



Growth Response And Yield Of Bambara Groundnut (*Vigna Subterranea (L.) Verdcourt*) To Nitrogen Fertilization

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Abstract. Bambara groundnuts are indeterminate legume plants that resist drought and less fertile land, so they have the potential for cultivation. The yield of bambara groundnut cultivated by farmers in Indonesia is still low. Nitrogen fertilizer is an important element for crop production, but the optimum dose of nitrogen for bambara groundnuts is not yet known. Therefore, this study aims to determine the optimum dose of N fertilization for optimal growth and yield of bambara groundnut plants. The research was conducted from July to October 2024 in Nanggela Village, Mandirancan District, Kuningan Regency. The experimental design used randomized block design (RBD) with six replications. The treatment was a dose of nitrogen fertilizer, namely 0, 100, 200, and 300% of the recommended dose. The 100% recommended dose is Urea 100 kg/ha, SP-36 150 kg/ha, and KCl 75 kg/ha. The experimental results showed that the application of N fertilizer gave results that had a real effect. This research can be used as a reference to determine the optimum dose of N fertilization in bambara groundnut cultivation, namely with a dose of Urea 100 kg/ha, SP-36 150 kg/ha, and KCl 75 kg/ha.

Keywords: response, Bambara groundnut, N fertilizer

INTRODUCTION

The Bambara groundnut is an underused legume native to the Sahel region of contemporary West Africa. Its name is derived from the Bambara tribe, which today resides in Mali (Mubaiwa et al., 2016). Bambara groundnut can serve as a significant supply of plant-based protein for the impoverished rural populations in sub-Saharan Africa who lack access to animal protein (Ho et al., 2017). Alake and Alake (2016) indicated that Bambara groundnut, in addition to protein, is rich in important minerals, including Zn, Mg, K, Fe, and Ca. They moreover affirmed that Bambara groundnut strains can be enhanced to create cultivars with elevated protein or mineral content. The consumption of Bambara groundnut provides numerous health advantages, including the reduction of type 2 diabetes (Becerra-Tomas et al., 2017), management of hypertension (Polak et al., 2015), regulation of weight and satiety (McCrory et al., 2010), and reduction of cholesterol levels (Bazzano et al., 2011).

The Bambara groundnut possesses the capability to endure adverse environmental and soil conditions. Bambara groundnut, as a legume, can assimilate atmospheric nitrogen to enhance soil fertility. Bambara groundnut presents a viable low-cost sustainable food alternative, particularly for individuals residing in arid and semi-arid areas. Bambara

groundnuts have drought resistance and can thrive in suboptimal soil conditions (Department of Agriculture, Forestry and Fishery Republic of South Africa, 2016). Halimi et al. (2019) assert that bambara groundnuts are legumes that remain underutilized. Bambara groundnuts possess the capacity to enhance food security and nutrition on both regional and global scales. Bambara nuts possess the capacity to generate revenue and sustenance in poor nations. Nonetheless, given the numerous potentials of the Bambara bean in enhancing and sustaining global food systems, it is crucial to acknowledge various factors that must be addressed in its cultivation, specifically: genetics, agroecology, nutrition, processing and utilization, and socioeconomic potential (Tan et al., 2020).

The main problem in bambara groundnut cultivation is its low yield. According to Massawe et al. (2005; Bachtiar et al., 2021), one of the efforts that can be made so that plants can produce optimally is by proper fertilization. According to Waugh et al. (1973; Lestari et al., 2015) to obtain preliminary data on fertilization recommendations, a shortcut can be taken through the multi nutrient response approach. The experiment was conducted by planting in N fertilization experiments using graded doses, so as to obtain N nutrient requirements at the threshold yield condition and also the maximum condition. Threshold yield refers to the starting point of the yield response due to no additional N. The multi nutrient response approach will produce fertilization recommendation options, which are based on maximum fertilization and the threshold fertilizer use. This study aims to determine the optimum dose of N fertilization for maximum growth and production of bambara groundnut plants as an effort to obtain preliminary data on fertilizer recommendations. The multi nutrient response approach was used as a method to determine the recommendation. Considering that bambara groundnut is a legume that can fix nitrogen by itself, this research also wants to prove whether the application of N fertilizer will affect the growth, yield, and quality of the bambara groundnut.

