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Response of Bambara Groundnut (*Vigna subterranea* (L.) Verdcourt) Growth and Yield to Potassium Fertilizer Dosage

Muhamad Ilhan[1], **Devi Nandira Khoeriyah**[2], **Wijaya**[3*]
[1]Universitas Swadaya Gunung Jati, Cirebon, Indonesia, muhamad.ilhan07@gmail.com
[2]Universitas Swadaya Gunung Jati, Cirebon, Indonesia, devinandira3@gmail.com
[3]Universitas Swadaya Gunung Jati, Cirebon, Indonesia, wijaya6104@gmail.com
***Corresponding Author** : wijaya6104@gmail.com

Abstract.
Bambara Groundnut (*Vigna subterranea* (L.) Verdcourt) is an indigenous legume with considerable potential to strengthen food security issues. This research focuses on examining the influence of potassium fertilizer on bambara groundnut. The experiment was carried out in Kaliaren, Kuningan, from April to August 2025, using a Randomized Block Design (RBD) consisting of six potassium fertilizer doses and four replications. Observed variables included the growth and yield parameters, and the data were analyzed through Analysis of Variance (ANOVA) and Duncan's multiple range test (DMRT). Application of potassium fertilizer resulted in significant changes in growth and yield indicators, including plant height, number of leaves and petioles, leaf area index, root volume, fresh and dry biomass, number of pods, fresh and dry pods weight, weight of 100 seed, and plant potassium uptake. Among the tested levels, the application of 75 kg/ha of potassium fertilizer produced the highest growth and yield performance. These findings highlight the essential role of potassium in enhancing vegetative development and productivity of bambara groundnut, and demonstrate that optimum nutrient management can improve the potential of this crop as a contributor to future food security strategies.

Keywords: Growth, Yield, Potassium, Bambara groundnut.

INTRODUCTION

Bambara groundnut (*Vigna subterranea* (L.) Verdcourt) or bambara beans are local crops that have the potential to be a solution for food security. According to DAFF (2016), these beans originate from West Africa. According to Alake & Alake (2016), in addition to being high in protein, bambara groundnut are also rich in other minerals such as Mg, K, Zn, Fe, and Ca. Adhi & Wahyudi (2018) state that 100 grams of bambara groundnut contain

6.3% fiber, 6.6% fat, 20.6% protein, and 56.61% carbohydrates, making bambara groundnut a recommended alternative food for good health.

The low production of bambara groundnut is the main obstacle in their cultivation. Efforts to optimize bambara groundnut production include proper fertilization. Potassium is one of the nutrients that affects the quality and quanity of legume production because it plays a role in helping the process of photosynthesis, acting as a catalyst in the process of protein synthesis, regulating the availability of other nutrients for plants, stimulating growth and increasing crop production. A deficiency in potassium will inhibit growth (Lestari et al. (2017) *as cited in* Ilmam & Guritno, 2023). Excessive potassium also inhibits the formation of new roots and root elongation, thereby hindering the absorption of nutrients for plant growth (Rogomulyo (2014) *as cited in* Ridwan & Hanifa, 2016). Therefore, research is needed on the appropriate dosage of potassium nutrients for bambara groundnut.

LITERATURE

Nutrients are part of the fertility element absorbed by plants through the soil, which are related to their availability and quantity for plant growth (Munawar, 2018). Plants need nutrients for their physiological processes, growth, and development. Nutrient deficiencies can reduce the growth rate and production of a plant. Another essential ingredient for plants is potassium, which strengthens the plant's body to prevent leaves, blossoms, and fruits from falling off easily and aids in the synthesis of proteins and carbohydrates (Purba et al., 2021). In addition, potassium can increase resistance to environmental stress, activate enzymes, regulate water balance in cells, control stomatal opening for photosynthesis, and support stem growth, root development, and protein formation (Wang et al., 2015). This nutrient is absorbed in large quantities by plants in the form of K^+ ions (Musa et al., 2024). According to Nieves-Cordones et al. (2014), the absorption of potassium in crops is facilitated by transport system. These system are situated on the plasma membranes of both epidermal and cortical cells within the plant's roots.

