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EFFICACY OF PHOSPHORUS FERTILIZER RATES ON THE GROWTH, YIELD AND YIELD CHARACTERS OF GROUNDNUT (*Arachis hypogea* L.) CULTIVARS ON JOS PLATEAU, NIGERIA

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ABSTRACT
This experimental research was conducted in 2018 and 2019 seasons at Federal College of Forestry demonstration farm Jos, Plateau State to determine the efficacy of phosphorus fertilizer rates on the growth and yield, and yield components of groundnut cultivars. The experimental design used was a randomized complete block design (RCBD) comprising of four treatments (0, 20, 40 and 60 kg $P_2O_5ha^{-1}$) and four groundnut cultivars (Samnut 10, 14, 17 and 18) that were replicated three times. Data were collected on plant height, number of leaves, stem girth, number of branches and pods/plant, harvest index, shelling percentage, total yield and biomass weight and data were analyzed using analysis of variance (ANOVA) at 5% level of probability with XLSTAT 2018 statistical package. Tukey's method was used to separate the means where significance was declared. The result showed that the application of 40 kg P ha^{-1} produced the highest plant height (73.96 cm and 73.92 cm), number of leaves (173.42 and 175.00), stem girth (4.02 and 3.92 cm), number of branches (43.33 and 43.50), number of pods or plant (25.67 and 26.58), harvest index (24.17% and 24.92%), total yield (2516.25 and 2574.58 kg/ha) and biomass weight (3551.58 and 3524.17 kg/ha). Samnut 14 recorded the highest plant height (72.19 cm and 72.54 cm), number of leaves (168.33 and 167.17), number of branches (42.25 and 41.67), number of pods or plant (23.83 and 24.08), harvest index (21.47 and 22.22%), total yield (2297.17 and 2361.33 kg/ha) and biomass weight (3267.58 and 3295.75 kg/ha). It was concluded that application of 40 kg $P_2O_5ha^{-1}$ to Samnut 14 produced the highest growth, yield and yield characteristics of groundnut. It was therefore recommended that farmers in the experimental area be encouraged to apply 40 kg P ha^{-1} to Samnut 14 for optimum productivity of groundnut.

Keywords: Cultivar, Groundnut, Growth, Phosphorus, Yield.

INTRODUCTION
Groundnut (*Arachis hypogaea L.*) is an annual legume native to South America. It is now grown in most tropical, sub-tropical and warm temperate regions of the World between 40° N and 40° S latitudes. In the world, the crop is grown in an area of 26.62 million with a production of 35.66 million tones with a productivity of 1348 kg ha^{-1}.The leading producers of the crop in the world are China, India, Nigeria, U.S.A, Sudan, Senegal and Argentina (Food and Agriculture Statistics [FAOSTAT], 2020). Nigeria is the leading and largest groundnut producing country in West Africa, accounting for 51% of regional production, 10% of global

production, and 39% of African production (Ibrahim *et al*., 2019). Nigeria's groundnut-producing states include Kano, Kaduna, Sokoto, Bauchi, Nassarawa, Zamfara, and the majority of the country's Northern states (International Crop Research Institute for Semi-Arid Tropics [ICRISTAT], 2015). Groundnut is an excellent food in Nigeria and other developing countries where the crop is cultivated, containing about 62% highly digestible protein, 22% carbohydrates, 6% minerals, and about 8% fat (Ibrahim *et al*., 2019).

Fertilizers are used to control the supply of vital elements to plants. Deficiencies in critical nutrient elements have been the leading cause of yield loss. These elements are needed as key factors in increasing growth, yield, and efficiency, as well as a factor in reducing the negative environmental effect. It is a well-known fact that fertilizer usage correlates with productivity, and fertilizers are responsible for about half of the increase in agricultural production in recent years (Purbajanti, 2019). Therefore, supplying essential nutrient elements is considered as one of the basic needs to achieve the potential yield of plants.

