	22.00 ab	24.67 ab	25.33 b
P4 (100% standard)	23.00 ab	34.00 c	30.00 bc
HSD 5%		8.32	

Note: mean values given with same letter indicate no significant difference according to the HSD test with a 95% confidence level.

Table 5. Effect of combination treatment NPK and guano fertilizer on the average number of pods per plot of Bogor peanuts

NPK Fertilizer Dosage (%)	Guano Fertilizer Dosage (ton/ha)		
	5	10	15
P1 (25% standard)	282.33 a	291.33 ab	565.00 f
P2 (50% standard)	343.33 abcd	374.00 bcde	386.00 cde
P3 (75% standard)	331.33 abc	369.67 abcde	383.00 cde
P4 (100% standard)	349.00 abcd	423.67 de	446.00 e
HSD 5%		90.76	

Note: mean values given with same letter indicate no significant difference according to the HSD test with a 95% confidence level.

The combination of these two fertilizers can also affect pod filling and seed formation. The nutrients provided in NPK fertilizer support energy formation and the translocation of photosynthesis products to reproductive organs, thereby accelerating seed filling and increasing pod weight. Meanwhile, guano fertilizer, with its organic matter, provides natural micronutrients and phosphorus to improve soil structure and increase microbial activity, which helps in phosphate dissolution, thus impacting nutrient absorption efficiency. This is supported by research by Suganda & Khoiri (2022) which confirms the synergistic benefits of bat guano and NPK fertilizers for egg plant cultivation. These results align with research by Mendrofa *et al*. (2025) which shows that a combination of organic and inorganic fertilizers can significantly increase peanut seed yield.

4. CONCLUSION

The use of a combination of 25% NPK fertilizer and 15 tons of guano per hectare proved to be the most effective treatment in accelerating plant height with an average height reaching 43.29 cm, in addition to also having an effect on the number of flowers with the highest average reaching 47.33 flowers. The combination at this dose also affected the number of pods per plant of 42.67 and 565 pods/plot. Guano plays a major role in providing macro and micro nutrients while improving the physical and chemical conditions of the soil, while NPK fertilizer with a low dose provides a quickly available supply of nutrients without causing nutrient imbalances. These results support the implementation of sustainable agricultural methods by reducing the excessive use of inorganic fertilizers. In addition, this combination when applied provides more practical nutrients for nutrient absorption by plants and minimizes damage to the soil. As a suggestion for further research, it is expected this research can be conducted on the residual effects and economic evaluation on a farmer scale.

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AUTHOR CONTRIBUTION STATEMENT

Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
VG	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	
Wid	✓	✓		✓	✓	✓	✓	✓		✓		✓		
JS		✓		✓				✓		✓				

C: Conceptualization
M: Methodology
So: Software
Va: Validation
Fo: Formal Analysis
I: Investigation
D: Data Curation
R: Resources
O: Writing - Original Draft
E: Writing - Review & Editing
Vi: Visualization
Su: Supervision
Fu: Funding Acquisition
P: Project Administration

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