Recommendations for KCl (K) fertilization for bambara groundnut vary, according to research by Turmudi & Suprijono (2010), recommends a potassium (KCl) fertilization of 75 kg/ha. Then Lestari et al. (2015) stated that potassium fertilization using KCl at doses of 86.4 – 118.95 kg KCl/ha can increase the fresh weight of roots, dry weight of pods at harvest, and N content of seeds. According to Akombo & Asema (2013), the recommended rate of K_2O fertilizer is 50 kg/ha (equivalent to 83 kg/ha of KCl fertilizer) affects plant height, pod weight, and number of leaves. Meanwhile, applying a potassium (K_2O) fertilizer rate at 75 kg/ha (equivalent to 125 kg/ha of KCl fertilizer) for peanuts tends to result in better growth and dry seed yield (Yusuf et al., 2024). The treatment of KCl fertilizer at 75 kg/ha led to the greatest pod weight per plant (Margenda et al., 2020).

METHOD

This research took place in Kaliaren, Kuningan, between April and August 2025, on soil with a pH value of 6.2 and a potassium concentration of 16 mg/100g. The equipment use in this research were hoes, shovels, measuring tapes, ropes, buckets, scales, writing instruments, name tags, bamboo, measuring cups, and an oven. Materials included bambara groundnut seeds, Decis pesticide, and various fertilizers including urea, SP-36, and KCl.

This research employed an experimental approach using a Randomized Block Design (RBD) with a single treatment factor. Six doses of potassium fertilizer were tested, namely 0, 25, 50, 75, 100, and 125 kg/ha, each treatment was applied with four replications, producing a total of 24 experimental units. The experiment was conducted on a 120 cm x 140 cm plot of land that was adjusted for the needs of the research. Turmudi & Suprijono (2010) recommended fertilizing bambara groundnut with an application rate of 100 kg of urea/ha combined with 150 kg of SP-36/ha.

Growth observations were conducted three times, namely at 28, 42, and 56 day after planting (DAP), covering plant height, number of petioles and leaves, Leaf Area Index (LAI), root volume, fresh and dry weight of biomass, Relative Growth Rate (RGR), and Net Assimilation Rate (NAR). Yield observations were conducted at 120 Days After Planting (DAP), this covered the number of pods, fresh and dry weight of pods, weight of 100 seed, and plant potassium uptake. The observation data were analyzed using Analysis of Variance (ANOVA) and followed by a DMRT test. These tests were conducted at a 5% significance level.

DISCUSSION

Plant Height

One of the increase additives frequently located in research is the plant height variable. The outcomes of the variance evaluation indicated that the potassium fertilizer dose remedy had a greatest impact on plant height at 42 DAP and 56 DAP. Moreover, the outcomes of the Duncan’s check at the common plant height between remedies are supplied in Table 1.

Table 1 indicates that a potassium fertilizer rate of 75 kg/ha produced the highest bambara groundnut plant height. Conversely, without potassium fertilizer or at the lowest and highest rates, plant height was lower. The results imply that an application rate of 75 kg/ha is optimal, while a deficiency or an excess of nutrients can inhibit plant growth.

These findings correspond to the study of Wahyudi et al. (2021), who said that applying KCl fertilizer has significantly affects plant height, flowering time, harvest time, and the quantity of mung bean pods. Plants will grow optimally if their nutrient requirements are met, and the provision of nutrients is a way to fulfill this (Iskandar (2003) *as cited in* Wahyudi et al., 2021). In addition, according to Armstrong (1987) *as cited in* Alfy (2022), legumes are in great need of potassium because this element is important in symbiosis with rhizobium bacteria to bind nitrogen from the air, which is beneficial for soil fertility and plant growth.

Table 1. Results of Plant Height and Number of Petioles in Response to Potassium Fertilizer

Treatment	Plant Height (cm)			Number of Petioles (pieces)		
	28 DAP	42 DAP	56 DAP	28 DAP	42 DAP	56 DAP
k_0 (0 kg/ha)	18.34 a	20.59 a	21.75 a	12.50 a	27.06 a	60.81 a
k_1 (25 kg/ha)	18.53 a	21.06 ab	22.50 a	12.83 ab	28.94 b	62.63 a
k_2 (50 kg/ha)	18.74 a	21.53 b	23.38 b	13.64 d	30.75 b	67.00 b
k_3 (75 kg/ha)	20.06 b	22.88 c	25.63 c	14.06 e	34.38 c	72.25 c
k_4 (100 kg/ha)	18.42 a	21.13 ab	24.50 b	13.50 cd	29.25 b	70.50 bc
k_5 (125 kg/ha)	18.41 a	20.88 ab	23.75 b	13.13 bc	29.00 b	67.25 b

Note : According to Duncan's test ($p < 0.05$), common letters following numbers in the column indicate no significant difference between the corresponding numbers.