Groundnuts need a lot of nutrients to produce high yields, but their responses to applied fertilizers have been found to be very inconsistent, earning them the nickname "the unpredictable legume." Groundnut has long been thought to have the potential to use soil nutrients that are comparatively unavailable to other crops, allowing it to make good use of residual fertility. Insufficient fertilizers have been identified as one of the critical constraints in groundnut production in Nigeria (Ibrahim *et al*., 2019). Since groundnut does not need a lot of nitrogenous fertilizers since it is a leguminous crop, most farmers in these ecological zones tend to grow it on poor soils without them. In many tropical soils, phosphorus is one of the most important elements for crop production. In most tropical soils and forest-transition zones, its deficiency is the most restricting plant nutrient for legume production (Boahene, 2013). Singh *et al*. (2011) claim that phosphorus deficiency can be so severe in some savanna soils that plant growth stops as soon as the phosphorus contained in the seed is depleted.

Low groundnut productivity has been attributed to several constraints (Ibrahim *et al*., 2019) including low permeability, poor aeration, and low availability of nutrients, especially phosphorus, which is important for root and kernel development; increased number, density, and efficiency of nodules, which can significantly increase the uptake of other nutrients; and increased number, density, and efficiency of nodules, which can significantly increase the uptake of other nutrients. In Nigeria, newly released varieties are resistant/tolerant to the majority of diseases and mature early to avoid drought. Several programs are being implemented in Nigeria's dry savanna region to encourage these varieties (Shuaibu *et al*., 2019). The purpose of this study therefore, was to determine the efficacy of phosphorus fertilizer rates on the growth, yield and yield characters of groundnut cultivars on the Jos, Plateau.

MATERIALS AND METHODS

Experimental Area

This experiment took place in Jos, Plateau State, Nigeria, at the Federal College of Forestry demonstration farm. It is an area in Nigeria's middle belt that lies between Latitude 9.9o and Longitude 8.8o, with an elevation of 1,200 meters above sea level (Olowolafe and Dung, 2000). With an average annual rainfall of 1200 mm, the vegetation in the region is typical guinea savannah. The rain usually starts from April and terminates between September and October with temperatures ranging from 20 - 30ºC (Inusa, 2002).

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 cultivars (Samnut10, 14, 17 and 18) were sourced from ICRISAT research station Kano. The tools were obtained from Crop Production Technology Department store.

Soil Analysis

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

Experimental Design

Randomized Complete Block Design (RCBD) was used involving four (4) phosphorus rates (0, 20, 40 and 60 kg P_2O_5 ha^{-1}) and four (4) groundnut cultivars (Samnut 10, 14, 17 and 18). Each treatment was replicated three (3) times.

Agronomic Practices

a. Land Preparation: Preparation of land for planting was done on the 23rd of July, 2019. 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 cultivars were carried out at a depth of 5 cm and at a spacing of 25 cm x 50 cm. Single super phosphate was applied immediately after sowing using the side placement method.
c. Weeding: Weeding was carried out twice within the first six weeks after sowing. This was carried out manually using a hoe.

Data Collection

Growth Parameters

a. Plant height (cm): Ten plants from each plot were randomly selected and tagged, plant height was measured from a point immediately above the soil surface to the tip of the last leaf of the plant, and the mean height per plant was recorded in centimeter (cm) after 70 days of sowing.
b. Number of leaves per plant: The leaves were counted from the randomly selected plants and the mean number of leaves per plant obtained at 70 days after sowing.
c. Stem Girth (cm): Ten plants from each plot were used and the diameter of the plant stem was measured using a Vernier caliper and the mean stem diameter estimated at 70 days after sowing.
d. Number of branches: From tagged plants the mean number of branches per plant was counted after 70 days of sowing.

