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Productivity of Groundnut (*Arachis hypogaea* L.) as influenced by variety and phosphorus levels in Billiri, Gombe State, Nigeria

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Abstract
Field experiments were conducted in the rainy seasons of 2017 and 2018 to evaluate the productivity of Groundnut as influenced by variety and levels of Phosphorus fertilizer at Tal, Billiri Local Government Area, Gombe State, Nigeria. Two varieties of groundnut; Ex-dakar and Samnut 22, and three different levels of Phosphorus fertilizer: 30 kg ha^{-1}, 40 kg ha^{-1}, 50 kg ha^{-1} and 0 kg ha^{-1} which served as control, were used for the study. The treatments were combined and laid out in a randomized complete block design (RCBD) with three replications. Data obtained were combined and subjected to analysis of variance (ANOVA) using Statistical Analysis System (SAS) version 9.1 (2002). The means were separated using Duncan's Multiple Range Test (DMRT). Generally, plant height, number of leaves per plant, number of branches per plant, number of pod per plant, 100 seed weight per hectare and pod yield per hectare differed significantly depending on variety and levels of Phosphorus fertilizer applied. The Samnut 22 variety was superior to Ex-dakar in all the parameters measured. 50 kg ha^{-1} of Phosphorus maintained a consistent advantage over the other levels of phosphorus fertilizer in all the measured variables. Groundnuts grown in 2018 rainy season were significantly ($P \leq 0.05$) better on the measured variables as compared with 2017 rainy season. Groundnut farmers in Billiri, Gombe State, are therefore advised to grow Samnut 22 with the application of Phosphorus fertilizer at the rate of 50 kg ha^{-1} for optimum yield.

Keywords: Growth, Yield, *Arachis hypogaea*, Genotypes and Fertilizer.
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Introduction

Groundnut (*Arachis hypogaea* L.) is a leguminous oilseed crop cultivated in the semi-arid and subtropical regions of the world. The crop originated in South America where it was cultivated as early as 1000 B.C. It is grown in nearly 100 countries on six continents between 40^0 N and S of the equator on nearly 24.6 m ha, with a production of 41.3 m.t. and productivity of 1676 kg ha^{-1} in 2012. China, India, Nigeria, USA and Myanmar are the leading groundnut producing countries in the world. Asia, with 11.6 m ha^{-1} (47.15%), and Africa, with 11.7 m ha^{-1} (47.56%), holds maximum global area under groundnut. Developing countries in Asia, Africa and South America account for over 97% of world groundnut area and 95% of total production. However, the productivity of Asia (2217 kg ha^{-1}) and Africa (929 kg ha^{-1}) is very poor as compared to Americas (3632 kg ha^{-1}) (FAOSTAT 2014). Groundnut is usually grown as a smallholder crop in the semi-arid tropics under rain fed conditions. It is an important crop in many countries, especially in South Sahara Africa, where it is a good source of protein (25%-34%), cooking oil (48%-50%) and vitamins. Groundnut kernels are consumed directly as raw, roasted or boiled kernels while the oil extracted from the kernel is used as culinary oil. It is also used as animal feed and industrial raw material. These multiple uses of groundnut makes it an excellent cash crop for foreign trade in the world and the haulm is the most important of its by-products that can be used to supply feed to livestock (Arslan, 2005). Groundnut was introduced into Nigeria in the 16th century. It is estimated that over 2 million hectares are planted to groundnut in Nigeria. The crop is mostly intercropped with cereals or can be planted sole in the tropics and sub-tropics (Nigam *et al*., 1991). Nigeria is the largest groundnut producing country in West Africa, accounting for 51% of production in the region. The country contributes 10% of total global production and 39% that of Africa. Between 1956 and 1967, groundnut was the country's most valuable single export crop, exemplified by the famous Kano groundnut pyramids. Groundnut is a major source of edible oil as well as livelihoods for small-scale farmers in Northern Nigeria. Being a labour-intensive crop, it generates employment for the rural poor. It is planted on about 34% of total cultivated area and contributes to 23% of household cash revenue. Groundnut products like oil and cake accounted for a significant percentage of total Nigerian export earnings. Before the fossil oil boom, groundnut was one of the major sources of revenue and foreign exchange earnings. However, in the post-1967 period, the combined effects of drought, increasing prevalence of diseases such as rust, leaf spots and groundnut rosette disease (GRD) have caused a decline in groundnut production. The total output of groundnut in 1970 was 1.6 m tons, but fell to 0.47 m tons in 1980. Since 1984, production has been increasing at an estimated growth rate of 8%, resulting both from area expansion (6%) and increase in productivity of 2% (Ajeigbe *et al*., 2014).