Number of Petioles

The variance analysis suggests that variations in potassium fertilizer levels lead to notable disparities in the number of petioles observed at 28 DAP, 42 DAP, and 56 DAP. The outcome of Duncan's multiple range test regarding the mean number of petioles across treatments are illustrated in Table 1.

Table 1 demonstrates that the number of petioles maintains to growth with plant age. During the early vegetative stage, supplying potassium up to an optimal dose can trigger the development of additional petioles, especially at a dose of 75 kg/ha. Optimal potassium application can support more efficient cell division and cell enlargement, resulting in more and stronger petioles. This can be attributed to potassium, which is the most important inorganic nutrient in forming the osmotic power of a cell, which in turn affects cell enlargement and plant growth (Dulon et al. (1988) *as cited in* Sholeh et al., 2016).

Number of Leaves

The variance analysis confirmed that variations in potassium fertilization had a substantial impact on leaf production at 28 DAP, 42 DAP, and 56 DAP. The outcomes of Duncan's test on the common number of leaves among treatments are offered in Table 2.

Table 2 shows the number of leaves increased from the first observation to 56 DAP, increasing beyond the vegetative stage because bambara groundnut plants have an indeterminate growth pattern, meaning that vegetative growth continues after flowering and during pod formation. The control treatment (k_0) had relatively fewer than the number of leaves in plants given potassium fertilizer. This is thought to be because plants in the treatment without potassium fertilizer experienced a potassium deficiency, resulting in relatively fewer leaves.

The average number of leaves indicates that potassium is very much needed and may be a limiting factor in vegetative phase of crop growth, leading to fewer leaves on bambara groundnut. According to Soegiman (2003) *as cited in* Sugianto et al. (2022), the leaves of plants suffering from potassium deficiency have dry, brownish-yellow edges and irregular chlorotic spots around the leaf margins.

The greatest number of leaves was found in plants given 75 kg/ha of potassium fertilizer. An increase in both plant height and the number of petioles supports this result. According to Rosmiati et al. (2016), a plant's leaf count can rise when nutrient requirements are met, thereby increasing metabolism and hormonal activity for leaf formation.

Table 2. Results of Leaf Number and Leaf Area Index in Response to Potassium Fertilizer

Treatment	Number of Leaves (trifoliate)						Leaf Area Index (cm^2)					
	28 DAP		42 DAP		56 DAP		28 DAP		42 DAP		56 DAP	
k_0 (0 kg/ha)	8.85	a	24.50	a	45.75	a	0.1018	a	0.2981	a	0.8227	a
k_1 (25 kg/ha)	9.54	b	24.75	a	46.58	b	0.1182	b	0.3942	b	1.1846	b
k_2 (50 kg/ha)	9.92	b	26.44	bc	47.83	cd	0.1427	c	0.4089	b	1.7457	c
k_3 (75 kg/ha)	11.10	c	27.17	c	48.50	d	0.1879	d	0.5948	d	2.1218	d
k_4 (100 kg/ha)	10.17	b	26.00	b	47.58	c	0.1446	c	0.5083	c	1.5037	c
k_5 (125 kg/ha)	9.73	b	25.94	b	46.50	ab	0.0988	a	0.2974	a	0.9361	ab

Note : According to Duncan's test ($p < 0.05$), common letters following numbers in the column indicate no significant difference between the corresponding numbers.

Leaf Area Index

The variance analysis confirmed that the potassium fertilizer dose had a significant effect on the leaf area index at 28 DAP, 42 DAP, and 56 DAP. Table 2 illustrates the Duncan's test findings for the leaf area index means across treatments.

Table 2 shows that potassium fertilizer application plays an important role during the vegetative growth period for leaf area formation. The application of 75 kg/ha of potassium showed the highest leaf area index, whereas an excessively high potassium dose in k_5 showed the lowest leaf area index, possibly due to toxicity or nutritional imbalance. Applying fertilizer below or above the optimal dose can reduce its effectiveness, resulting in a decrease in the leaf area index value. According to Kelik (2010) *as cited in* Harahap et al. (2021), leaf area reflects the process and rate of plant photosynthesis. The larger the leaf area, the more light can be absorbed, thereby supporting the formation of photosynthates and influencing the increase in plant biomass.