Yield and Yield Components

a. Number of pods per plant: The number of pods for the ten tagged plants was counted and the mean number of pods per plant recoded. The harvest index (H.I) adopted was calculated as:

$$\text{H.I. } (\%) = \frac{\text{GY}}{\text{BY}}(100) \qquad \text{...(1)}$$

where;
H.I = Harvest index,
GY = Grain Yield (g),
BY = Biological Yield (g)

b. Shelling percentage (%): The pods from the selected plants of groundnut were each air dried thoroughly. Harvest from ten tagged groundnut plants was weighed before and after shelling, the shelled nuts were weighed and recorded. The shelling percentage was determined as:

$$SP = \frac{\text{Weight of groundnut seed}}{\text{Weight of pods}}(100) \qquad \ldots(2)$$

Weight of pods

c. Plant Biomass (g): The weight of the selected tagged plants was measured with the aid of a weighing balance and the mean weight of plant measured.

d. Yield (kg/ha): The weights of groundnut harvested from each plot were recorded before shelling using a weighting balance. The total weight of groundnut pods from the respective plots was then extrapolated to give the total pod yield per hectare. The pods of the harvested plants were threshed and seeds were collected. The grain yield per unit area was converted into kg/hectare as:

$$\text{Yield (kg/ha)} = \frac{\text{Plot yield x 10000}}{\text{1000x1000}} \qquad \ldots(3)$$

Statistical methods

The data collected were subjected to statistical analysis using XLSTAT 2018. The analysis of variance procedure was followed to determine whether differenced existed among treatments. Treatments were compared using the Duncan Multiple Range Test (DMRT) at 5 % probability level.

RESULTS AND DISCUSSION

Physical and Chemical Properties of Soil in the Study Area

The physical and chemical characteristics of soil at the experimental area for 2018 and 2019 seasons are presented in Table 1. The result indicates that the soil was predominantly sandy loam in texture at the experimental site. The soil was moderately acidic with pH value of 5.96 and 4.47 at 0 – 15 cm and 15 – 30 cm depth, respectively.

Table 1: Physical and Chemical Characteristics of the Soil at Experimental Site

Soil Composition	2018 Season		2019 Season	
	0 - 15 cm	15 - 30 cm	0 - 15 cm	15 - 30 cm
pH	5.96	4.47	6.28	6.40
N (%)	0.71	0.42	0.15	0.09
OM (%)	1.18	1.84	5.27	3.37
OC (%)	3.0	1.86	3.06	1.96
P (ppm)	9.5	6.8	11.0	13.0
Na (ppm)	0.97	0.95	0.011	0.087
Ca (ppm)	4.5	4.9	1.01	0.99
Mg (ppm)	4.8	3.6	0.41	0.40
K (Cmol/kg)	4.5	3.5	0.074	0.079
CEC (Cmol/100 g)	3.5	3.4	3.09	3.04
Clay (%)	4.2	4.0	18.44	12.44
Silt (%)	10.8	13.0	16	18
Sand (%)	85.0	83.0	63.56	69.56
Textural Class	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam

Source: Field work, 2019

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From Table 1 results, the available percentage nitrogen (0.71 and 0.42%), organic matter (1.18 and 1.84%), organic carbon (3.0 and 1.86%), phosphorus (9.5 and 6.8 ppm), the exchangeable cations especially K, Ca, Mg and Na were all found to be low in 2018 season for both depths. The soil composition in 2019 season reveals that the soil pH is slightly acidic (6.28 and 6.40), low percentage N (0.15 and 0.09%) and exchangeable cations than in 2018 but higher organic matter (5.27 and 3.37%) and organic carbon (3.06 and 1.96%). The soil was therefore low in nutrient status in 2018 but slightly higher in 2019. The physical and chemical characteristic of the soil in the experimental area reveals that the soil is low in nutrients especially in 2018. The slightly higher nutrients value in 2019 was due to the added phosphorus and decomposed groundnut residues and left over of the 2018 season.

