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Optimizing NPK Fertilizer Dosage and Planting Distance on the Growth and Yield of Bambara Bean Plants of Local Variety (*Vigna subterranea* (L) Verdc)

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Abstract

Bambara beans (*Vigna subterranea* (L.) Verdc.) are a horticultural crop belonging to the Fabaceae family. Production in Indonesia remains relatively low because of factors such as planting time, limited availability of bambara bean varieties—which causes farmers to rely on local varieties—and declining land productivity. This study aimed to determine the effects of NPK fertilizer doses and planting distances on the growth and yield of bambara beans (*Vigna subterranea* L.). We used a factorial Randomized Block Design (RBD) with two factors. The first factor was the NPK fertilizer dose at five levels: 200 kg/ha, 300 kg/ha, 400 kg/ha, 500 kg/ha, and 600 kg/ha. The second factor was planting distance at three levels: 40 x 20 cm, 40 x 30 cm, and 40 x 40 cm. The results showed a significant interaction between NPK fertilizer dose and planting distance affecting plant height at 7–9 weeks after sowing, the number of flowers, and the fresh and dry weight of pods per plant. A single treatment of 400 kg/ha NPK fertilizer was optimal for plant height at 5–6 weeks after planting. The planting distance of 40 x 40 cm was most effective for increasing leaf number. The application of NPK fertilizer doses and planting distances individually had no significant effect on the number of gynophores or the number of pods per plant. The highest yield was observed at a planting distance of 40 x 30 cm combined with an NPK dose of 400 kg/ha, which can enhance productivity and yield. Therefore, this combination is recommended for cultivating local varieties of bambara beans.

Keywords: Combination, Generative, Nutrients, Productivity, Vegetative

1. Introduction

Bambara bean (*Vigna subterranea* L.) is a horticultural commodity of the legume type belonging to the Fabaceae (legume) family. The Bambara bean is a native plant of Africa, especially in Nigeria and Cameroon. In Indonesia, the Bambara bean is often called the Bogor bean. Cultivation of the Bambara bean in Indonesia is still limited, even though it has a fairly high content of 20.6% protein, 6.6% fat, 6.3% fiber, and 56.61% carbohydrates. Other advantages of bambara beans include their adaptability, ability to grow well in dry climates, disease resistance, and low production costs.

The production of bambara beans in Indonesia is still relatively low; bambara beans from Sumedang produce dry pods between 1.13-2.04 tons on / ha $^{-1}$ and an average production of 1.7 tons -1 (Rahmawati et al., 2016). The cause of low yields from year to year is the lack of farmer knowledge about efficient agricultural techniques, planting time, and the lack of bambara bean varieties that causes farmers to still rely on local varieties as well as declining land productivity conditions. The application of better agricultural techniques by providing sufficient nutrients to the land is expected to increase the target of bambara bean production by up to 50% in the next few years.

Poor soil quality can be improved by providing adequate plant nutrition, such as using NPK fertilizer and adjusting plant spacing when cultivating bambara beans. The main challenge is determining the correct dosage and spacing, making optimizing NPK fertilizer dosage and spacing crucial for maximizing productivity.

Fertilization aims to increase and maintain the availability of nutrients plants need. NPK fertilizer contains

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16% nitrogen, 16% phosphorus, and 16% potassium. NPK fertilizer can increase nutrient absorption and vegetative growth. (leaves, stems, roots) and generative (flowers, fruit, seeds) growth of plants (Manullang et al., 2024). Fertilizer application depends on the ability of plants and soil to absorb nutrients based on their needs. Low levels of macronutrients, especially nitrogen, can inhibit plant growth. Farmers often use NPK fertilizer as the primary nutrient supplement to increase yields. However, applied doses often fall short of recommendations, affecting the growth and development of Bambara peanut plants.

Planting distance is a strategy in plant cultivation that aims to increase plant production by regulating plant population through determining optimal planting distance. The closer the planting distance, the greater the number of plants that can grow in an area, thus potentially increasing competition between individuals for light, water, and nutrients. Adjusting the planting distance appropriately can meet the needs of sunlight, water, and nutrients in plants. Planting density can influence the increase in production on the planting land. Proper planting distance can also support maintenance activities such as watering, fertilizing, and pest control.