According to Nuryani et al. (2019), the application of nutrients in an available form and balanced dosage can support good plant growth. Sitompul & Guritno (1995) *as cited in* Indra et al. (2019) stated that the larger the leaves and the more light converted into photosynthates, the greater the dry weight of the plant. Kania & Maghfoer (2018), add that the more and larger leaves, the greater the absorption of light and water by plants, so that photosynthesis occurs optimally and produces photosyntates as an energy source driving plant growth and improvement.

Root Volume

The variance analysis confirmed that the potassium fertilizer dose has a enormous effect on root volume at each observation period of 42 DAP and 56 DAP, while at 28 days after planting (DAP), it has no significant effect. The effect of Duncan's test on the common root volume between treatments are presented in Table 3.

Table 3 shows that at 42 DAP and 56 DAP, a potassium fertilizer dose of 75 kg/ha consistently produced the highest root volume. An optimal root system is very important in the absorption of water and nutrients to support overall plant growth. Conversely, a deficiency in the control treatment and an excessive dose of k_5 had a negative impact on root growth, as seen from the low root volume values.

Potassium deficiency can inhibit growth and reduce root number, thereby limiting water and nutrient uptake (Rohmawati (2013) *as cited in* Lestari et al., 2015). Chantal et al.

(2019) in their study stated that potassium is the main element that stimulates root growth and development. Optimally grown roots help plants absorb nutrients efficiently, supporting overall growth. Furthermore, Gardner et al. (1991) *as cited in* Harahap et al. (2021) also stated that root growth is in line with canopy growth, where an increase in root weight is followed by an increase in plant canopy.

Table 3. Results of Root Volume in Response to Potassium Fertilizer

Treatment	Root Volume (ml)					
	28 DAP		42 DAP		56 DAP	
k_0 (0 kg/ha)	2.25	a	3.13	a	5.38	a
k_1 (25 kg/ha)	2.38	a	3.38	ab	6.13	bc
k_2 (50 kg/ha)	2.63	a	3.75	c	6.25	c
k_3 (75 kg/ha)	2.88	a	4.13	d	6.75	d
k_4 (100 kg/ha)	2.50	a	3.75	c	6.25	c
k_5 (125 kg/ha)	2.38	a	3.50	bc	5.88	b

Note : According to Duncan's test ($p < 0.05$), common letters following numbers in the column indicate no significant difference between the corresponding numbers.

Fresh Biomass Weight and Dry Biomass Weight

The effect of the analysis of variance confirmed that different potassium fertilizer treatments produced significantly different fresh and dry biomass weights at 28, 42, and 56 day after planting. Table 4 presents Duncan's test compared the mean fresh and dry biomass weight among treatment.

Table 4. Results of Fresh Biomass Weight and Dry Biomass Weight in Response to Potassium Fertilizer

Treatment	Fresh Biomass Weight (g)						Dry Biomass Weight (g)					
	28 DAP		42 DAP		56 DAP		28 DAP		42 DAP		56 DAP	
k_0 (0 kg/ha)	6.20	a	19.80	a	44.93	a	1.28	a	4.72	a	10.58	a
k_1 (25 kg/ha)	7.05	b	21.70	bc	47.05	ab	1.33	a	4.85	ab	11.28	ab
k_2 (50 kg/ha)	7.60	c	22.38	c	51.53	c	1.58	bc	4.88	ab	12.18	c
k_3 (75 kg/ha)	8.58	d	24.58	d	55.28	d	1.75	c	5.20	c	13.28	d
k_4 (100 kg/ha)	8.13	d	22.30	c	49.05	bc	1.55	b	4.93	b	11.63	bc
k_5 (125 kg/ha)	7.38	bc	20.90	ab	48.03	b	1.23	a	4.85	ab	11.53	bc

Note : According to Duncan's test ($p < 0.05$), common letters following numbers in the column indicate no significant difference between the corresponding numbers.