Efficacy of Phosphorus Fertilizer Rates on the Growth Characters of Groundnut Cultivars

The plant height of groundnut showed significant ($p \leq 0.001$) increase on the application of phosphorus fertilizer rates (Table 2). In 2018 and 2019 seasons, the application of 40 kg P_2O_5 ha^{-1} gave the highest plant height (73.96 cm and 73.92 cm) followed by the application of 20 (72.32 cm and 71.80 cm) and 60 (71.97 cm and 71.66 cm) kg P_2O_5 ha^{-1} which are statistically similar in height and 0 kg P_2O_5 ha^{-1} gave the least plant height of groundnut (64.14cm and 67.74cm), respectively. The statistically significant difference in improving plant height was as a result of the phosphorus fertilizer applied. The role of phosphorus in the production of a more extensive root system, which improves proper absorption of water and nutrients from the soil, may account for the increase in plant growth caused by phosphorus application (Imam *et al*., 2014). This result is consistent with the results of Shuaibu *et al*. (2019), who found that phosphorus application at 40 to 120 kg P_2O_5/ha resulted in an increase in plant height. The result is contrary to Kabir *et al*. (2013) and Ibrahim *et al*. (2019) who reported that application of phosphorus at 50-60 kg P ha^{-1} significantly increase plant height. However, the result contradicts the research work carried out by Shiyam (2010) who reported that different phosphorus levels insignificantly affects plant height.

The main efficacy of cultivars in 2018 and 2019 on the plant height of groundnut (Table 2) reveals that Samnut 14 produces the tallest plant (72.19 cm and 72.54 cm) and Samnut 10, 18 and 17, respectively produced groundnut plants of 70.37 cm and 71.16 cm, 70.00 cm and 70.64 cm, 69.82 cm and 70.37 cm heights. Significant ($P \leq 0.001$) efficacy of cultivars on the plant height of groundnut was measured. The difference in plant height between the cultivars was as a result of the difference in the genetic makeup of the cultivars. The interaction effect of phosphorus fertilizer rates on the plant height of groundnut cultivars shows that there were highly significant ($P \leq 0.001$) changes in both 2018 and 2019 seasons.

With regards to the number of leaves, **s**ignificant ($P \leq 0.001$) effect of phosphorus fertilizer application (Table 2) was observed in 2018 and 2019 seasons. More leaves (173.42 and 175.00) were produced in both seasons at the application of 40 kg P_2O_5 ha^{-1}as against the application of 60 (166.25 and 166.42), 20 (162.92 and 163.58), and 0(153.67 and 151.25) kg P_2O_5 ha^{-1}. The application of 20 and 60 kg P_2O_5 ha^{-1} shows statistically similar leaves in both growing seasons.

The main efficacy of cultivar (2018 and 2019 seasons) on the leaves of groundnut was found to be significant in both 2018 and 2019 seasons. Samnut 14 (168.33 and 167.17) was found to be significantly ($P \leq 0.001$) different producing more leaves than Samnut 17 (163.42 and 163.58), 18 (162.00 and 162. 75) and Samnut 10 producing 162.50 and 162.75 number of leaves. Significant ($P \leq 0.001$) interaction effect of phosphorus fertilizer rates on the number of leaves of groundnut cultivars was obtained in both 2018 and 2019 seasons. The result contradicts the results of Ibrahim *et al*. (2019), who stated that 60kg P ha^{-1} of phosphorus provided the best data for both the amount of leaves and branches. According to Salve and Gunjal (2011), applying phosphorus fertilizer at a rate of 50-60 kg ha^{-1} increases groundnut vegetative development. The differences between the varieties may be due to the better variety's better tolerance to the climate (Shuaibu *et al*., 2019).

The efficacy of phosphorus fertilizer rates application on stem girth of groundnut was presented in (Table 2). The result showed significant ($P \leq 0.001$) effect among the fertilizer rates in 2018 and 2019 seasons. Application of 40 kg P_2O_5 ha^{-1}tended to be higher (4.02 and 3.92 cm) than those of the other fertilizer rates and the lowest mean stem girth (2.72 and 2.55 cm) was scored by the application of 0 kg P_2O_5 ha^{-1} for the 2018 and 2019 seasons. According to Shuaibu *et al.* (2019), optimum groundnut production necessitates balanced nutrition because nutrient deficiencies can stunt groundnut development. No significant ($P \geq 0.05$) cultivar differences were obtained on the stem girth of groundnut plant in both 2018 and 2019 seasons even though Samnut 14 recorded the highest mean stem girth of groundnut plant as against the other cultivars. Similarly, no significant ($P \geq 0.05$) interaction effect was recorded in both seasons for the application of phosphorus rates and groundnut cultivars on the stem girth.