The poor productivity of groundnut cultivation in African countries may be attributed to a combination of factors such as unreliable rains, mostly non irrigated nature of cultivation, traditional small-scale farming with little mechanization, outbreaks of pests and diseases, use of low-yielding varieties, increased and/or continued cultivation on marginal land, poor adoption of agronomic practices and limited extension services. Groundnut production in Nigeria has suffered major setbacks from the groundnut rosette epidemics and foliar diseases, aflatoxin contamination and lack of sufficient and consistent supply of seed of improved varieties. This has significantly affected productivity and thus production and subsequently led to loss of its share in the domestic, regional and international markets. To regain its competitiveness, groundnut yield would have to increase substantially, using yield enhancing technologies including varieties tolerant or resistant to biotic and abiotic stresses (Ajeigbe *et al*., 2014).

The important of Phosphorus for legume production has been recognized for a long time. Franco and Avillio (1976) suggested that legumes may require more phosphorus than non-legumes because of their high requirement of phosphorus for symbiotic nitrogen fixation. Anil *et al*., (2008) stated among the essential plant nutrient phosphorus is the most important for seed production, helping to form healthy and sound root system which is essential for nutrient uptake from the soil. Furthermore, phosphorus is a component of adenosine diphosphate (ADP) and adenosine triphosphate (ATP). Phosphorus plays a role in cell division, flowering and crop maturation, root development and nodulation (Tarawali and Quee, 2014). Phosphorus deficiency is the most frequent nutrient stress for growth and development of grain legumes including groundnut (Karama *et al*., 2008). One of the most important soil nutrients for crop production is phosphorus (Tarawali and Quee, 2014). Phosphorus plays an important role in maturation of crop, root development, photosynthesis, nitrogen fixation and other vital physiological processes. In order of important to crop performance, phosphorus is rated second to nitrogen (Gervey, 1987). Sharma and Yaday (1997) reported that phosphorus plays a beneficial role in legume growth by promoting extensive root development and thereby ensuring a good yield. Balasubramanian *et al*., (1980) observed in a fertility study that phosphorus application results in better nodulation and seed yield. Rhodes (1983) reported that phosphorus application improved nodulation and seed yield of cowpea. El-Dsouky and

Attia (1999) also attributed increased number and weight of nodules, nitrogen activity and groundnut yield to phosphorus fertilization. Kwari 2005 reported that, low P content of the soil may restrict rhizobia population and legume development, which in turn can affect their nitrogen fixing potential. Studies conducted by researchers in savanna region of Nigeria showed that application of phosphorus at a rate of 20 to 40 kg ha^{-1} significantly improved performance of the grain legumes, groundnut (Balasubramanian *et al*., 1980); and soybean (Karama *et al*., 2007). Crop species and varieties; differ in their tolerance to low soil phosphorus and in their ability to utilize phosphorus sources under different climate, soil and management conditions (Tarawali and Quee, 2014). The objective of this work is to ascertain what level phosphorus fertilizer can be applied to the major varieties of groundnut in the locality of study to obtain the optimum yield.

