International Journal of Plant & Soil Science
7(3): 186-191, 2015; Article no.IJPSS.2015.144
ISSN: 2320-7035

SCIENCEDOMAIN *international*
www.sciencedomain.org

Influence of Phosphorus Sources on the Yield and Yield Components of Groundnut (*Arachis hypogaea* L.) Varieties in Sokoto, Semi-Arid Zone of Nigeria

M. Musa[1*], A. Singh[2] and A. I. Take-tsaba[3]

[1]Department of Crop Science, Usmanu Danfodiyo University, Sokoto, P.M.B. 2346, Sokoto State, Nigeria.
[2]School of Biosciences, University of Nottingham, Malaysia Campus, 43500 Semenyih, Selangor, Malaysia.
[3]Department of Agricultural Education, School of Vocational Education, Federal College of Education (Technical), P.M.B 1088, Gusau, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. The authors of this manuscript worked together to design, conduct, analyze and interpret the findings of this experiment. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2015/16850
Editor(s):
(1) A. Mujib, Department of Botany, Hamdard University, India.
Reviewers:
(1) Klára Kosová, Division of Crop Genetics and Breeding, Crop Research Institute, Prague, Czech Republic.
(2) Alhassan Idris Gabasawa, Department of Soil Science, Faculty of Agriculture, Institute for Agricultural Research, Ahmadu Bello University, P.M.B. 1044, Zaria, Nigeria.
(3) Anonymous, University of Douala, Cameroon.
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=1095&id=24&aid=9248

Original Research Article

Received 16th February 2015
Accepted 21st April 2015
Published 14th May 2015

ABSTRACT

Groundnut (*Arachis hypogaea* L.), is a valuable source of edible oil, cakes and livestock feeds (haulm) produced throughout the tropics. However, its production is constrained by high cost of water soluble P fertilizers that are beyond the reach of most tropical poor farmers and hence, the need to study alternative sources of P that could provide information on how to increase the yield of the crop. Thus the present study was undertaken to study the influence of phosphorus sources on the yield and yield components of groundnut varieties in the region. Two field experiments were conducted during 2007 and 2008 rainy seasons at the Dryland Teaching and Research Farm of the Department of Crop Science, Usmanu Danfodiyo University Sokoto, Sokoto State, Nigeria. Treatments consisted of factorial combination of two groundnut varieties and three phosphorus

**Corresponding author: E-mail: mukhtar.musa@udusok.edu.ng;*

sources [Sokoto rock phosphate, single super phosphate and a control (the crop relying on soil residual P from the preceding crop's fertilizer application)]. The treatments were laid out in a randomized complete block design replicated three times. The results revealed that number of pods per plant, pod yield, kernel yield, shelling percentage and harvest index were higher in Ex-Dakar variety. The performance of the crop was not influenced by direct application of phosphorus on the crop. Thus, from the findings of this study Ex-Dakar variety could be suggested for increased groundnut production in the study area. The crop could be grown with or without direct application of phosphorus.

Keywords: Legume; residual soil P; rock phosphate; single super phosphate; valuable cash crop.

1. INTRODUCTION

Groundnut (*Arachis hypogaea* L.), also known as peanut, is an important source of edible oil and the seeds are reported to contain high quality edible oil (50%), easily digestible protein (25%) and carbohydrates (20%). The crop is a valuable source of E, K and B vitamins (it is the richest plant source of thiamine (B1) and is also rich in niacin, which is low in cereals). Groundnut cakes, formed after the oil is extracted, are a high-protein animal feed [1,2]. In Nigeria, the crop is produced in the arid and semi-arid regions where the hay (haulm) is used as livestock feed and is a valuable source of cash for small scale farmers [3,4].