The application of phosphorus fertilizer rates showed significant ($P \leq 0.001$) effect on number of branches of groundnut (Table 2). The application of 40 kg P_2O_5 ha^{-1} gave the highest number of branches (43.33 and 43.50) followed by the application of 60 (41.58), 20 (40.83 and 40.92) and 0 (38.42 and 37.75) kg P_2O_5 ha^{-1} for the 2018 and 2019 seasons, respectively. Number of primary branches $plant^{-1}$ was the highest (10.55) in the application of 60 kg P/ ha (Mouri *et al*., 2018). Significant ($P \leq 0.001$) cultivar differences was obtained by Samnut 14 on the number of branches of groundnut plant as against the other cultivars in both 2018 and 2019 seasons recording the highest mean branches (42.25 and 41.67) of groundnut plant. Statistically, similar number of branches were counted for SAMNUT 17 (40.83) and SAMNUT 18 (40.50) cultivars in both seasons. According to Mouri *et al.* (2018), variety had a major impact on the number of primary and secondary branches in $plant^{-1}$. In 2018, there was no important ($P \geq 0.05$) interaction impact between phosphorus rates and groundnut cultivars on the number of groundnut plant branches, but it was significant ($P \leq 0.05$) in 2019. Phosphorus increases the number of branches, thus resulting in more leaves per plant (Ibrahim *et al*., 2019).

Table 2: Efficacy of Phosphorus Fertilizer Rates on the Growth Characters of Groundnut Cultivars

Treatment	Plant height (cm) 2018	Plant height (cm) 2019	Number of leaves 2018	Number of leaves 2019	Stem girth (cm) 2018	Stem girth (cm) 2019	Number of branches 2018	Number of branches 2019
Phosphorus Fertilizer (kgP_2O_5/ha)								
0	64.14^{c}	67.74^{c}	153.67^{d}	151.25^{b}	2.72^{c}	2.55^{c}	38.42^{d}	37.75^{c}
20	72.32^{b}	71.80^{b}	162.92^{c}	163.58^{b}	3.20^{b}	3.45^{b}	40.83^{c}	40.92^{b}
40	73.96^{a}	73.92^{a}	173.42^{a}	175.00^{a}	4.02^{a}	3.96^{a}	43.33^{a}	43.50^{a}
60	71.97^{b}	71.66^{b}	166.25^{b}	166.42^{b}	3.43^{b}	3.49^{b}	41.58^{b}	41.58^{b}
P-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LS	***	***	***	***	***	***	***	***
Groundnut Cultivar								
SAMMNUT 10	70.37^{b}	71.16^{b}	162.50^{b}	162.75^{b}	3.33	3.33	40.58^{b}	40.75^{b}
SAMMNUT 14	72.19^{a}	72.54^{a}	168.33^{a}	167.17^{a}	3.48	3.54	42.25^{a}	41.67^{a}
SAMMNUT 17	69.82^{c}	70.77^{b}	163.42^{b}	163.58^{b}	3.26	3.29	40.83^{b}	40.83^{b}
SAMMNUT 18	70.00^{bc}	70.64^{b}	162.00^{b}	162.75^{b}	3.29	3.29	40.50^{b}	40.50^{b}
P – value	0.000	0.000	0.000	0.004	0.52	0.38	0.000	0.02
LS	***	***	***	**	NS	NS	***	*
Interaction								
PF * GV	***	**	NS	NS	NS	NS	NS	*