Based on research (Rahmawati et al., 2016), planting spacings of 60 cm x 25 cm and 40 cm x 40 cm provided good growth and production in bambara bean plants. At a planting spacing of 60 cm x 25 cm, bambara beans had the highest number of leaves at 4 WAP (9.60), canopy width at 4 WAP (32.15), and the highest dry pod weight of2.04 tons/ha. Planting spacing of 40 x 40 cm produced the number of green pods of 3.6 and the highest seed weight of 1.29 tons/ha.

Based on research results (Gulo et al., 2020), the use of Mutiara NPK fertilizer at a dose of 300 kg/ha gives the best results. It can increase peanut growth and production of peanut plants, including plant height, number of main branches, inflorescence age, gynophore formation, empty pods, total pods/plant, pod weight per plot, and weight of 100 seeds. This study aims to determine the best NPK fertilizer dosage and planting distance for the growth and yield of Bambara peanut plants (*Vigna subterranea* L.).

2. Material and Methods

2.1. Time and Place

This research was conducted in March–June 2025 in the Agricultural Land of Mojoroto Petak Village, Pacet District, Mojokerto Regency, East Java. Geographically located at coordinates 7^0 38'52" S, 112^0 32' 23" 7.647778, 112.539722 with an average height of 500-700 meters above sea level, it has a temperature of 23^0 C – 31^0 C with rainfall of 1,500-3,000 mm per year.

2.2. Tools and materials

The tools used were a hoe, trowel, digital scale, meter, camera, sprayer, and alfaboard. Materials included Bambara bean seeds, manure, NPK Mutiara 16-16-16 fertilizer, Dithane M-45, Deltamethrin, and Furadan 3GR.

2.3. Research methods

This experiment used a factorial design based on the Randomized Block Design (RAK) method with two treatment factors. The data were analyzed using Analysis of Variance (ANOVA), and if a significant effect was found, the HSD (Honestly Significant Difference) test was performed at the 5% level. Data were analyzed using SPSS or Microsoft Excel. The first treatment factor was the NPK fertilizer dose consisting of five levels, and the second factor was the planting distance consisting of three levels. The first factor was the NPK fertilizer dose with 5 levels (200kg/ha, 300kg/ha, 400kg/ha, 500kg/ha, 600kg/ha). The second factor was the planting distance with 3 levels (40 x 20 cm, 40 x 30 cm, 40 x 40 cm). Based on the two experimental treatment factors, 15 treatment combinations were obtained; each treatment was repeated 3 times, resulting in 45 experimental units. The planting pattern was carried out by making a planting distance of J1 = 40 x 20 cm with a population of 35 plants, J2 = 40 x 30 cm with a population of 25 plants, and J3 = 40 x 40 cm with a population of 15 plants. Each plot contains 3 sample plants selected randomly using the random sampling method so that the total sample observed was 135 plants.

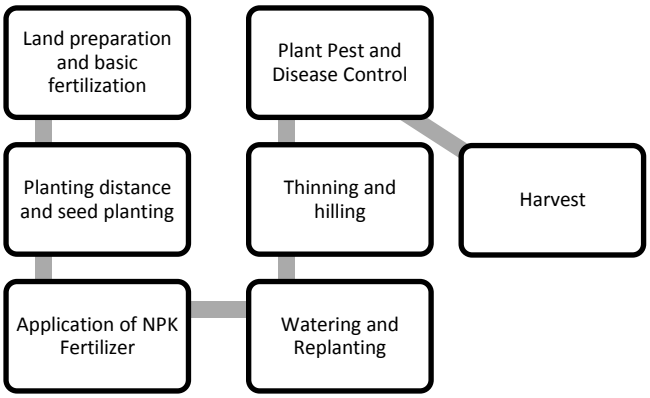


Figure 1. Research flow diagram

2.4. Observation Parameters

2.4.1. Plant Height (cm)

Observations of plant height were measured from the base of the stem to the longest part of the plant upwards using a meter. Plant height is measured when it is 2 MST - 9 MST old.

2.4.2. Number of leaves (stalks)

The number of leaves on a Bambara peanut plant is calculated by counting the fully opened trifoliate leaves. Each stalk has compound leaves consisting of three leaves. Observations on the number of leaves were carried out when the plants were 2 MST - 9 MST old.

2.4.3. Number of Flowers (buds)

Bambara bean flowers were carried out by counting the flowers that had bloomed on each plant sample and observing them every 3 days.

2.4.4. Number of Gynophores (strands)

Observations on the number of gynophores were conducted by counting the number of gynophores formed on each sample plant. The length of the gynophores recorded was approximately 3 cm.