Despite the immense importance of the crop, the yield obtained by farmers in Nigeria [5] is very low when compared to some other African countries. The lower yield of the crop in this region could be attributed to the inherent low soil P status and the inability of the farmers to access water soluble form of P fertilizers such as the single super phosphate (SSP). In Africa and India, most of the crop is produced on highly weathered sandy soils [2,4]. One way the yield could be improved is through the use of alternative sources of P such as rock phosphate which is locally and easily available to resource poor farmers in the region [4] and the identification of a more suitable variety. Reddy et al. [6] reported that the yield of groundnut can be increased up to 30-89% provided high yielding varieties are identified.

Therefore, this study was undertaken to evaluate the influence of phosphorus sources on the yield and yield components of groundnut varieties under semi-arid conditions of Nigeria.

2. MATERIALS AND METHODS

2.1 Experimental Site

Field trial was conducted in 2007 and 2008 rainy seasons at the DryLand Teaching and Research Farm of Usmanu Danfodiyo University Sokoto. Sokoto is located in the Sudan Savanna agro-ecological zone of Nigeria on latitude 13º01'N; longitude 5º15'E and at an altitude of about 350m above sea level. The climate of the area is semi-arid characterized with erratic and scanty rainfall. The relative humidity ranges from 21-47% in the dry season and 51-79% during the rainy season and the temperature ranges from 14 to 41ºC [7,8]. The annual rainfall data in 2007 and 2008 cropping seasons were 452.3 and 667.6 mm respectively (Table 1). Textural class of the soil in the experimental site was sandy. The soil was slightly acidic (pH 6.75 in H_20), low in organic carbon (0.56 g kg^{-1}), low in available phosphorus (0.21 ppm), low in Ca (0.27 cmol kg^{-1}) and low in residual nitrogen (0.04%) the physico-chemical properties of the experimental site are presented in Table 2.

2.2 Treatments and Experimental Design

Treatments consisted of factorial combination of three phosphorus sources [Sokoto rock phosphate (33.9% P_2O_5), Single Super Phosphate (18% P_2O_5) and a control (no application of P fertilizer during the growing season therefore the plants relied solely on the residual effect of the P applied to preceding crop). The fertilizers in the P treatments were applied at the recommended level of 40 kg P_2O_5 ha^{-1}] and two varieties of groundnut [Ex-Dakar (SAMNUT-14) and RMP-12 (SAMNUT-10)] laid out in a randomized complete block design (RCBD) replicated three times.

2.3 Cultural Practices

In both 2007 and 2008, the land was prepared by mechanical plowing using tractor and the pulverized soil was leveled using a hoe. Plots measuring 3.75 m x 3.00 m (11.25 m^2) were demarcated and ridged at 75 cm inter-row spacing. The net plot area was maintained at 2.25 m x 2.6 m (5.85 m^2). Seeds of the two

groundnut varieties [EX-Dakar and RMP-12 released by IAR in 1988 [9] were sourced from Sokoto Agricultural and Rural Development Authority (SARDA), Sokoto. Ex-Dakar (SAMNUT-14) is a short season (90-100 days) drought tolerant Spanish bunch type of erect growing habit characterized by small pods and thinner hulls with almost no constriction. The seeds are small and round weighing 32-40 g 100-seeds^{-1}. The leaves are small and dark shiny green in color (IAR, 1989). RMP-12 (SAMNUT-10) is a late maturing (130-150 days) rosette resistant of semi erect growing habit. The pods are large and moderately constricted with slightly humped and prominent beak. The hulls are thicker and the seeds have variegated seed coat color weighing 50-55 g 100-seeds^{-1} [9]. Sowing was done on ridges spaced at 75cm apart. Two seeds were dibbled at about 3-5 cm depth at a plant-plant distance of 20 cm. Sowing was carried out on 9th July and 23rd June for 2007 and 2008, respectively. Weeding was carried out manually at 4 and 8 weeks after sowing to ensure good crop establishment and subsequent weeding only involved hand pulling. Harvesting was carried out from the net plot at physiological maturity. The crop was air-dried to a constant weight, as harvesting was at the onset of the dry season when the relative humidity was very low. Threshing, sorting and shelling were all manually carried out. The moisture content at the time of weighing was determined to be 10%.