Materials and Methods

Field experiments were conducted in the rainy seasons of 2017 and 2018 at Tal, Billiri Local Government Area, Gombe State, Nigeria. The experimental site lies $9^0 51'53''$N $11^0 13'31''$ at an altitude of 564 m above sea level. Two varieties of Groundnut: Ex-dakar and Samnut 22 used as test crops were obtained from the Agricultural Development Programme in Billiri. The three levels of phosphorus fertilizer used were 30 kg ha^{-1}, 40 kg ha^{-1} and 50 kg ha^{-1} including no-fertilizer treatment (0 kg ha^{-1}) as control. The two groundnut varieties and four fertilizers (including control), were combined to form eight factorial treatments, replicated three times and fitted into a randomized block design (RCBD). Prior to land preparation, soil samples were randomly taken from 0 – 15 cm depth using soil auger, bulked and sub-sampled for routine soil analysis (Black 1965). Each year, land was harrowed before the plots of 3 m by 3 m dimension were marked out. Each plot was separated from the next one by 0.5 m border where as the replications were separated by 1 m borders. Each replication has 8 plots, giving a total of 24 plots for the study. Sowing was done at a depth of 3 - 5 cm with intra and inter row spacing of 25 cm and 75 cm, respectively following the recommendation of FAO, 2006. This gave a total of 36 plants per plot (40,000 plants per hectare). Fertilizer application was done before sowing; the fertilizer was thoroughly incorporated into the soil (FAO, 2006). Weed control was manually done at 4 and 8 weeks after sowing using hand hoe to obtain weed free plots and avoid weed – crop competition. All the data were collected within the net plot of $4m^2$. A total of 10 plants were selected at the centre of the plots and tagged using a coloured rope for easy identification and for the data collection within each net plot. The data collected were plant height, number of leaves, number of branches, number of pod, 100 pod weight and pod yield. The data were subjected to Analysis of Variance (ANOVA) using Statistical Analysis System (SAS) version 9.1 (2002). The means were separated using the Duncan's Multiple Range Test (DMRT) method described by Duncan (1955).

Results

The soil of the experimental field was of sandy loam texture (Table 1). The pH (H_2O) was acidic with a reading of 6.16. Organic carbon (g kg^{-1}) was 5.11 in 2017 and 5.14 in 2018. Total nitrogen was 1.91 and 2.01 in 2017 and 2018 respectively. Available phosphorus (mg kg^{-1}) of the experimental site was higher in 2018 (60.11) compared 2017 (58.61), CEC in 2017 and 2018 were 6.32 and 7.01 respectively. Table 2 showed that the combined mean values for plant height measured at 4, 6, 8 and 10 weeks after sowing (WAS) differed significantly with variety, levels of phosphorus application and seasons. Samnut 22 variety was significantly taller than the Ex-dakar variety. This was consistent from 4 WAS through the various weeks evaluated. The response of the groundnut varieties to phosphorus application varied significantly ($P \leq 0.05$). The application of 50 kg ha^{-1} produced taller plants than other levels of phosphorus application and the 0 kg ha^{-1} produced the least. This was consistent from 4 WAS through 10WAS. With the seasons under evaluation, 2018 produced significantly taller groundnut than 2017. Interaction between variety and phosphorus V × P, variety and seasons V × S, as well as phosphorus and seasons P × S on plant height were significant at 5% ($P \leq 0.05$).