METHODS

The research was conducted in Nanggela, Mandirancan, Kuningan from July to October 2024. In this study the tools used included hoes, shovels, stakes, meters, ropes. While the materials used consisted of bambara groundnut seeds, manure, Urea fertilizer, SP-36, and KCl. The experimental design used was randomized block design (RBD) with six replications. The treatment was four fertilization doses, namely 0, 100, 200, and 300% of the nitrogen recommended dose. The 100% recommended dose is Urea 100 kg/ha referring

to Turmudi and Suprijono (2010; Lestari et al., 2015). Manure 10 ton/ha, SP-36 150 kg/ha, and KCl 75 kg/ha were applied as base fertilizer. The treatments tested in this experiment were as follow:

P0 : 0 kg urea/ha

P1 : 100 kg urea/ha

P2 : 200 kg urea/ha

P3 : 300 kg urea/ha

Fertilizers were only applied once at four weeks after planting (WAP). The experiment began with the preparation of experimental land, and treatment plots were made according to the predetermined design. Seeds germinated between 5-7 days after planting (DAP); after 7-15 DAP, the plants began to grow. Plant growth observations were made four times, at the age of 28, 42, 56, and 70 DAP. The parameters observed were plant height, number of leaves, root length, root volume, number of root nodules, plant dry weight, relative growth rate, net assimilation rates, and yield of bambara.

The area that was used in each plot was 2 m x 2 m. The application of goat manure was done 2 weeks before planting by spreading it in each plot. Bambara seed planting was done by digging the soil 5 cm deep, filled with two seeds per planting hole, and then applying 3% carbofuran. The planting distance used was 40 cm x 40 cm, according to the research of Rahmawati et al. (2016). Maintenance activities carried out include weed control and fertilization at 3, 5, 7, 9, 11, and 12 WAP. Bambara groundnut harvesting is done when the plants are 16 weeks old. Harvesting is characterized by yellowing leaves and stems and pods that have hardened and are white in color.

The collected data were subjected to variance analysis (F test at the 5% significance level); if the variance analysis indicated a significant treatment effect, subsequent tests were performed using the LSD tests at the 5% level.

DISCUSSION

Soil Analysis in Field Experiment

The results of the soil structure and nutrients analysis in the Nanggela, Mandirancan, Kuningan district are presented below (Table 1). The soil analysis indicated a low total nitrogen concentration, necessitating the use of nitrogen fertilizer. Concurrently, the soil pH was conducive for cultivating Bambara groundnut, which thrives at a pH range of 5.0-6.5.

Table 1. Results of soil analysis

Parameters	Results	Unit
pH H ₂ O	5.95	-
pH KCl	5.21	-
C-Organic	1.48	%
N-Total	0.16	%
P-Available	73.47	ppm
P-Potential	173.77	mg/100g
K-Potential	19.43	mg/100g

Response of Plant Growth to N fertilization

The analysis of variance indicated that nitrogen fertilizer significantly influenced the plant height of Bambara groundnut at 42-56 days after planting (Table 2). No significant difference was seen among treatments for plant height at 70 days after planting.

Table 2. Response of N fertilizer application on plant height (cm)

Treatment	28 DAP	42 DAP	56 DAP	70 DAP
0 kg N/ha	32.20 a	33.90 b	34.07 a	36.50 a
100 kg N/ha	30.47 a	30.97 a	32.60 a	33.97 a
200 kg N/ha	33.00 a	35.30 b	37.53 b	37.93 a
300 kg N/ha	33.27 a	35.57 b	37.07 b	36.59 a

Notes: The number followed by the same letter in the same column shows no significant differences based on the DMRT test at the 5% level.

The situation was influenced by the incorporation of manure into the soil before planting. Accordance the results of research by Kurnia et al. (2018) stated that applying goat manure to the soil can improve the soil's physical, chemical, and biological properties, which affect plant height. Applying inorganic fertilizers supplies essential nutrients to Bambara groundnut plants, with nitrogen being a crucial macronutrient for early growth (Rabani et al., 2015). The element nitrogen (urea) enhances plant height, accelerates photosynthesis, and stimulates root nodule development, hence increasing crop yield.

N fertilizer affected the leaf number at 28 and 70 DAP. At the end of observation (70 DAP), the control treatment (without N application) had a higher number of leaves than the other treatments (Table 3).

Table 3. Response of N fertilizer use to the leaf number of Bambara groundnut

Treatment	28 DAP	42 DAP	56 DAP	70 DAP
0 kg N/ha	8.90 b	15.07 a	24.77 a	45.67 b
100 kg N/ha	7.03 a	13.33 a	27.20 a	43.67 b
200 kg N/ha	8.00 b	15.30 a	23.93 a	32.93 a
300 kg N/ha	9.07 b	17.37 a	26.43 a	34.63 a

Notes: The number followed by the same letter in the same column shows no significant differences based on the DMRT test at the 5% level.