2.4.5. Number of Pods Per Plant (pods)

This observation was conducted after harvesting the plants. Data were collected by counting all pods formed per plant, including both full and empty pods.

2.4.6. Wet Weight and Dry Weight of Pods Per Plant (g)

Observations of the wet and dry weight of pods per plant were carried out when the bambara bean plants had been harvested. Data were collected by separating the pods from the plants and then weighing the pods using a scale and recording the weight in grams (g). Observations of dry weight per plant were made after drying the bambara beans in the sun for 3 days.

3. Results and Discussion

3.1. Plant Height

The results of the analysis of variance showed that the combination of NPK fertilizer doses and planting distance had a very significant effect on the height of bambara bean plant height at 7, 8, and 9 WAP. The single factor of NPK fertilizer dose treatment had a significant effect at the age of 5-9 WAP, but had no significant effect at 2, 3, and 4 WAP, while the planting distance treatment had an effect at 7-9 WAP, but had no significant effect at 2-6 WAP. The average results of plant height on the combination of NPK fertilizer doses and planting distance on the parameters of bambara bean plant height are presented in Table 1. Table 2 presents the average results of plant height under single factors are presented in Table 2.

Table 1 Average Height of Bambara Bean Plants in the Combination Treatment of NPK Fertilizer Doses and Planting Distances at 7 WAP-9 WAP

Age (MST)	Planting Distance	Plant Height (cm)				
		NPK Fertilizer Dosage (kg/ha)				
		200	300	400	500	600
7	40 x 20 cm	29.89 ± 0.19 a	33.56 ± 0.20 b	33.06 ± 0.42 b	33.22 ± 0.39 b	33.37 ± 0.06 b
	40 x 30 cm	30.78 ± 0.39 a	33.17 ± 1.04 b	33.78 ± 0.69 b	32.78 ± 0.51 b	33.33 ± 0.34 b
	40 x 40 cm	32.94 ± 0.59 b	33.28 ± 0.86 b	33.28 ± 0.25 b	32.89 ± 0.51 b	33.36 ± 0.38 b
BNJ 5%				**1.40**		
8	40 x 20 cm	30.56 ± 0.29 a	34.78 ± 0.35 c	34.89 ± 0.10 c	34.78 ± 0.29 c	34.83 ± 0.17 c
	40 x 30 cm	32.44 ± 0.29 b	34.56 ± 0.22 c	35.33 ± 0.33 c	34.33 ± 0.19 c	34.78 ± 0.20 c
	40 x 40 cm	34.78 ± 0.19 c	34.58 ± 0.37 c	34.56 ± 0.22 c	34.94 ± 0.44 c	35.11 ± 0.20 c
BNJ 5%				**1.29**		
9	40 x 20 cm	30.78 ± 0.48 a	35.44 ± 0.11 bc	35.00 ± 0.19 bc	35.16 ± 0.16 bc	35.06 ± 0.05 bc
	40 x 30 cm	34.06 ± 0.34 b	34.76 ± 0.27 bc	36.11 ± 0.11 c	35.29 ± 0.35 bc	35.09 ± 0.31 bc
	40 x 40 cm	34.72 ± 0.20 bc	35.57 ± 0.32 c	35.09 ± 0.39 bc	35.44 ± 0.11 bc	35.39 ± 0.15 bc
BNJ 5%				**1.44**		

Description: The average number followed by the same letter in the combination treatment shows no significant difference in the 5% BNJ test; MST: Weeks After Planting

Table 1. shows that the highest average plant height results in the combination of 400kg/ha NPK fertilizer dose and 40 x 30 cm spacing at the age of 7 WAP amounted to 33.78 cm, 35.33 cm at the age of 8 WAP and 36.11 cm at 9 WAP which is significantly different from the 200kg/ha NPK fertilizer dose with a spacing of 40 x 20 and 40 x 30 cm. The lowest average plant height is found in the combination treatment of 200kg/ha NPK fertilizer with a spacing of 40 x 20 cm, namely at the age of 7 WAP, which amounted to 29.89 cm, at the age of 8 WAP amounted to 30.56 cm, and at the age of 9 WAP amounted to 30.78 cm. The 200kg/ha NPK dose with a spacing of 40 x 20 cm at