Table 3 showed that the combined mean values for number of branches measured at 4, 6, 8 and 10 WAS differed significantly with variety, levels of phosphorus application and seasons. Samnut 22 variety was statistically superior to Ex-dakar. While Samnut 22 had 38.22 branches at 4 WAS, Ex-dakar had 11.01 branches. The superiority was consistent through all the weeks under study. The levels of phosphorus application followed the same trend like plant height. The order of significant difference at 0.05 level of probability was 50 kg ha^{-1} > 40 kg ha^{-1} > 30 kg ha^{-1} > 0 kg ha^{-1} where 50 kg ha^{-1} produced the highest number of branches and this also was consistent from 4WAS through 10 WAS. Interaction between variety and phosphorus V × P, variety and seasons V × S, as well as phosphorus and seasons P × S on plant height were significant ($P \leq 0.05$). Table 4 showed that the combined mean values for number of leaves measured at 4, 6, 8 and 10 weeks after sowing differed significantly with variety, levels of phosphorus application and seasons. Samnut 22 variety had higher number of leaves per plant compared with Ex-dakar. The differences were significant for the various weeks 4, 6, 8 and 10 weeks after sowing. The trend observed with the levels of phosphorus application was not different from the one observed with number of branches. The order of significant difference ($P \leq 0.05$) was 50 kg ha^{-1} > 40 kg ha^{-1} > 30 kg ha^{-1} > 0 kg ha^{-1} where 50 kg ha^{-1} produced the highest number of leaves and this also was consistent from 4 WAS through 10 WAS. Interaction between variety and phosphorus V × P, variety and seasons V × S, as well as phosphorus and seasons P × S on plant height were significant ($P \leq 0.05$). Table 5 showed that the combined mean values of the yield parameters measured at maturity differed significantly with variety, levels of phosphorus application and seasons. Samnut 22 variety was statistically superior to Ex-dakar. Samnut 22 variety differed significantly from Ex-dakar variety by 42.11 %, 14.05 % and 42.51 % in number of pods per plant, 100 seed weight (kg ha^{-1}) and pods yield (kg ha^{-1}), respectively. Phosphorus application at 50 kg ha^{-1} produced the highest number of pods per plant (25.21) followed by 40 kg ha^{-1} (19.21) and the least number of pods per plant were observed at 0 kg ha^{-1} (6.00). This trend was the same for 100 seed weight and pod yield per hectare. The rainy season of 2018 significantly produced higher number pod per plant, 100 seed weight (kg ha^{-1}) and pods yield (kg ha^{-1}) compared to 2017. Interaction between variety and phosphorus V × P, variety and seasons V × S, as well as phosphorus and seasons P × S on plant height were significant ($P \leq 0.05$).

Table 1: Physical and chemical properties of the soil within 0-15 cm depth at the experimental Site in 2017 and 2018 rainy season, Billiri, Gombe.

Chemical composition	**2017**	**2018**
P^H (H_2O)	6.21	6.1
Organic Carbon (gkg^{-1})	5.11	5.14
Total carbon (gkg^{-1})	1.91	2.01
Available P ($mgkg^{-1}$)	58.61	60.11
Exchangeable base (mol(+)kg^{-1})	0.42	0.31
Ca	1.52	1.21
Mg	0.21	0.19
K	0.41	0.43
Na	4.11	3.99
CEC	6.32	7.01
Physical composition (%)		
Sand	60.5	70.6
Silt	9.5	7.4
Clay	21	22
Textural class	sandy loam	sandy loam

Table 2: Influence of phosphorus fertilizer and varieties on plant height of groundnut grown during 2017 and 2018 rainy season in Billiri, Gombe State.

Treatments	**Plant height**			
Varieties	**4 WAS**	**6 WAS**	**8 WAS**	**10 WAS**
Ex-dakar	10.01^b	12.21^b	20.61^b	22.11^b
Samnut22	18.22^a	25.11^a	32.55^a	37.91^a
LS	*	*	*	*
SE±	0.16	0.18	0.19	0.21
Level of Phosphorus				
0	10.00^d	14.10^d	22.91^d	28.12^d
30	12.11^c	15.30^c	24.99^c	29.41^c
40	15.21^b	24.34^b	30.31^b	33.12^b
50	19.21^a	28.11^a	38.28^a	40.01^a
LS	*	*	*	*
SE±	0.18	0.51	0.51	1.71
Season				
2017	13.21^b	15.25^b	26.91^b	29.21^b
2018	18.57^a	24.01^a	32.11^a	38.11^a
SE±	0.15	1.52	1.58	2.02
Interaction				
VXP	*	*	*	*
VXS	*	*	*	*
PXS	*	*	*	*

Means followed by different letters within a treatment are significantly different following DMRT
*Significant at 5 % ($P \leq 0.05$). WAS = Weeks after sowing.

Table 3: Influence of phosphorus fertilizer and varieties on number of branches of groundnut grown during 2017 and 2018 rainy season in Billiri, Gombe State.