Leaf number also affects photosynthesis ability and determines the optimization of light absorption for photosynthesis. According to Yustiningsih (2019), sunlight is the main energy source of photosynthesis, and optimal light absorption can increase the rate of plant photosynthesis.

The variance analysis indicates that variations in the supply of N nutrients across treatment plots significantly influence root length at 28, 56, and 70 days after planting (DAP). Root development will occur in nutrient-rich soil. Soil fertility is contingent upon the application of manure. According to Julaieha (2017), manure fertilizer can enhance soil texture, rendering it more loose.

Table 4. Response of N fertilizer application to root length (cm)

Treatment	28 DAP	42 DAP	56 DAP	70 DAP
0 kg N/ha	22.00 b	18.83 a	23.50 b	26.17 a
100 kg N/ha	17.47 a	18.17 a	18.00 a	20.00 a
200 kg N/ha	16.98 a	22.17 a	28.50 c	27.50 a
300 kg N/ha	18.17 a	20.83 a	29.00 c	25.17 a

Notes: The number followed by the same letter in the same column shows no significant differences based on the DMRT test at the 5% level.

The variance analysis indicated that nitrogen fertilizer influenced the total leaf area of Bambara groundnut at 56 and 70 days after planting (DAP) (Table 5). Applying 100 kg N/ha resulted in a greater leaf area than the other treatments. The presence of a substantial effect arises from the leaf area, which influences photosynthetic capacity and dictates the optimization of light absorption for photosynthesis. According to Yustiningsih (2019),

sunlight is the primary energy source for photosynthesis, and effective light absorption enhances the rate of plant photosynthesis.

Table 5. Response of N fertilizer application to leaf area of bambara groundnut (cm²)

Treatment	28 DAP	42 DAP	56 DAP	70 DAP
0 kg N/ha	290.99 a	493.69 a	810.83 a	1494.12 a
100 kg N/ha	316.41 a	601.18 a	1229.48 b	1975.28 b
200 kg N/ha	302.06 a	557.68 a	902.40 a	1242.24 a
300 kg N/ha	215.46 a	411.98 a	625.06 a	819.20 a

Notes: The number followed by the same letter in the same column shows no significant differences based on the DMRT test at the 5% level.

The treatment of N fertilizer significantly affects the dry weight of bran with a quadratic response pattern (Table 6). The quadratic increase shows that the addition of N fertilizer dose with a dose range of 0-300% has an optimum value at a point between these doses; after the optimum point, the stalk's dry weight will decrease. The average dry weight of stalks increased in plants with 100% N fertilizer dose, then decreased with 0, 200%, and 300% N fertilizer doses. Applying 100% N fertilizer dose showed the highest average dry weight of stalks. From the data above, the plants that received 100 kg/ha N fertilizer gave the highest response to the dry weight of the stalks, which was 13.02, and those that received 0 kg/ha N fertilizer gave the lowest response, which was 4.48.

Table 6. Response of N fertilizer use to dry weight of Bambara groundnut (g)

Treatment	28 DAP	42 DAP	56 DAP
0 kg N/ha	1.75 a	3.00 a	8.77 a
100 kg N/ha	2.07 a	3.48 a	9.22 a
200 kg N/ha	1.95 a	3.07 a	5.52 a
300 kg N/ha	1.63 a	2.85 a	7.42 a

Notes: The number that was followed with same letter in the same column show no significant differences based on the DMRT test at 5% level.

Relative Growth Rate

Tabel 7. Response of N fertilizer application to relative growth rate (g/g/day)

Treatment	28 - 42 DAP	42 - 56 DAP
0 kg N/ha	0.068 a	0.080 a
100 kg N/ha	0.075 a	0.072 a

200 kg N/ha	0.056 a	0.057 a
300 kg N/ha	0.065 a	0.084 a

Notes: The number that was followed with same letter in the same column show no significant differences based on the DMRT test at 5% level.

Relative Growth Rate (LPR) is the increase in plant dry weight over a time interval, closely related to the initial plant weight. The assumption used for the LPR quantitative equation is that the increase in plant biomass per unit time is not constant but depends on the initial weight of the plant. The relative growth rate test was conducted to assess the response of plant growth to the treatment given. From the calculations carried out, the results of the relative growth rate in the time span 28-56 DAP obtained positive results. This shows that plant growth continues to increase in the 28-56 DAP timeframe.