the age of 7 WAP is not significantly different from the combination of 200kg/ha NPK fertilizer and a spacing of 40 x 30 cm. NPK fertilizers contain essential nutrients such as nitrogen (N), phosphorus (P), and potassium (K), which play a vital role in supporting growth, particularly stem and leaf formation. Nitrogen stimulates plant growth, while phosphorus and potassium enhance root development and plant resilience. These results are consistent with research (Rozak, 2020) that found that planting distance affects plant height. The best results were achieved with a planting distance of 40 x 30 cm, with a height of 77.40 cm. Meanwhile, research (Naibaho et al., 2024) found that applying 400 kg/ha of NPK increased plant heights of 8.38 cm, 19.59 cm, 35.41 cm, and 50.33 cm at 2-8 weeks after planting. Optimal planting distance and proper plant population management ensure Plants get enough space to grow, avoiding excessive competition for nutrients, water, and sunlight. This result is in accordance with the statement (Hanafi et al., 2023) that balanced NPK fertilizer will play a role in the vegetative and generative growth of plants, while planting distance will affect plant roots in obtaining nutrients and minimize competition in obtaining energy.

Table 2. Average Height of Bambara Bean Plants in NPK Fertilizer Dose and Planting Distance Treatments

Treatment	Plant Height (cm)				
	2 MST	3 MST	4 MST	5 MST	6 MST
NPK fertilizer					
200 kg/ha	15.26 ± 0.14	20.59 ± 0.25	23.49 ± 0.20	27.07 ± 0.20 a	29.06 ± 0.25 a
300 kg/ha	14.81 ± 0.25	20.69 ± 0.37	23.63 ± 0.32	27.80 ± 0.16 b	30.37 ± 0.30 b
400 kg/ha	15.30 ± 0.33	21.79 ± 0.55	23.70 ± 0.34	28.1 0 ± 0.15 b	30.49 ± 0.32 b
500 kg/ha	14.82 ± 0.31	21.15 ± 0.33	23.93 ± 0.21	28.06 ± 0.11 b	30.37 ± 0.31 b
600 kg/ha	15.02 ± 0.16	20.76 ± 0.36	23.94 ± 0.26	27.89 ± 0.11 b	30.39 ± 0.34 b
BNJ 5%	**tn.**	**tn.**	**tn.**	**0.30**	**0.21**
Planting Distance					
40 x 20 cm	15.24 ± 0.14	21.20 ± 0.25	23.93 ± 0.18	27.76 ± 0.20	30.01 ± 0.30
40 x 30 cm	14.75 ± 0.21	20.31 ± 0.22	23.33 ± 0.14	27.84 ± 0.13	29.97 ± 0.21
40 x 40 cm	15.14 ± 0.12	21.47 ± 0.42	23.95 ± 0.21	27.71 ± 0.18	30.26 ± 0.30
BNJ 5%	**tn.**	**tn.**	**tn.**	**tn.**	**tn.**

Description: The average number followed by the same letter in each treatment shows no significant difference in the 5% BNJ test; MST: Weeks After Planting; tn: not significantly different

Table 2 shows that the single factor of NPK fertilizer administration did not differ significantly at the age of 2, 3, and 4 MST; however, it differed significantly at 5 and 6 MST. The highest average at 5 and 6 MST was obtained from the administration of NPK doses. 400kg/ha with values of 28.10 cm and 30.49 cm, respectively, which were not significantly different with all NPK doses except the 200kg/ha dose. The lowest average yield at 5 and 6 WAP was found at the 200kg/ha NPK dose with values of 27.07 cm and 29.06 cm, respectively. The single factor of plant spacing treatment was not significantly different in observations of 2, 3, 4, 5, and 6 WAP.

A dose of 400 kg/ha of NPK is thought to increase growth. During this phase, plants have a more developed root system, allowing them to absorb nutrients more effectively. Plants begin to prepare for the generative phase, so the response to nutrients, especially P and K, is more visible in plant height growth. Applying a low dose of 200 kg/ha results in nutrients being completely absorbed or leached, so it has no impact on plant growth. This yield is in accordance with the opinion (Pulungan et al., 2018) that insufficient NPK doses can cause nutrient deficiencies that negatively impact plant growth variables.

