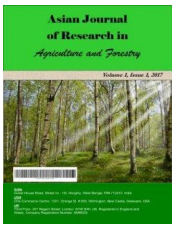

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Growth and Yield Components of Groundnut (*Arachis hypogeal* L.) as Affected by Phosphorous Fertilizer Application on the Jos Plateau

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Authors' contributions

This work was carried out in collaboration among all authors. Author III designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors AJ and KNN managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

The experiment was conducted in Federal College of Forestry demonstration farm Jos, Plateau State to determine the growth and yield components groundnut as affected by phosphorous fertilizer application on the Jos plateau. The experimental design used was a randomized complete block design (RCBD) comprising of four treatments (0, 20, 40 and 60 kg P ha^{-1}) that were replicated four times on groundnut (SAMNUT 25). Data was collected on germination percentage, plant height, leaf count, number of branches, days to 50% flowering, number of pods/plant, 100 seeds weight, total yield and biomass weight which were analysed using analysis of variance (ANOVA) at 5% level of probability with Minitab 23. Where significance was declared, Fisher LSD method was used to separate the means. The result reveals that no significant effect was recorded for germination percentage. Highly significant effect of phosphorous was observed on the growth and yield components of groundnut. The highest (34.63 cm) plant height, leaf (100.78) count, number (27.13) of branches, days (27.75 days) to 50% flowering, number (34.50) of pods/plant, 100 seeds (52.08 g) weight, total (2.26tha^{-}1) yield and biomass (5.42 tha^{-1}) weight at the application of 60 kg P

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ha^{-1}. Thus, groundnut farmers are encouraged to engage in the application of 60kg P ha^{-1} for optimum growth and yield. Further research on other varieties should be conducted to ascertain the best variety and phosphorous rate for optimum groundnut production in the study area.

Keywords: Growth; yield; groundnut; phosphorous fertilizer.

1. INTRODUCTION

Tropical soils are inherently low in nutrients particularly nitrogen and phosphorus [1]. Phosphorus is among the most needed elements for crop production in many tropical soils. Its deficiency is one of the most limiting plant nutrients for leguminous crop production in most tropical soils. Legumes are phosphorus loving plants; they require phosphorus for growth and seed development and most especially in nitrogen fixation which is an energy-driving process [2]. Legumes can fix up to 11-20 kgN /ha but this is not achievable in the tropics because of low soil fertility and poor farming practices. Phosphorus although not required in large quantities is critical to yield of most crops (particularly for improved photoperiod-insensitive cultivars) because of its multiples effects on nutrition. It not only increases seed yields but also nodulation [2].

Groundnut is one of the world's most popular crops cultivated throughout the tropical and sub-tropical areas where annual precipitation is between 1000 -1200 mm for optimum growth of the crop. The leading producers of the crop in the world are China, India, Nigeria, U.S.A, Sudan, Senegal and Argentina amongst others [3]. Nigeria is the leading and largest groundnut producing country is West Africa, accounting for 51% of production in the region, 10% of total global production and 39% that of Africa. Groundnut producing states in Nigeria include Kano, Kaduna, Sokoto, Bauchi, Nassarawa, Zamfara and most of the Northern states in the country [4]. In Nigeria like in other developing countries where the crop is grown, groundnut is an excellent food, containing about 60% highly digestible protein, 22% carbohydrates, 4% minerals and about 8% fat.

Groundnut has high economic and nutritional potential and is an important cash crop for peasants in poor tropical countries including Nigeria [5]. Groundnuts are the second largest source of vegetable oils, the first being soybean. Groundnut flour, groundnut proteins, groundnut milk are other important products used human consumption. The oil is used in cooking, salads, margarine, soap and lubricants as well as source of fatty acids. The residue left after extraction of oil is used as livestock feed and green leaves for fodder.

Low level of productivity of groundnut has been ascribed to several constraints due to low permeability; poor aeration and low availability of nutrients especially phosphorus which is essential for root and kernel development; increased number, density and efficiency of nodules and can significantly increase the uptake of other nutrients. In Nigeria most farmers do not use fertilizer or they sometimes use insufficient nutrient based input, inappropriate level of fertilizer that resulted in low productivity. Lack of efficient fertilizer use and low soil fertility (very low organic carbon and very low available phosphorus) are important limiting factors in achieving desirable yield of groundnut. Thus, this research will be conducted to determine the effect of phosphorus level on the growth and yield of groundnut on the Jos Plateau.

2. MATERIALS AND METHODOLOGY

2.1 Study Area

The experiment was conducted in Federal College of Forestry, Jos, Plateau State, Nigeria. It is a region in the middle belt of Nigeria and it falls between Latitude 9.9º and Longitude 8.8º each with an attitude of 1,200 m above sea level [6]. The vegetation of the area is a typical guinea savannah with an average annual rainfall of 1200 mm. The rain usually starts from April and terminates between September and October with temperatures ranging from 20-30ºC [7].