Yield of Bambara Groundnut

The results of observations of production variables show that the application of N fertilizer has a significant effect on the number of pods per plant (Table 8), pod weight per plant, total pod weight, and 100 seed weight (Table 11). This proves that the application of N fertilizer does not determine the total number of pods, the number of pods per plant, and the weight of 100 dry seeds. From the use of N fertilizer (0 kg/ha), the average weight of 100 dry seeds is 201.83 grams, when compared to the results of research by Adhi and Wahyudi (2017), which resulted in an average weight of 100 seeds of 76.10 grams, this study shows that without dosing N fertilizer gives statistically significantly different results.

Table 8. Response of N application to a number of pods in Bambara groundnut.

Treatment	Number of pods per plant (grains)
0 kg N/ha	14.87 b
100 kg N/ha	17.47 b
200 kg N/ha	7.48 a
300 kg N/ha	12.03 a

Notes: The number followed by the same letter in the same column shows no significant differences based on the DMRT test at the 5% level.

From the data above, plants that received 100 kg/ha N fertilization gave the highest response to the number of pods, 17.47 grains, and those that received 200 kg/ha N fertilization gave the lowest response, 7.48 grains.

Table 9. The response of N fertilizer application on the weight of Bambara groundnut production

Treatment	Pod weight plots (g)	Pod weight per plant (g)	100 seed weight (g)
0 kg N/ha	1181.67 b	47.27 b	201.83 b
100 kg N/ha	1118.00 b	44.72 b	200.50 b
200 kg N/ha	545.00 a	21.80 a	165.00 a
300 kg N/ha	757.83 a	30.31 a	162.00 a

Notes: The number that was followed with same letter in the same column show no significant differences based on the DMRT test at 5% level.

From the data above, plants that get 0 kg/ha N fertilization give the highest response to the weight of bambara groundnut production, namely pod weight per plot 1181.67 grams, pod weight per plant 47.27 grams, 100 seed weight 201 grams and those that get 200 kg/ha N fertilization give the lowest response, namely pod weight per plot 545.00 grams, pod weight per plant 21.80 grams, 100 seed weight 165.00 grams.

Bambara groundnuts are harvested after some of the plant leaves have started to brown (between the ages of 115-120 DAP). In accordance with the journal Ramadhani Kurnia and Soleh Wahyudi (2018) bambara groundnut can be harvested if the plant already has the characteristics of plant leaves that have begun to brown and pods already look filled and brownish seeds. Plant results can be seen in (table 10) and (table 11). The results of the number of pods per plant ranging from 7.48 - 17.46, pod weight per plot ranging from 545.00 - 1181.67, pod weight per plant ranging from 21.80 - 47.27, 100 seed weight. Ranging from 162.00 - 201, 83. From the data above, plants that received 0 kg/ha N fertilization gave the highest response to plant growth and bambara groundnut production with an average; pods per plant 14.87 grains, pod weight per plant 47.27 grams, pod weight per plot 1181 grams, and 100 seed weight 201.83 grams and those that get N fertilization 200 kg/ha give the lowest response to plant growth and production of bambara groundnut with an average of; pods per plant 7.48 grains, pod weight per plant 21.80 grams, pod weight per plot 545.00 grams, and 100 seed weight 162.00 grams. From the results of the data above, bambara groundnuts have the potential to be developed as an alternative to carbohydrate substitutes.

Recommendation for N fertilization on bambara groundnut plants

Based on the observation data and the results of the variance test which was further tested using the LSD and HSD tests, plants that received 0 kg/ha N fertilization gave an optimal response to plant growth and production of bambara groundnut with an average of 14.87 pods per plant, pod weight per plant 47.27 grams, pod weight per plot 1181 gram, and 100 seed weight 201.83 grams. The observation data above shows that the production of bambara groundnuts is not determined by the amount of nitrogen fertilizer used. This is because bambara groundnuts have root nodules that can bind free N from the air in accordance with the expression conveyed by Hanafiah, A, K (2014). Rhizobium can absorb free nitrogen from the environment that the soil can utilize. plants. As a recommendation, 100 kg/ha of urea fertilizer should spur early plant growth and promote the formation of rhizobium/root nodules.

CONCLUSIONS

Based on the study results conducted to determine the dose of N fertilizer that responds to growth and yield, plants that received 0 kg/ha N fertilizer treatment gave the best response compared to those that received fertilization in other amounts. Regarding production, the results obtained from plants that used 0 kg/ha N fertilizer treatment were not significantly different from those of plants that received 100 kg/ha N fertilization. In fact, plants that received more than 100 kg/ha fertilization gave much lower production results. This proves that N fertilization in bambara bean plants affects growth and yield. Bambara bean plants are legumes that can fix nitrogen by themselves.

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