Planting distances of 40 x 20 cm, 40 x 30 cm, and 40 x 40 cm had no significant effect on plant height at 2-6 weeks after planting. This is consistent with research (Nono & Ceunfin, 2019). Variations in planting distance did not significantly affect plant height; a distance of 40 x 20 cm was 31.96 cm, 40 x 30 cm was 29.20 cm, and 40 x 40 cm was 29.28 cm. According to Zamriyetti et al. (2023), a planting distance of 30 x 40 cm produced the highest plant height (45.20 cm) compared to other planting distances because, at that distance, the plants did not experience significant competition during the growth period. Plant density in that range did not reach the critical point of competition that can suppress or stimulate stem elongation. In accordance with the opinion of Poorter (2002), the availability of adequate growing space encourages greater carbon allocation to stem growth, which directly affects the increase in plant height.

3.2. Number of Leaves

The results of the analysis of variance showed that the combination of NPK fertilizer dosage and planting distance had no significant effect on the number of leaves of the bambara bean. The single factor of NPK fertilizer dosage application had no significant effect at the age of 2-9 WAP, while the single factor of planting distance had a significant effect on the number of leaves at the age of 2 and 4 WAP and had a very significant effect at the age of 5-9 WAP, but had no significant effect at 3 WAP. The results of the average number of leaves of the bambara bean in the treatment of NPK dosage and planting distance are presented in Table 3.

Table 3. Average Number of Bambara Bean Leaves in NPK Fertilizer Dose Treatments and Planting Distance

Treatment	Number of leaves (stalks)							
	2 MST	3 MST	4 MST	5 MST	6 MST	7 MST	8 MST	9 MST
NPK fertilizer								
200 kg/ha	2.85 ± 0.05	5.22 ± 0.14	7.44 ± 0.11	9.00 ± 0.20	11.04 ± 0.25	12.96 ± 0.26	15.96 ± 0.42	17.44 ± 0.58
300 kg/ha	2.81 ± 0.06	5.04 ± 0.25	6.89 ± 0.16	9.19 ± 0.16	11.04 ± 0.25	13.52 ± 0.30	16.33 ± 0.41	17.85 ± 0.43
400 kg/ha	3.26 ± 0.12	5.04 ± 0.25	7.11 ± 0.18	9.26 ± 0.15	10.96 ± 0.21	13.52 ± 0.30	16.52 ± 0.49	18.07 ± 0.54
500 kg/ha	3.11 ± 0.08	5.11 ± 0.33	7.11 ± 0.18	9.26 ± 0.15	11.04 ± 0.25	13.52 ± 0.30	16.70 ± 0.48	18.19 ± 0.50
600 kg/ha	2.89 ± 0.05	5.19 ± 0.36	7.48 ± 0.17	9.48 ± 0.11	11.04 ± 0.25	13.33 ± 0.25	16.52 ± 0.49	18.44 ± 0.42
BNJ 5%	**tn.**	**tn.**	**tn.**	**tn.**	**tn.**	**tn.**	**tn.**	**tn.**
Planting Distance								
40 x 20 cm	2.84 ± 0.06 a	4.91 ± 0.14	6.98 ± 0.11 a	8.80 ± 0.20 a	10.31 ± 0.30 a	12.49 ± 0.19 a	15.18 ± 0.16 a	17.20 ± 0.32 a
40 x 30 cm	3.31 ± 0.04 b	5.18 ± 0.21	7.09 ± 0.10 a	9.11 ± 0.13 b	10.67 ± 0.20 b	13.31 ± 0.17 b	15.91 ± 0.25 b	17.36 ± 0.28 a
40 x 40 cm	3.36 ± 0.04 b	5.27 ± 0.12	7.56 ± 0.12 b	9.80 ± 0.18 c	12.09 ± 0.21 c	14.31 ± 0.21 c	18.13 ± 0.20 c	19.44 ± 0.24 b
BNJ 5%	**0.11**	**tn.**	**0.12**	**0.14**	**0.14**	**0.17**	**0.16**	**0.20**

Description: The average number followed by the same letter in each treatment shows no significant difference in the 5% BNJ test; MST: Weeks After Planting; tn: not significantly different