2.2 Materials

The materials used for this research work include seed (groundnut), Fertilizer (Single Super Phosphate), Measuring tape, Meter rule, Line or rope, Cutlass, Auger bit, Shovel, Rake, Wheelbarrow, Bucket or watering can, and Hoe. The seed (Samnut 25) was sourced from ICRISAT research station Kano.

2.3 Soil Analysis

Soil Sample was collected at random from different locations on the field form two depths (0-15 cm and 15-30 cm) with the aid of augar bit, hand trowel and polythene bag to store the sample which was later dried under room temperature and taken to ASTC (Agricultural Service and Training Centre) for analysis.

2.4 Experimental Design

A Randomized Complete Block Design (RCBD) was used involving four (4) treatments; 0 kg P ha^{-1} as control, 20 kg P ha^{-1}, 40 kg P ha^{-1} and 60 kg P ha^{-1}. Each treatment was replicated four (4) times.

2.5 Agronomic Practices

a. Land Preparation: Preparation of land for planting was done on the 3rd of July, 2018. The land was cleared using a cutlass and hoe. The soil was thoroughly dogged and the clumps were broken into fine tilth particles.
b. Sowing and Spacing: sowing of groundnut (samnut25) variety were plant at a depth of 5 cm and at a spacing of 25 cm x 75 cm. Single super phosphate was applied immediately after sowing using the ring method of 5 cm radius.
c. Weeding: Weeding was carried out twice within the first 6 weeks after sowing. This was done using a hoe.

2.6 Data Collection

The data was collected on;

a. Germination Percentage: This was taken a week after sowing. The germination percentage was obtained using the formula below:

$$\textit{Germination percentage} = \frac{number\ of\ germinated\ seeds}{number\ of\ sown\ seeds} \times 100 \quad (1)$$

b. Plant height: The plant height was measured from the base of the plant to tip of the plant with the aid of meter rule in cm.
c. Leaf count: Number of leaves was counted per plant at 2 weeks interval.
d. Branch counts: Number of branches was counted per plant at 2 weeks interval.
e. Days to 50% flowering: This was done by counting the number of days for 50% of the plant to flower
f. Number of pods/plant: This was done by counting the number of pods each plant produced
g. Yield: The yield was obtained from harvest in each plot then per treatment which was weighed using weighing balance to obtain data for analysis.
h. Biomass: This was done by weighing the dry matter of the plant using a weighing balance in Kg.

Data collected was subjected to analysis of variance (ANOVA) at 5% level of significance using Minitab 23 and where significance was declared, Fisher LSD method was used to separate the means.

3. RESULTS AND DISCUSSION

3.1 Physical and Chemical Properties of Soil at Federal College of Forestry Jos

The results of physical and chemical properties of the soil sample for the experimental site before sowing is shown in Table 1. The result indicates that the soil was predominantly sandy loam in texture. The soil was moderately acidic with pH value of 5.78. The available phosphorus was low (9.5 and 6.8mgkg^{-1}) while the exchangeable cations were low especially K, Ca, Mg and Na were low .The soil was therefore low in nutrient status.

3.2 Germination Percentage

The result from Table 2 indicates that there is no significant difference between the applications of phosphorus fertilizer at different rates for germination percentage, statistically. But the control has higher (68.94%) germination percentage than the other treatments.

3.3 Plant Height

The results (Table 2) indicate that there was significant (P < 0.01) effect of phosphorus on plant height at different levels of application. The application rate at 60 kg P ha^{-1} recorded the tallest plants (34.63 cm) with 40 and 20 kg P ha^{-1} having the mean plant height of 29.10 cm and 25.98 cm respectively. The control (0 kg P ha^{-1}) has the shortest (21.25 cm) plants.

3.4 Leaf Count

There was significant effect between the different fertilizer levels and number of leaves. Application rate at 60 kg P ha^{-1} of phosphorus fertilizer

recorded the highest number of leaves with the mean leaf count of 100.78. 40 kg P ha^{-1} with mean leaf count of 83.53, 20 kg P ha^{-1} had 66.58, while the control (0 kg P ha^{-1}) recorded the lowest mean leaf count of 61.25.

3.5 Number of Branches

Significant (P < 0.01) effect was observed between the application levels and number of branches, with 60 kg P ha^{-1} rate of application having the highest number of branches with the mean of 27.13, followed by 40 kg P ha^{-1} with 23.13 branches. 20 kg P ha^{-1} recorded 22.53 while the control (0 kg P ha^{-1}) recorded the lowest with a mean number of branches of 18.40.