Table 1. Meteorological data at the experimental site during 2007 and 2008 cropping seasons

Year	2007		2008	
Month	**Mean monthly temp (°C)**	**Mean monthly rainfall (mm)**	**Mean monthly temp (°C)**	**Mean monthly rainfall (mm)**
May	34	0.2	34	57.0
Jun.	32	18.0	32	114.2
Jul	29	101.0	28	79.6
Aug.	27	214.8	27	190.4
Sep.	28	118.3	28	221.6
Oct.	31	0.0	30	4.8
Total		452.3		667.6

Sources: rainfall data: Sokoto Energy Research Centre, Sokoto; temperature data: Sultan Abubakar III International Airport, Sokoto

Table 2. Physico-chemical characteristics of the soil at the experimental site in 2007 and 2008 cropping seasons

Properties	Cropping season	
	2007	**2008**
Physical Properties		
Sand (g kg^{-1})	940	960
Silt (g kg^{-1})	10	10
Clay (g kg^{-1})	50	30
Textural class	Sand	Sand
Chemical Properties		
pH in (H_20) 1:1 ratio	6.13	6.02
Total nitrogen (%)	0.04	0.03
Organic C (g kg^{-1})	0.58	0.54
Available P (mg kg^{-1})	0.22	0.19
Exchangeable bases (cmol kg^{-1})		
Ca	0.30	0.25
Mg	0.50	0.45
K	0.33	0.31
Na	0.42	0.33
CEC (cmol kg^{-1})	8.2	5.8

2.4 Data Collection and Analysis

Data were collected on number of pods per plant, pod yield, kernel yield, haulm yield, shelling percentage and harvest index.

At harvest, five plants from each plot were randomly sampled and for each, the number of pods per plant was counted and the average was recorded. The pod yield which represents the weight of the grain + shell, the haulm yield (literally called hay) and the grain yield were computed from the entire net plot area and the values were extrapolated to yield per hectare. The harvest index which represents the weight of the grain as a ratio of the total dry matter in percentage and the shelling percentage which represents the weight of the grain as a ratio of the pod weight also in percentage were computed using the values obtained from the total net plot area.

The data collected were subjected to analysis of variance (ANOVA) procedure using SAS 2003® (SAS Institute Inc. Cary, NC, USA.) computer software. Least significant difference (LSD) was adopted for means separation.

3. RESULTS AND DISCUSSION

3.1 Number of Pods per Plant, Pod Yield and Grain Yield

The mean performance of the crop in number of pods per plant, pod yield and grain yield as influenced by variety and P source during the 2007 and 2008 cropping seasons is presented in Table 3. Significant (P=.05) difference between the varieties in number of pods per plant, pod yield and grain yield was observed during the trial (Table 3). Ex-Dakar variety recorded higher number of pods per plant (27 pods), pod yield (1940 kg ha^{-1}) and grain yield (1338 kg ha^{-1}) than RMP-12 which recorded 15 pods per plant, 1000 kg ha^{-1} pod yield and 643 kg ha^{-1} grain yield. In the P source treatments however, the number of pods per plant which ranged from 21-22 pods, pod yield (1393- 1552 kg ha^{-1}) and grain yield (966-1029 kg ha^{-1}) were not influenced by P application on the crop.

The differences observed between the two varieties could be attributed to the differences in their genetic make-up and to the adaptation of the varieties to the present environment of studies. The higher performance of Ex-Dakar variety compared to RMP-12 could be attributed to its shorter duration of growth (90-110 days) compared to RMP-12 (130-150 days) and hence it is said to suit the growing conditions obtained in the semi-arid tropical regions. This finding is in support of Musa et al. [4].

The non-significant difference observed between the treatments receiving SSP and RP as P sources and with the control treatments (where no P was applied but plants relying on previous P fertilization) suggests that the crop does not respond to direct application of phosphorus and hence relied on the residual soil P.