Table 3 showed that the single factor of NPK dose did not significantly differ in the number of leaves at any observation age. The single factor of planting distance did not differ significantly at 3 WAP; however, it significantly affected the number of leaves of bambara beans at the ages of 2, 4, 5, 6, 7, 8, and 9 WAP. The highest average number of leaves was obtained from the single factor of planting distance, namely at a planting distance of 40 x 40 cm, while the lowest average was at a planting distance of 40 x 20 cm. The planting distance of 40 x 40 cm produced the highest number of leaves compared with other planting distances, so it was significantly different from the other planting distances, but at the age of 2 WAP it was not significantly different from the planting distance of 40 x 30 cm. The number of leaves in bambara beans was not affected by NPK fertilizer because the allocation of photosynthates was more dominant in the growth of plant height due to light competition. The number of leaves was influenced by other factors such as light availability, genetics, and growth hormones, so that it had less influence on the fertilizer dose. This is in accordance with the research of Djafar et al. (2023), where a wide planting distance of 40 x 30 cm produced a higher average number of leaves of 62.48 at 4 MST compared to a close planting distance of 30 x 20 cm of 67.14 leaves, indicating that a wide planting distance provides more optimal growing space for leaf development. (2025) stated that, apart from the availability of external nutrients, the characteristics of the number of leaves in bambara beans are more influenced by intrinsic plant factors.

3.3. Amount of Interest

The results of the analysis of variance showed that the combination of NPK fertilizer dosage and planting distance had a very significant effect on the number of flowers. The treatment of NPK fertilizer dosage and planting distance alone also had a very significant effect on the number of flowers in the bambara bean plant. The average number of flowers in the bambara bean plant in the combination of NPK fertilizer dosage and planting distance is presented in Table 4.

Table 4. shows that the combination treatment of NPK fertilizer doses and planting distances produced the highest average number of flowers in the combination treatment of NPK doses of 400gr/ha with a planting distance of 40 x 30 cm of 89.39 flowers, almost all doses and planting distance treatments were not significantly different except for the NPK dose of 200kg/ha with a planting distance of 40 x 20 cm. The lowest average number of bambara bean flowers was 59.50 flowers in the combination treatment of NPK doses of 200kg/ha with a planting distance of 40 x 20 cm. Research by Rajeshkumar et al. (2017) stated that a spacing of 40 x 30 cm produced a yield of 69 flowers per plant, which was much higher in terms of branching and root nodules than close spacing, which is the main foundation for the supply of acidity for flower formation. Research by Supandji et al. (2020) stated that a dose of 250 kg/ha produced the highest number of flowers, namely 96.33

flowers. This shows that each type of legume plant has different nutrient requirements. The phosphorus (P) in Mutiara NPK fertilizer promotes plant growth and development, including flower formation. This is supported by the statement (Eri & Edy, 2023) that available phosphorus will produce more flowers because P promotes cell division, root development, accelerates growth, accelerates flower emergence, and promotes fruiting and ripening.

Table 4. Average Number of Flowers Per Bambara Bean Plant in Combination Treatment of NPK Fertilizer Dosage and Planting Distance

Planting Distance	Number of Flowers (flowers)				
	NPK Fertilizer Dosage (kg/ha)				
	200	300	400	500	600
40 x 20 cm	59.50 ± 5.69 a	64.22 ± 2.73 ab	75.00 ± 2.52 ab	71.78 ± 5.29 ab	72.89 ± 2.42 ab
40 x 30 cm	69.94 ± 1.79 ab	69.83 ± 1.01 ab	89.39 ± 3.66 b	78.67 ± 4.72 b	80.00 ± 3.38 b
40 x 40 cm	67.33 ± 3.10 ab	83.50 ± 3.31 b	70.50 ± 2.18 ab	71.17 ± 5.45 ab	76.22 ± 2.80 b
BNJ 5%			**15.57**		

Description: The average number followed by the same letter in the combination treatment shows no significant difference in the 5% BNJ test.

3.4. Number of Gynophores

The results of the analysis of variance showed that the combination of NPK fertilizer dose and planting distance had no significant effect on the number of gynophores. The treatment of NPK fertilizer dose and planting distance alone also had no significant effect on the number of gynophores in Bambara bean plants. The average number of gynophores in Bambara bean plants due to NPK fertilizer and planting distance is presented in Table 5.

Table 5. Average Number of Gynophores in Bambara Bean Plants at Dose Treatments NPK Fertilizer and Planting Distance

Treatment	Number of Gynophores (strands)
NPK fertilizer	
200 kg/ha	54.15 ± 2.79
300 kg/ha	57.96 ± 2.49
400 kg/ha	58.89 ± 2.03
500 kg/ha	56.41 ± 2.07
600 kg/ha	58.26 ± 1.75
BNJ 5%	**tn.**
Planting Distance	
40 x 20 cm	54.98 ± 2.02
40 x 30 cm	58.04 ± 1.42
40 x 40 cm	58.38 ± 1.58
BNJ 5%	**tn.**

Description: tn= not significantly different

Table 5 shows that the single factors of NPK fertilizer dose and planting distance did not significantly affect the average number of gynophores in Bambara bean plants. The highest average value of the single factor of NPK fertilizer was 58.89 at a dose of 400 kg/ha of 58.89, and the lowest was 54.15 at a dose of 200 kg/ha of 54.15 gynophores. The highest average value of the single factor of planting distance was obtained at a distance of 40 x 40 cm of 58.38, and the lowest average was at 40 x 20 cm of 54.98 gynophores.