Note: Means that do not share the same letter(s) are significant, LS = Level of Significance, NS = Not Significant, * = Significant at $P \leq 0.05$, ** = Significant at $P \leq 0.01$, *** = Significant at $P \leq 0.001$

Efficacy of Phosphorus Fertilizer Rates on the Yield and Yield Characters of Groundnut Cultivars

The main efficacy of phosphorus fertilizer rates on the number of pods or plant of groundnut is presented in Table 3. The application of 40 kgP_2O_5/ha significantly ($P \leq 0.001$) affect the number of pods/plant with the highest pods or plant of 25.67 and 26.58 pods or plant in 2018 and 2019 seasons. The application of 20 and 60 kgP_2O_5/ha produced statistically similar number of pods or plant with 23.50 and 23.83 and 23.50 pods or plant apiece, respectively, and the control (0 kgP_2O_5/ha) produced the least (18.75 and 19.25) pods or plant. The effect of phosphorus on total pods plant^{-1} was significantly higher (43.21) when 60 kg P ha^{-1} was applied, followed by 40, 20, and 0 kg P ha^{-1} (Mouri *et al*., 2018). Phosphorus fertilizer increases the number of pods per plant as 60 kg P ha^{-1} recorded higher number of pods per plant and also gained higher weight (Ibrahim *et al*., 2019). According to Kabir (2010) and Rahman (2013), increased application of phosphorus fertilizer (50-60 kg/ha) promotes the development of nodes and pods in groundnut and other legumes, resulting in an increase in the number of pods per hectare. The main efficacy of cultivar on the number of pods or plant as presented in Table 3 reveals that Samnut 14 produced significantly ($P \leq 0.01$) higher number of pods or plant (23.83 and 24.08) as against the other cultivars that produced statistically similar number of pods or plant in both seasons. This finding is consistent with Mouri *et al*. (2018), who found that the number of total pods plant^{-1} was significantly affected by variety, owing to genetic differences between varieties. No significant ($P \geq 0.05$) interaction effect was recorded for the application of phosphorus rates and groundnut cultivars on the number of pods/plant of groundnut in 2018 but was significant ($P \leq 0.05$) in 2019.

The harvest index of phosphorus fertilizer rates and groundnut cultivars is presented in Table 3. In 2018 and 2019 seasons, higher harvest index was measured at the application of 40kgP_2O_5/ha of 24.17 and 24.92% followed by 60 kgP_2O_5/ha with 22.92 and 23.25%, 20 kgP_2O_5/ha with 19.86 and 21.02% and 0 kgP_2O_5/ha with 16.42 and 17.62%. The improvement of pod yield and stover yield were mainly responsible for the increased harvest index in 50 kg P ha^{-1} and 60 kg P ha^{-1} (Kabir, 2010 and Mouri, 2018). Significant efficacy of cultivar was recorded in 2018 ($P \leq 0.001$) and 2019 ($P \leq 0.05$) seasons with Samnut 14 producing higher harvest index (21.47 and 22.22%) as against the other cultivars with the least harvest index recorded for Samnut 10. The effect of variety on harvest index was significant (Mouri, 2018) No significant ($P \geq 0.05$) interaction effect was recorded for the application of phosphorus rates and groundnut cultivars on the harvest index of groundnut in 2018 but was significant ($P \leq 0.05$) in 2019.

The results of Table 3 also shows that no significant ($P \geq 0.05$) efficacy of phosphorus fertilizer rates was observed on the shelling percentage of groundnut in both 2018 and 2019 seasons. Similarly, no significant changes are recorded for the different cultivars and the interaction between phosphorus fertilizer rates and groundnut cultivars in 2018 and 2019 growing seasons. This result is contrary to Mouri (2018) who opined that shelling percentage was the highest (81.29%) in 60 kg P ha^{-1} followed by 40, 20 and 0 kg P ha^{-1}, respectively.