Table 3. Mean number of pods per plant, pod yield and kernel yield of groundnut as influenced by variety and P source at the dryland teaching and research farm, Usmanu Danfodiyo University Sokoto during the 2007 and 2008 cropping seasons

Treatments	Number of pods $plant^{-1}$	Pod yield (kg ha^{-1})	Kernel yield (kg ha^{-1})
Variety (V)			
Ex-Dakar	27a	1940a	1338a
RMP 12	15b	1000b	643b
SE	1.75	174.02	106.47
Significance	*	*	*
Phosphorus Source (S)			
Control	22	1393	969
SSP	21	1427	966
PR	22	1552	1029
SE	2.05	203.15	124.29
Significance	ns	ns	ns
Interaction			
V X S	ns	ns	ns

Means within each column followed by the same letter (s) are not significantly different at 5% using LSD test.
** = significant at 5 % probability level, ns = not significant at 5 % probability level*

This opinion on the response of the crop to direct application of nutrients was earlier suggested by Gibbons et al. [3]. The reason could probably be due to the inadequate rainfall of these regions to allow full dissolution and utilization of the applied fertilizers during the first growing season.

The higher number of pods per plant, pod yield and grain yield recorded by Ex-Dakar variety compared to RMP-12 could be attributed to its early maturing (90-100 days) and drought tolerant ability [9] to escape late season drought. Whereas, for RMP-12 which recorded lower performance could be attributed to its longer duration requirement (130-150 days) which was not satisfied in either of the growing seasons. In a related studies, Omokanye et al. [10] working on IAR varieties at Shika, Zaria reported the superiority of RMP-12 for both forage and grain production but Shika, Zaria is located in the sub-humid Agro-ecological zone [10]. Also, the higher grain and pod yield recorded by Ex-Sokoto variety could be attributed to its higher number of pods per plant as these parameters are positively correlated [11]. The contradiction could be attributed to shorter rain duration received during the trial as De Waele and Swanevelder [1] reported moisture stress to be the most limiting factor to groundnut production in the tropics. Gibbons et al. [3] reported long duration varieties to have more number of pods. Likewise, Duncan et al. [12] reported length of the growing period among the three physiological processes to explain most of the yield variation in peanut. However, since Sokoto environment is semi-arid with shorter rain duration the performance of Ex-Dakar was not surprising as the short duration matches its requirement and hence the better performance of the crop.

3.2 Haulm Yield, Shelling Percentage and Harvest Index

The mean performance of the crop in haulm yield, shelling percentage and harvest index as influenced by variety and P source during the 2007 and 2008 cropping seasons is presented in Table 4. Significant (*P*=.05) difference between the varieties in shelling percentage and harvest index was observed during the trial. Ex-Dakar variety recorded higher shelling percentage (72.0%) and harvest index (33.8%) than RMP-12 which recorded 64.3 and 33.8% for the shelling percentage and harvest index respectively. However, despite the differences in the shelling percentage and harvest index between the two varieties, the haulm yield which ranged from 1845-1997 kg ha^{-1} was not significantly different between the varieties. In the P treatments, the haulm yield which ranged from 1829 - 2004 kg ha^{-1}, shelling percentage (65.8-69.0%) and harvest index (26.6-28.5 %) were not influenced by P application on the crop.

The higher shelling percentage and harvest index recorded by Ex-Dakar variety compared to RMP-12 could be attributed to its thinner shells and higher grain yield since the haulm yield was not different between the varieties. Phudenpa et al. [11] reported small seed size to be associated with high shelling percentage, because of the thinner shells. Also this is in agreement with the earlier report by many researches [1-3].