3.6 Days to 50% Flowering

Table 3 shows the effect of application of phosphorus fertilizer at different levels with regards to the yield components of groundnut. Days to 50% flowering was found to be highly significant (P < 0.01) at the application of phosphorous fertilizer. Application rate of 60 kg P ha^{-1} produced the least (27.75 days) number of days for groundnut to reach 50% flowering, 40 kg P ha^{-1} and 20 kg P ha^{-1} attained 50% flowering at equal days (29.50 days) while the control (0 kg P ha^{-1}) attained 50% flowering at a mean of 30.50 days.

3.7 Number of Pods/Plant

The result (Table 3) indicates that significant difference (P < 0.01) was observed between the different application rates with regards to number of pods per plant. Application rate at 60kg P ha^{-1} produced the highest amount of pods per plant with a mean pods number of 34.50. 40 kg P ha^{-1} recorded the second highest number of pods per plant with a mean of 29.00 and then followed by 20 kg P ha^{-1} with the mean number of pods per plant of 26.50. The control recorded the least number of pods per plant with a mean of 19.75.

3.8 100 Seeds Weight

Table 3 shows the effect phosphorus fertilizer at different level with regards to 100 seeds weight. The result indicates that there was significant difference (P < 0.01) between the treatments. 60kg P ha^{-1} application rate had the greatest effect with regards to 100 seeds weight (52.08 g) than the other treatments. 40 kg P ha^{-1} of phosphorus was significantly lower than 60 kg P ha^{-1} with the weight of 43.53 g but higher than 20 kg P ha^{-1} with 41.00 g, while the control (0 kg P ha^{-1}) recorded the least with 35.98 g.

3.9 Total Yield

Table 3 shows the effect of phosphorus fertilizer application at different levels on total yield in tons per hectare. Significant difference (P < 0.01) were observed between the treatments with 60 kg P ha^{-1} of phosphorus having the greatest effect 2.26tha^{-1}, followed by 40 kg P ha^{-1} and 20 kg P ha^{-1} of phosphorus having the total yields of 1.75tha^{-1} and 1.34tha^{-1} respectively, while the control (0kg P ha^{-1}) recorded the least total yield with 1.16tha^{-1}.

3.10 Biomass Weight

Table 3 shows the effect of application phosphorus fertilizer at different rate on biomass. The result indicates that significant difference (P < 0.01) was observed between the treatments with 60 kg P ha^{-1} having the greatest effect with regards to biomass 5.42 tha^{-1}. 40 kg P ha^{-1} recorded the second greatest effect with 4.78tha^{-1}. 20 kg P ha^{-1} showed lower effect than 40 kg P ha^{-1} with 4.18tha^{1} but was higher than the control (0 kg P ha^{-1}) with 3.59tha^{-1}.

The findings from this research work indicate that there was no significant (P=0.05) effect in the application of different levels of phosphorus fertilizer on germination percentage. The control recorded higher germination percentage than the other treatments. This result is in agreement with Shiyam [8] who reported that 0-20 kg of phosphorus gives a higher germination rate. This may be as a result of the slow release of the nutrients at the initial stage of growth of groundnut. The result indicates that there was significant difference in the application of different levels on phosphorus with regards to plant height. Application rate at 60 kg P ha^{-1} has effect than the other treatments at different periods. The result is similar to [9] and Kabir et al. [10] who reported that application of phosphorus at 50-60 kg P ha^{-1} will significantly increase plant height. The increase in plant growth due to phosphorus application may be attributed to the role of phosphorus in the development of more extensive root system which enhances proper absorption of water and nutrients from the soil [11]. However, the result contradicts the research work carried out by Shiyam [8] who reported that different phosphorus levels insignificantly affects plant height.

Table 1. Physical and chemical characteristics of the soil at federal college of forestry Jos demonstration farm

Sample (cm)	p^H	N %	Om %	P ppm	Na ppm	Ca ppm	Mg ppm	K Cmol/kg	H^+mMol/100g	$Al3^+$mMol/ 100 g	CEC mMol/100g	Clay %	Silt %	Sand %	Textural class
0-15	5.96	0.7	0.18	9.5	0.97	4.5	4.8	4.5	1.4	Nil	3.5	4.2	10.0	85.2	Loamy sand
15-30	4.47	0.04	1.84	6.8	0.95	4.9	3.6	3.4	1.4	Nil	3.4	4.2	10.0	83.2	Loamy sand

Source: Field work, 2018

Table 2. Growth characteristics of groundnut as affected by phosphorous fertilizer on the Jos plateau

P_2O_5 (kgha^{-1})	Germination percentage (%)	Plant Height (cm)	Leaf count	Number of branches
0	68.94a	21.25d	61.25d	18.40c
20	65.63a	25.98c	66.58c	22.53b
40	67.17a	29.10b	83.53b	23.13b
60	65.63a	34.63a	100.78a	27.13a
SE±	7.20	0.48	0.60	0.66
CV (%)	16.02	18.32	20.54	20.54
LS	ns	**	**	**