Treatments	**Number of branches per plant**			
Varieties	**4 WAS**	**6 WAS**	**8 WAS**	**10 WAS**
Ex-dakar	11.01^b	18.21^b	20.61^b	22.11^b
Samnut22	38.22^a	49.11^a	52.55^a	58.91^a
LS	*	*	*	*
SE±	0.16	0.18	1.19	2.01
Level of Phosphorus				
0	11.00^d	15.10^d	18.91^d	23.12^d
30	15.11^c	18.30^c	22.99^c	29.41^c
40	30.21^b	35.34^b	42.31^b	48.12^b
50	35.21^a	38.11^a	50.28^a	58.01^a
LS	*	*	*	*
SE±	1.4	0.71	1.15	2.01
Season				
2017	15.21^b	19.25^b	23.91^b	29.21^b
2018	30.57^a	32.01^a	48.11^a	52.11^a
SE±	0.19	1.22	1.52	2.02
Interaction				
VXP	*	*	*	*
VXS	*	*	*	*
PXS	*	*	*	*

Means followed by different letters within a treatment are significantly different following DMRT
*Significant at 5 % ($P \leq 0.05$). WAS = Weeks after sowing.

Table 4: Influence of phosphorus fertilizer and varieties on number of leaves of groundnut grown during 2017 and 2018 rainy season in Billiri, Gombe State.

Treatments	**Number of leaves per plant**			
Varieties	**4 WAS**	**6 WAS**	**8 WAS**	**10 WAS**
Ex-dakar	15.01^{b}	18.21^{b}	35.61^{b}	62.11^{b}
Samnut22	20.22^{a}	25.11^{a}	40.55^{a}	82.91^{a}
LS	*	*	*	*
SE±	0.16	0.18	0.19	0.21
Level of Phosphorus				
0	16.00^{d}	20.10^{d}	32.91^{d}	58.12^{d}
30	19.11^{c}	26.30^{c}	41.99^{c}	69.41^{c}
40	23.21^{b}	29.34^{b}	50.31^{b}	80.12^{b}
50	28.21^{a}	35.11^{a}	56.28^{a}	99.01^{a}
LS	*	*	*	*
SE±	1	0.01	0.15	1.51
Season				
2017	18.21^{b}	28.25^{b}	40.91^{b}	52.21^{b}
2018	24.57^{a}	32.01^{a}	58.11^{a}	98.11^{a}
SE±	0.19	1.22	1.52	2.02
Interaction				
VXP	*	*	*	*
VXS	*	*	*	*
PXS	*	*	*	*

Means followed by different letters within a treatment are significantly different following DMRT
*Significant at 5 % ($P \leq 0.05$). WAS = Weeks after sowing.

Table 5: Influence of phosphorus fertilizer and varieties on yield characters of groundnut grown during 2017 and 2018 rainy season in Billiri, Gombe State.

Treatments	**NPP**	**% Diff**	**100SW(**kg ha^{-1})	**% Diff**	**PY (**kg ha^{-1})	**% Diff**
Varieties						
Ex-dakar	15.00^{b}	(42.1)	124.80^{b}	(14.1)	619.90^{b}	(42.5)
Samnut22	25.91^{a}		145.20^{a}		1078.30^{a}	
LS	*		*		*	
SE±	4		34		187.31	
Level of Phosphorus						
0	6.00^{d}		82.10^{d}		421.12^{d}	
30	8.21^{c}		96.30^{c}		501.41^{c}	
40	19.21^{b}		112.34^{b}		812.12^{b}	
50	25.21^{a}		148.11^{a}		1201.01^{a}	
LS	*		*		*	
SE±	1		22.01		137.51	
Season						
2017	19.21^{b}	(21.8)	98.25^{b}	(25.8)	8211.21^{b}	(18)
2018	24.57^{a}		132.01^{a}		1011.11^{a}	
SE±	4.57		32.32		172.98	
Interaction						
VXP	*		*		*	
VXS	*		*		*	
PXS	*		*		*	

Means followed by different letters within a treatment are significantly different following DMRT.
*Significant at 5 % ($P \leq 0.05$). NPP = Number of Pod per Plant, 100 SW = 100 Seed Weight **(**kg ha^{-1}), PY = Pod Yield **(**kg ha^{-1}). Numbers in parentheses indicate % differences between the two varieties and the two seasons.