This is thought to be influenced by internal factors such as genetics and the availability of growth hormones, as well as external factors such as suboptimal environmental conditions, which can hinder the effectiveness of NPK fertilizer in increasing the number of gynophores. The results of research by Naibaho et al. (2024) showed that the highest number of gynophores was produced at a dose of 400 kg/ha with an average of 60.55, which means that every increase in the dose of NPK fertilizer by 1 g per plot will increase the number of gynophores by around 0.1037 pieces. The results of research by Situmorang & Irshal (2024) showed that a planting distance of 40 x 25 cm gave the highest number of gynophores of 29.50 stalks. However, the treatment of planting distance had no significant effect on the number of gynophores in all observed parameters. Not all gynophores can penetrate into the soil because, according to the opinion of Adisarwanto (2003) *in*), the critical phase of legume plants occurs during the flowering and pod formation period. If plants are planted at the beginning of the rainy season, rainfall is often too much during the flowering phase, thus reducing the number of pods formed.

3.5. Number of Pods Per Plant

The results of the analysis of variance of the combination of NPK fertilizer dose and planting distance

did not significantly affect the number of pods per plant, as did the single factors of NPK fertilizer dose and planting distance. The average number of pods per Bambara bean plant in the NPK fertilizer and planting distance treatments is presented in Table 6.

Table 6. Average Number of Pods Per Plant in NPK Fertilizer Dose and Planting Distance Treatments

Treatment	Number of Pods Per Plant (pods)
NPK fertilizer	
200 kg/ha	47.78 ± 2.10
300 kg/ha	52.96 ± 3.35
400 kg/ha	51.07 ± 2.88
500 kg/ha	51.15 ± 2.92
600 kg/ha	5 5 .63 ± 3.82
BNJ 5%	**tn.**
Planting Distance	
40 x 20 cm	50, 40 ± 2.15
40 x 30 cm	51.78 ± 2.90
40 x 40 cm	52.98 ± 3.35
BNJ 5%	**tn.**

Description: tn= not significantly different

Table 6 shows that, for the single factors of NPK fertilizer dose and planting distance, the number of pods per plant did not differ significantly across treatments. This is likely due to environmental influences, as well as the NPK dose and planting distance used being sufficient for generative growth, so that even plants in the low treatment were still able to form a relatively similar number of pods. Additional nutrients increased pod filling, and flower pollination and gynophore formation influenced pod formation. However, gynophores that do not penetrate the soil do not increase the number of new pods. Research by Akpalu et al. (2012) showed that plant spacing did not significantly affect the number of pods per plant at 87 and 107 Days After Planting (DAP). However, at 67 DAP, a plant spacing of 50 x 20 cm (the highest density) produced 3399 pods per plant, which was higher than other treatments. Research by Wilis et al. (2022) showed that the dose of NPK fertilizer (200, 250, 300 kg/ha) had no significant effect on the number of full pods per clump, with an average number of pods obtained of 14.22-22.89 pods. This is in accordance with the opinion (Wirawan et al., 2018) that planting at the beginning of the rainy season often causes excessive rainfall during the flowering phase, which ultimately reduces pod formation, so it is suspected that the critical phase of legume plants is the pod formation period.

3.6. Wet Weight and Dry Weight Per Plant

The results of the analysis of variance of the combination of NPK fertilizer doses and planting distance have a real influence on the observed parameters of wet and dry pod weight per plant. The single factor of NPK fertilizer administration did not significantly affect the wet and dry weight of pods per plant. The single factor is planting distance. The average values of the wet and dry weight of pods per plant are presented in Table 7.