Table 4 shows the results of variance analysis of fresh and dry biomass weight, indicating that the treatment with dose of 75 kg/ha produced the highest fresh and dry biomass weight. This treatment showed the best results compared to other results. The findings of this study align with Lestari et al. (2015), who reported that K fertilizer implementation had a substantial quadratic relationship with straw dry weight. Kharisma et al. (2021) said plant dry weight depends on the number and area of leaves, given that photosynthesis occurs in leaves and produces photosynthates that affect biomass accumulation.

Relative Growth Rate (RGR) and Net Assimilation Rate (NAR)

The results of the analysis of variance showed that potassium fertilizer doses had no significant effect on RGR and NAR, both at 28 DAP to 42 DAP and 42 DAP to 56 DAP. The outcome of Duncan's test on the average RGR and NAR between treatments are presented in Table 5.

Table 5. Results of Relative Growth Rate (RGR) and Net Assimilation Rate (NAR) in Response to Potassium Fertilizer

Treatment	RGR (g/day)		NAR (g/cm^2/day)	
	28 – 42 DAP	42 – 56 DAP	28 – 42 DAP	42 – 56 DAP
k_0 (0 kg/ha)	0.0950 a	0.0565 a	0.001287 a	0.000574 a
k_1 (25 kg/ha)	0.0822 a	0.0601 a	0.001143 a	0.000723 a
k_2 (50 kg/ha)	0.0939 a	0.0653 a	0.001520 a	0.001058 a
k_3 (75 kg/ha)	0.0778 a	0.0669 a	0.001153 a	0.000889 a
k_4 (100 kg/ha)	0.0826 a	0.0609 a	0.001196 a	0.000789 a
k_5 (125 kg/ha)	0.0995 a	0.0617 a	0.001478 a	0.000862 a

Note : According to Duncan's test ($p < 0.05$), common letters following numbers in the column indicate no significant difference between the corresponding numbers.

As presented in Table 5, Potassium contributes greatly to plant metabolic process and photosynthesis, however in this study, the fertilizer rate did not significantly affect the relative growth rate (RGR) or the net assimilation rate (NAR) of bambara groundnut. Both parameters are affected by dry biomass weight and leaf area. With potassium fertilization, an increase in dry weight corresponded with a similar increase in leaf area.

The increase in dry biomass was accompanied by an increase in leaf area, keeping the ratio between the two stable. This finding is consistent with the results of Sulistiani et al. (2020), who stated that the effect of potassium on RGR and NAR is highly influenced by environmental conditions, and that increasing nutrient doses does not necessarily enhance assimilation efficiency. Therefore, the stability of RGR and NAR values in this study indicates that environmental factors and the balance of vegetative growth play a more crucial role than merely increasing potassium dosage.

Number of Pods

The outcome of the variance analysis indicated that potassium fertilizer application has an important effect on the number of pods. The results of Duncan's test on the common number of pods between treatments are presented in Table 6.

The highest dose found in the variance analysis of pods was 75 kg/ha. The use of doses above the optimal point is ineffective and can actually reduce crop yields due to nutritional imbalance and physiological stress on plants. According to Dinariani et al. (2014) *as cited in* Abdulah & Syakur (2022), well-developed roots facilitate the plants absorption of water and nutrients, thereby achieving optimal growth and high yield. However, low potassium content in the soil causes the growth of bambara groundnut, especially in the vegetative phase, to be less than optimal. Rachmadhani et al. (2014) *as cited in* Alfy (2022) emphasize that generative growth is highly dependent on an optimal vegetative phase, especially through photosynthesis, which produces photosynthates for pod development. Therefore, the availability of potassium from the early stages of growth is very important in increasing crop yields.

Table 6. Results of Number of Pods in Response to Potassium Fertilizer

Treatment	Number of Pods (pieces)			
	per Plants (pieces)		per Plot (pieces)	
k_0 (0 kg/ha)	22.4	a	455.0	a
k_1 (25 kg/ha)	22.8	a	467.8	ab
k_2 (50 kg/ha)	24.6	b	502.8	bc
k_3 (75 kg/ha)	26.8	d	570.0	d
k_4 (100 kg/ha)	25.6	c	508.0	c
k_5 (125 kg/ha)	24.3	b	480.8	abc

Note : According to Duncan's test ($p < 0.05$), common letters following numbers in the column indicate no significant difference between the corresponding numbers.