Table 6: Meteorological data covering the experimental site during 2017 rainy season

Year	Month	Rainfall (mm)	Temperature		Relative humidity	
			(Min)	(Max)	(Min)	(Max)
2017	April	20.21	21	38	21	85
	May	25.22	20	37	44	80
	June	79.31	19	34	38	85
	July	229.31	19	32	39	86
	August	384.21	18	34	41	85
	September	241.01	19	37	45	91
	October	3.1	18	36	25	10
2018	May	22.22	21	34	42	81
	June	72.31	20	32	38	80
	July	219.11	20	35	33	88
	August	314.01	19	31	40	82
	September	221	20	35	42	90
	October	3.1	18	36	29	20

Gombe State Agricultural Development Project, Ladongor Metrological Section, Billiri, Gombe State, Nigeria.

Discussion

The experiment unveiled the superiority of Samnut 22 variety over Ex-dakar variety in Billiri, having surpassed it in all the growth and yield parameters assessed. Dissimilarity in performance may be ascribed primarily to genotypic variability among the varieties. Tarawali and Quee, 2014 reported genetic variability among Samnut 22 and Samnut 23. There was significant difference in growth parameters; plant height, number of branches per plant and number of leaves per plant in this study. Animasaun *et al*., 2014 also reported significant differences with plant height, number of leaves, leaf length, leaf breadth and petiole length performance in two varieties of groundnut. In this study, Samnut 22 variety out performed Ex-dakar variety in all the yield parameters studied by 42.11%, 14.05% and 42.51 % with number of pods per plant, 100 seed weight (kg ha^{-1}) and pods yield (kg ha^{-1}), respectively. From the foregoing, Samnut 22 is inherently higher-yielding than Ex-dakar which implies that the variety is more efficient in the manufacture of assimilate and partitioning of same to the reproductive sink. This may explain the superiority in seed yield production of Samnut 22 over Ex-dakar variety. In similar study, Karama *et al*., (2011) reported the superior performance of Samnut 23 over Samnut 22. The experiment shows that the phosphorus level of 50 kg ha^{-1} is more suitable for productivity of groundnut in Billiri using sandy loam soil having performed better than other levels of phosphorus application for all the measured growth and yield indices. In this study, there were consistent incremental responses of all parameters with levels of phosphorus application. Similar results were reported by Tran Thi (2003) and Anil *et al*., (2008) who reported increase in grain yield with phosphorus application. Rajkishore (2005) reported that the number of filled pods per plant, total number of pods per plant at harvest and yield per hectare and consequently yield in groundnut were influenced by different levels of phosphorus application. All growth and yield parameters assessed in 2018 differed significantly from the assessment of 2017. The rainy season of 2018 outperformed 2017 by 21.82%, 25.57% and 18% with number of pods per plant, 100 seed weight **(**kg ha^{-1}) and pod yield **(**kg ha^{-1}), respectively. This may be attributed to the fact that the available phosphorus 60.11 mg kg^{-1} in 2018 was higher compared to that of 2017 (58.61 mg kg^{-1}). Karama *et al*., (2011) reported that phosphorus addition increased the dry matter production of groundnut. The observed significant variety × fertilizer interaction V × F, V × S as well as P × S for all parameters assessed has practical implication. The interaction revealed that 50 kg ha^{-1} of phosphorus is not comparable to other levels of phosphorus application used in this study irrespective of the variety. However, variety is a key factor in achieving higher yield as demonstrated in this study.

Conclusion

This study found that variety has significant effect on growth characters such as plant height, number of branches per plant, number of leaves per plant as well as yield character such as number of pods per plant, 100 seed weight per hectare and pod yield per hectare. The variety Samnut 22 is inherently genetically superior to Ex-dakar in terms of yield. It was also found that response of groundnut to phosphorus application was steady and consistent with all parameter assessed, which validates the importance of phosphorus for production of groundnut. In a sandy loam soil, 50 kg ha^{-1} of phosphorus is recommended for groundnut optimum yield production in Gombe, Nigeria.

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