*Means that do not share a letter are significantly different, SE = Standard Error, CV = Coefficient of Variation, LS = Level of Significance, ns = Not Significant, ** = Significant at p ≤ 0.01 Level of Significance*

Table 3. Yield characteristics of groundnut as affected by phosphorous on the Jos Plateau

P_2O_5 (kgha^{-1})	Days to 50% flowering	Number of pods/plant	100 seeds weight (g)	Total yield (tha^{-1})	Biomass (tha^{-1})
0	30.50a	19.75c	35.98d	1.16d	3.59d
20	29.50a	26.50b	41.00c	1.34c	4.18c
40	29.50a	29.00b	44.53b	1.75b	4.78b
60	27.75b	34.50a	52.08a	2.26a	5.42a
SE±	0.42	1.37	0.80	0.03	0.04
CV (%)	4.08	21.38	14.90	27.16	15.76
LS	**	**	**	**	**

*Means that do not share a letter are significantly different, SE = Standard Error, CV = Coefficient of Variation, LS = Level of Significance, ** = Significant at p ≤ 0.01 Level of Significance*

There was significant difference in the different application levels of phosphorus on both the number of branches and leaves at different periods. The maximum data for both number of branches and branches were obtained by 60kg P ha^{-1} of phosphorus. This is similar to Zeidan (2007) and Kamara et al. (2011) who reported that application of phosphorus fertilizer at a rate of 50-60 kgha^{-1} increases the vegetative growth of groundnut. Phosphorus increases the number of branches, thus resulting in more leaves per plant.

Significant difference was observed between the different application levels of phosphorus fertilizer with regards to both days to 50% flowering and number of flowers. Application rate (60 kgha^{-1}) attained 50% flowering earlier and recorded a higher number of flowers than the other treatments. This result is in agreement with Brady and Weil [12] and Rahman [13] who reported that increasing the application of phosphorus fertilizer at the early stages stimulates and promotes rapid cell division, shortens days to maturity and hastens maturity of groundnut.

From the result obtained from this research work with regards to number of pods per plant, there was significant difference due to various levels of phosphorus fertilizer. Phosphorus increased the number of pods per plant as 60kg P ha^{-1} recorded higher number of pods per plant and also gained higher weight. This result is in agreement with [10,13] who reported that there is increment in number of pods per due to increase application of phosphorus fertilizer (50-60kgha^{-1}) as it promotes the formation of nodes and pods in groundnut and other legumes. Also, the effect of phosphorus on weight of 100 seeds was significant. The findings is in agreement with El-Habbasha et al. [14] and Kabir [10] who reported that increasing phosphorus levels increased 100 seeds weight.

The result obtained from this research work with regards to total yield is in agreement with Gobarah et al. [15] and Kabir et al. [16] who reported increased yield and yield components in response to 30-60 kgha^{-1} of phosphorus but with optimum yield at 60kgha^{-1}.This result is contrary to that of Shiyam [8] who reported that groundnut yield increased when 30 and 40kgha^{-1} of phosphorus were applied. They recorded reduced seed yield in plots fertilized with 50 and 60 kgha^{-1} of phosphorus and stated that it might

be a reflection of the suppressive effect of phosphorus on pod filling.

Shiyam [8] found out that different phosphorus levels insignificantly affected biomass. On the other hand, the results obtain from this research work are consistent with the results reported by Ibrahim and Eleiwa (2008) regarding significant increase in both straw and seed yield in response to increased fertilizer levels. This report is also supported by the findings of Gobara et al. [15] and Kabir et al. [16] who reported increase yield and yield components on response to increasing phosphorus levels up to 60kg/ha. Such increase in phosphorus which is known to help in developing extensive root systems that helps plants in absorbing water and nutrients efficiently, which in turn enhances plants to produce more assimilates which was reflected in higher biomass.

4. CONCLUSION

In conclusion, phosphorous was found to have a significant effect on the growth and yield of groundnut. There was a significant increase in plant height, number of leaves, number of branches, days to 50% flowering, number of flowers, number of pods/plant, 100 seeds weight, total yield and biomass weight as a result of the increase in the rate of phosphorous fertilizer application. The application of 60kg P ha^{-1} gave the highest plant height, number of leaves, number of branches, days to 50% flowering, number of flowers, number of pods/plant, 100 seeds weight, total yield and biomass weight of groundnut. Thus, groundnut farmers are encouraged to engage in the application of 60 kg P ha^{-1} for optimum growth and yield. Further research on other varieties should be conducted to ascertain the best variety and phosphorous rate for optimum groundnut production in the study area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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