The efficacy of phosphorus fertilizer rates on the plant biomass of groundnut cultivars is presented from Table 3. The main effect of phosphorus fertilizer rates on groundnut reveals that there were significant ($P \leq 0.001$) differences between the fertilizer rates on plant biomass. The fertilizer rate at 40 kgP_2O_5/ha gave the highest plant biomass of 3551.58 and 3524.17kg/ha followed by statistically similar biomass at 20(3323.33 and 3358.33kg/ha) and 60(3198.83 and 3213.00kg/ha) kgP_2O_5/ha at both seasons. Shiyam (2010) found out that different phosphorus levels insignificantly affected biomass. On the other hand, the findings of this study are consistent with the findings of Ibrahim *et al*. (2019) who reported a significant increase in both straw and seed yield in response to increased fertilizer levels. The main effect of cultivar (Table 3) indicates that that there was significant difference on the plant biomass of groundnut with Samnut 14 having more plant biomass of 3267.58 and 3295.75kg/ha in 2018 and 2019, respectively. Similarly, statistically similar plant biomass was measured for Samnut 10, 17 and 18. No significant ($P \geq 0.05$) interaction effect was recorded in both seasons for the application of phosphorus rates and groundnut cultivars on the plant biomass of groundnut plant.

The total yield of phosphorus fertilizer rate application on groundnut cultivar is shown in Table 3. The result reveals that the application of 40 kgP_2O_5/ha produced significantly ($P \leq 0.001$) higher yield (2516.25 and 2574.58 kg/ha) than the other fertilizer rates in 2018 and 2019 seasons. However, statistically similar yield were measured at the application of 20 and 60 kgP_2O_5/ha. Similar trend was followed at the main effect of cultivar on yield. The result reveals that Samnut 14 produced significantly ($p \leq 0.01$) higher yield (2297.17 and 2361.33 kg/ha) than the other cultivars in 2018 and 2019 seasons. However, statistically similar yield were measured for Samnut 18, 17 and 10. No significant ($P \geq 0.05$) interaction effect was recorded for the application of phosphorus rates and groundnut cultivars on the total yield of groundnut in 2018 but was significant ($P \leq 0.05$) in 2019. The total yield obtained from this study differs from that reported by Kabir *et al*. (2013), who reported increased yield and yield components in response to 30-60 kg ha^{-1} of phosphorus, with optimum yield at 60 $kgha^{-1}$. This finding is consistent with Shiyam's (2010) finding that applying 30 and 40 $kgha^{-1}$ of phosphorus increased groundnut yield. They observed lower seed yield in plots fertilized with 50 and 60 kg ha^{-1} phosphorus and speculated that this could be due to phosphorus's suppressive effect on pod filling. This could be because at 40 kg P ha^{-1}, more dry matter was translocated to the pods at the expense of fodder production, implying better partitioning of photosynthates between the vegetative and reproductive components. The higher pod yields of groundnut varieties at this P level support this (Kamara *et al*., 2011).

Interaction of Phosphorus Fertilizer Rates and Groundnut Cultivar on Total Yield in 2019 Season

The interaction between phosphorus fertilizer rates and groundnut cultivar on total yield in 2019 Season is presented in Table 4. The result indicates that the application of 40 kg P_2O_5/ha to Samnut 14 produced the highest yield of groundnut with a total yield of 2923.33 kg/ha while the control (0 kg P_2O_5/ha) applied to Samnut 17 gave the least total yield of 1800.00 kg/ha. Interaction effect of variety and phosphorus on stover yield was significant with yield having the highest (6.92 t ha^{-1}) in V1× P4 combination and the lowest (5.87 t ha^{-1}) in V2× P1combination. Shuaibu *et al*. (2019) observed that as a result of influence of phosphorus fertilizer in promoting root growth which translates to the production of heavier grains.