Fresh Pods Weight, Dry Pods Weight, and 100 Seed Weight

The outcome of the analysis of variance shows that potassium fertilizer application has an important effect on fresh pods weight, dry pods weight and 100-seed weight. The outcomes of Duncan's test on the average fresh pods weight, dry pods weight and 100 seed weight between treatments are presented in Table 7.

Table 7. Results of Fresh Pods Weight, Dry Pods Weight, and 100 Seed Weight in Response to Potassium Fertilizer

Treatment	Fresh Pods Weight (g)				Dry Pods Weight (g)				100 Seed Weight (g)	
	per Plant		per Plot		per Plant		per Plot			
k_0 (0 kg/ha)	37.8	a	823.8	a	24.1	a	502.3	a	80.5	a
k_1 (25 kg/ha)	43.8	b	924.5	ab	28.5	ab	560.8	ab	82.6	b
k_2 (50 kg/ha)	47.0	b	978.3	b	32.0	b	572.5	b	82.7	b
k_3 (75 kg/ha)	58.5	d	1277.5	c	40.6	c	724.8	c	86.8	d
k_4 (100 kg/ha)	51.0	c	1007.5	b	30.6	b	595.5	b	84.7	c
k_5 (125 kg/ha)	46.4	b	951.5	b	29.0	b	575.3	b	83.0	bc

Note : According to Duncan's test ($p < 0.05$), common letters following numbers in the column indicate no significant difference between the corresponding numbers.

Table 7 shows that implementation of a potassium fertilizer rate of 75 kg/ha resulted in the highest pods weight, namely 58.5 g/plant and 1227.5 g/plot for fresh pods, as well as dry pods weight of 40.6 g/plant and 724.8 g/plot. These results reflect the efficiency of pod filling after drying, where potassium plays a role in mobilizing photosynthates to the pods so that the seeds are optimally filled. The weight of 100 seed was also highest in treatment k_3, at 86.8 g. This is an indicator of the quality and effectiveness of seed filling, which affects crop yield. These findings are in line with the potassium fertilization recommendations from Akombo & Asema (2013), which recommend the use of 83 kg/ha of KCl fertilizer to affect pods weight.

Sumarno et al. (1986) *as cited in* Susilo et al. (2019) explain that potassium, along with phosphorus, is crucial for the formation of peanuts and regulates metabolic processes, including photosynthesis, nutrient transport, and photosynthate distribution. Saptarini et al. (2001) *as cited in* Syahrani (2014) also stated that applying potassium at the right rate can increase yields, although according to Belinda & Sugito (2019), nutrient uptake by plants still has limits even if the soil is rich in nutrients.

Plant Potassium Uptake

The outcome of the variance analysis indicated that potassium fertilizer application has an important effect on plant potassium uptake. The results of Duncan's test for plant potassium uptake treatments are presented in Table 8.

Table 8 shows the application of potassium fertilizer affected potassium uptake in plants, with uptake increased with increasing potassium fertilizer rate. Potassium uptake reaching highest level at 75 kg/ha (k_3) before declining at higher doses. According to Masriani & Pata'dungan (2021), greater potassium availability in the soil leads to higher concentrations of this element in plant tissues. As a vital nutrient influencing crop yield, potassium is taken up as K^+ and is mainly distributed in rapidly growing tissues, such as the meristem. Plants demand a high amount of potassium, which is considered the second most essential nutrient following nitrogen. In fertile soils, potassium levels in plant tissues are nearly equal to those of nitrogen, but excessive fertilizer doses may lower tissue K concentration (Sagita et al., 2025).

Table 8. Results of Plant Potassium Uptake in Response to Potassium Fertilizer

Treatment	Potassium Uptake (%)	
k_0 (0 kg/ha)	12.3	a
k_1 (25 kg/ha)	16.6	b
k_2 (50 kg/ha)	18.1	c
k_3 (75 kg/ha)	19.5	e
k_4 (100 kg/ha)	18.7	cd
k_5 (125 kg/ha)	17.5	c

Note : According to Duncan's test ($p < 0.05$), common letters following numbers in the column indicate no significant difference between the corresponding numbers.

CONCLUSION

Based on the findings of the research and previous discussions, the following conclusions can be drawn:

1. The implementation of potassium fertilizer at different levels will results in different growth and yields.
2. The implementation of potassium fertilization at 75 kg KCl/ha is the most suitable dose for the cultivation of bambara groundnut.

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