Table 7. Average Wet Weight and Dry Weight of Pods per Plant in Combination Treatment of NPK Fertilizer Dose and Planting Distance

Planting Distance	Fresh Weight of Pods Per Plant (grams)				
	NPK Fertilizer Dosage (kg/ha)				
	200	**300**	**400**	**500**	**600**
40 x 20 cm	151.22 ± 2.90 ab	149.33 ± 2.03 ab	147.22 ± 7.84 ab	149.67 ± 2.07 ab	149.56 ± 2.03 ab
40 x 30 cm	148.00 ± 3.84 ab	133.44 ± 2.90 ab	183.89 ± 32.28 b	174.33 ± 7.84 b	126.22 ± 2.00 a
40 x 40 cm	142.33 ± 18.00 ab	136.22 ± 11.93 ab	147.56 ± 7.85 ab	137.44 ± 11.05 ab	173.56 ± 3.84 b
BNJ 5%	**42.51**				
Planting Distance	**Dry Weight of Pods Per Plant (grams)**				
	NPK Fertilizer Dosage (kg/ha)				
	200	**300**	**400**	**500**	**600**
40 x 20 cm	122.44 ± 3.57 ab	118.44 ± 5.42 ab	113.56 ± 2.55 ab	122.67 ± 7.30 ab	118.67 ± 3.29 ab
40 x 30 cm	116.78 ± 3.90 ab	103.56 ± 4.77 ab	136.89 ± 15.07 b	131.00 ± 19.87 ab	98.56 ± 4.47 a
40 x 40 cm	107.44 ± 9.24 ab	107.78 ± 10.75 ab	117.44 ± 7.60 ab	109.44 ± 11.96 ab	133.22 ± 16.72 ab
BNJ 5%	**36.92**				

Description: The average number followed by the same letter in the combination treatment shows no significant difference in the 5% BNJ test.

Table 7 shows that the combination of NPK fertilizer doses and planting distances significantly differed in the

wet weight and dry weight of pods per plant.



Figure 2. Comparison of Plant Spacing Treatments

The highest average wet weight of pods per plant was in the combination of NPK fertilizer doses of 400kg/ha and a planting distance of 40 x 30 cm, with a wet weight of 183.89 grams, which was significantly different from the NPK dose of 600kg/ha and a planting distance of 40 x 30 cm, but not significantly different from other doses and planting distances. The highest average dry weight of pods per plant was in the combination of NPK fertilizer doses of 400kg/ha and a planting distance of 40 x 30 cm at 136.89 grams, which was significantly different from the NPK fertilizer dose of 600kg/ha and a planting distance of 40 x 30 cm, but not significantly different from other NPK doses and planting distances. The lowest yield was obtained from the combination of a 600 kg/ha NPK fertilizer dose and 40 x 30 cm spacing, with a wet weight of 126.22 grams per plant and a dry weight of 98.56 grams per plant. Research by Pamungkas et al. (2022) showed that an NPK fertilizer dose of 400 kg/ha produced optimal pod weight. The 400 kg/ha fertilizer dose produced the highest pod weight of 280.34 g, while the 200 kg/ha treatment produced the lowest pod weight of 184.24 g. Quantitatively, the difference between the 400 kg/ha and 200 kg/ha treatments reached 96.10 grams, or about 52.2% higher at the 400 kg/ha dose. Research by Chotechung & Ratchanuch (2024) on bambara beans with a 40 x 40 cm spacing produced the highest wet and dry pod yields, respectively, at 422 kg/ha and 123 kg/ha. This shows that NPK Mutiara fertilizer and planting distance are able to increase the fresh weight and dry weight of pods per plant through a mechanism involving the availability of balanced nutrients. This is in accordance with the opinion of (Oktavianti et al., 2017) that NPK Mutiara has a comprehensive content consisting of N, P, and K elements of 16% each; the dose given is sufficient and available to support plant growth and productivity. The planting distance of 40 x 30 cm is not too close and not too wide, so it is suspected that root development is more effective in increasing the plant's capacity to absorb nutrients from NPK fertilizer. In accordance with the opinion of (Jumiatun et al., 2023) that planting distance can increase the dry weight of pods per plant, because the higher fresh weight of pods per plant has a significant impact on the dry weight of plant pods.

4. Conclusion

This study showed that a combination of 400 kg/ha of NPK fertilizer with a planting distance of 40 x 30 cm increased the growth and yield of bambara peanuts, particularly in terms of height, number of flowers, and fresh and dry weight of pods per plant. Therefore, a planting distance of 40 x 30 cm and an NPK dose of 400 kg/ha are recommended for farmers growing local bambara peanut varieties.

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