Table 4. Mean haulm yield, shelling percentage and harvest index of groundnut as influenced by variety and P source at the Dryland teaching and research farm, Usmanu Danfodiyo University Sokoto during the 2007 and 2008 cropping seasons

Treatments	Haulm yield (kg ha^{-1})	Shelling percentage (%)	Harvest index (%)
Variety (V)			
Ex-Dakar	1997	72.0a	33.8a
RMP 12	1845	64.3b	21.2b
SE	166.01	1.36	0.86
Significance	ns	*	*
Phosphorus source (S)			
Control	1829	65.8	28.0
SSP	2004	67.6	26.6
PR	1841	69.0	28.5
SE	193.79	1.59	1.01
Significance	ns	ns	ns
Interaction			
V X S	ns	ns	ns

Means within each column followed by the same letter(s) are not significantly different at 5% using LSD test.
** = significant at 5 % probability level, ns = not significant at 5 % probability level*

4. CONCLUSION

The study revealed that pod and kernel yield, shelling percentage, harvest index and pods per plant were higher in Ex-Dakar variety than RMP-12. The effect of direct P application on the crop was not observed during the trial. Hence, it could be concluded that Ex-Dakar variety could be adopted for increased groundnut production in the study area and the crop could be grown with or without direct application of phosphorus.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the tireless effort of Alhaji Musa Bawa Bodinga (a renowned farmer from the study area) for single-handedly funding this research work and the Department of Crop Science, Usmanu Danfodiyo University Sokoto, Sokoto State, Nigeria for providing the experimental site where the study was conducted.

COMPETING INTERESTS

The authors declare that they have no competing interest whatsoever.

REFERENCES

1. De Waele D, Swanevelder CJ. Groundnut. In: Romain HR, (ed). Crop Production in Tropical Africa. DGIC Belgium; 2001.
2. Basu M, Bhadoria PBS, Mahapatra SC. Growth, nitrogen fixation, yield and kernel quality of peanut in response to lime, organic and inorganic fertilizer levels. Bioresource Technology. 2008;99(11): 4675-4683.
3. Gibbons R, Nigam S, Chater S. The tropical agriculturalist-groundnut. Macmillan Education Ltd. London and Oxford; 2002.
4. Musa M, Singh A, Abubakar L, Noma SS, Alhassan J, Haliru BS. Influence of cultivar and sokoto phosphate rock levels on the yield and yield components of groundnut (*Arachis hypogaea* L.) in dry sub-humid Sokoto Area, Nigeria. Nigerian Journal of Basic and Applied Sciences. 2012; 20(1):49-54.
5. FAOSTAT. Food and Agricultural Organizations Statistics; 2005.
   Available: http://www.fao.org (Accessed 01 May 2007)
6. Reddy LJ, Nigam SN, Subrahmanyam P, Reddy RGS. Registration of ICGV-86590, peanut cultivar. Crop Sci. 1993;33:357-358.
7. Singh BR. Soil management strategies for the semi-arid ecosystem in Nigeria. The case of Sokoto and Kebbi states; Afr. Soil. 1995;25:317-320.
8. Ojanuga AG. Agro ecological Zones of Nigerian MAPS. National Special Programme on Food Security, FAO-UNESCO; 2004.
9. IAR. Institute for agricultural research. Code and descriptor list of crop varieties. IAR, Samaru. Ahmadu Bello University, P.M.B. 1044, Zaria, Nigeria; 1989.
10. Omokanye AT, Onifade OS, Olorunju PE, Adamu AM, Tanko RJ, Balogun RJ. The Evaluation of dual-purpose groundnut (*Arachis hypogaea* L.) varieties for fodder and seed production at Shika, Nigeria. The Journal of Agricultural Science. 2001;136(1):75-79.
11. Phudenpa A, Jogloy S, Toomsan B, Wongkaew S, Kesmala T, Patanothai A. Heritability and phenotypic correlation of traits related to N_2-fixation and agronomic traits in groundnut (*Arachis hypogaea* L.) Songklanakarin J. Sci. Technol. 2004; 26(3):317-325.
12. Duncan WG, Mc Cloud DE, Mc Graw RL, Boote KJ. Physiological aspects of peanut yield improvement. Crop Science. 1978; 18:1015-1020.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=1095&id=24&aid=9248