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Table 3: Efficacy of Phosphorus Fertilizer Rates on the Yield and Yield Characters of Groundnut Cultivars

Treatment	Number of pods or plant		Harvest index (%)		Shelling Percentage (%)		Plant biomass (Kg/ha)		Total yield (Kg/ha)	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Phosphorus Fertilizer (kgP_2O_5/ha)										
0	18.75^{c}	19.25^{c}	16.42^{d}	17.62^{d}	10.54	10.68	2556.33^{c}	2566.67^{c}	1681.67^{c}	1773.33^{c}
20	23.50^{b}	23.83^{b}	19.86^{c}	21.02^{c}	10.60	11.10	3323.33^{b}	3358.33^{b}	2283.47^{b}	2314.17^{b}
40	25.67^{a}	26.58^{a}	24.17^{a}	24.92^{a}	10.89	11.17	3551.58^{a}	3524.17^{a}	2516.25^{a}	2574.58^{a}
60	23.50^{b}	23.50^{b}	22.92^{b}	23.25^{b}	10.57	10.81	3198.83^{b}	3213.00^{b}	2266.67^{b}	2300.08^{b}
P-value	0.000	0.000	0.000	0.000	0.288	0.254	0.000	0.000	0.000	0.000
LS	***	***	***	***	NS	NS	***	***	***	***
Groundnut Cultivar										
SAMMNUT 10	22.50^{b}	22.92^{b}	20.26^{c}	20.92^{b}	10.41	10.78	3165.75^{ab}	3190.92^{ab}	2096.50^{b}	2171.50^{b}
SAMMNUT 14	23.83^{a}	24.08^{a}	21.47^{a}	22.22^{a}	10.80	10.99	3267.58^{a}	3295.75^{a}	2297.17^{a}	2361.33^{a}
SAMMNUT 17	22.67^{b}	23.33^{ab}	21.12^{ab}	21.92^{a}	10.67	11.02	3115.17^{b}	3081.83^{b}	2205.67^{ab}	2247.33^{ab}
SAMMNUT 18	22.42^{b}	22.83^{b}	20.51^{bc}	21.76^{ab}	10.73	10.98	3081.58^{b}	3093.67^{b}	2148.67^{b}	2182.00^{b}
P-value	0.002	0.01	0.006	0.039	0.236	0.816	0.05	0.03	0.007	0.008
LS	**	*	**	*	NS	NS	*	*	**	**
Interaction										
PF * GV	NS	NS	NS	0.024*	NS	NS	NS	NS	NS	0.015*

Note: Means that do not share the same letter(s) are significant, LS = Level of Significance, NS = Not Significant at P≥0.05, * = Significant at P≤0.05, ** = Significant at P≤0.01, *** = Significant at P≤0.001

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Table 4: Interaction of Phosphorus Fertilizer Rates and Groundnut Cultivar on Total Yield in 2019

Phosphorus Fertilizer (kgP_2O_5/ha)	Groundnut cultivar			
	Samnut 10	**Samnut 14**	**Samnut 17**	**Samnut 18**
0	1816.67^{d}	1786.67^{d}	1800.00^{d}	1690.00^{d}
20	2083.33^{c}	2400.00^{b}	2383.33^{b}	2390.00^{b}
40	2506.33^{b}	2923.33^{a}	2456.00^{b}	2412.66^{b}
60	2279.67^{bc}	2335.33^{b}	2350.00^{b}	2235.33^{bc}
P-value		0.015		
LS		*		

Note: Means that do not share the same letter(s) are significant, LS = Level of Significance, * = Significant at $P \leq 0.05$

CONCLUSION AND RECOMMENDATION

It can be concluded that, phosphorus fertilization plays a significant role in groundnut production in 2018 and 2019 growing seasons. Similarly, Samnut 14 cultivar performed better than Samnut 10, 17 and 18 throughout the experimental period in both growing seasons. Thus, the application of 40 kgP_2O_5 ha^{-1} to Samnut 14 produces the highest growth, yield and yield characteristics of groundnut. Therefore, farmers in the experimental area should be encouraged to apply 40 kgP_2O_5 ha^{-1} to Samnut 14 for optimum productivity of groundnut.

CONFLICT OF INTEREST

The authors declared that there is no conflict of interest whatsoever throughout the course of undertaking this research work.

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