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THE GROWTH AND YIELD PERFORMANCE OF GROUNDNUT (*ARACHIS HYPOGEA*) CULTIVATED UNDER VARIOUS FERTILIZER INPUTS ON AN ALFISOLS IN THE SOUTHERN GUINEA SAVANNA ZONE OF NIGERIA

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ABSTRACT

The response of groundnut variety SAMNUT22 to various fertilizer inputs was examined on a field experiment at the Teaching and Research Farm of the Federal University of Technology, Minna during the 2010 cropping season. A total land area of 0.06 ha was cleared, harrowed, ploughed and ridged. Thirty plots of size 4 x 3.5m were marked out at plot spacing of 1m and replicate spacing of 2m. Soil samples were taken randomly from 20 points at soil depth of 0-20cm with the aid of an auger. Samples taken were bulked to form a composite, air dried and screened through a 2mm sieve to remove contaminants. Physicochemical properties of sub-samples were determined using the methods described by IITA, 1979. Seeds of Groundnut variety, SAMNUT22 were planted on the 24th of July, 2010 at an inter and intra row spacing of 75cm x 25cm and at the rate of 3 seeds per stand. Seedlings were later thinned to two seedlings per stand at 2 weeks after planting (WAP), prior to fertilizer treatments. There were five fertilizer treatments as follows: SSP at 30 kg P ha^{-1}, Rock phosphate at 30 kg P ha^{-1}, SSP + Urea at 30 kg P ha^{-1} and 20 kg N ha^{-1} respectively; SSP + Agrolyzer at 30 kg P ha^{-1} and 900g ha^{-1} respectively and the zero fertilizer treatment. All the treatments were arranged in a Randomized Complete Block Design replicated 3 times. Tissue sampling was done destructively within the two inner ridges when the plants were at mid flowering while harvesting was done at physiological maturity. Data collected were statistically analyzed and results revealed that apart from shoot biomass, nodule No, % P in leaf and seed, fertilizer treatments affected growth, nodulation and yield parameters of SAMNUT22 significantly at $P<0.05$. Plots without fertilizer treatments were not the poorest in response: they recorded the best nodule weight and number and the second best yield. Plants that were supplied with Rock phosphate gave significant improvement in leaf number, nodule weight and yield compared with those receiving SSP alone. Inclusion of SSP to Urea significantly improved plant height and leaf number than when plants received zero fertilizer application and SSP alone.

Key words: Growth, nodulation, yield response, Groundnut variety, fertilizer inputs.

INTRODUCTION

Groundnut (*Arachis hypogaea.*) is an annual soil enriching, self pollinated legume, cultivated widely in the arid and semi-arid regions of the world (40^{o} N and 40^{o} S), in temperature regimes ranging from warm temperate to equatorial. It is an important oilseed crop of the semi-arid tropics-SAT (Fletcher *et al.*, 1992; Tarimo, 1997; Anon, 2004; ICRISAT, 2008), and ranks thirteenth (13th) in importance as a food crop.

Groundnuts are staple food in a number of developing countries. (Peanut CRSP, 1990). Groundnuts are protein rich fruits that grow well in semi-arid regions (Schilling and Gibbons, 2002). They are also grown as a protein source and source of income. It is a good source of edible oil for humans as well as a nutritive feed supplement (as protein cake) for livestock (Goldsworthy and Fisher, 1987).).

Groundnut an important oilseed crop in Nigeria is widely grown in the tropics and subtropics
(Nigram et al.,1991). It is one of the most important crop that have the ability to thrive on newly reclaimed sandy soils by adding symbiotically (biologically) fixed nitrogen to the soil. In many parts of arid the climates, virtually every part of the crop is useful (from seed to vine and shell) after harvest. As far as nitrogen is concerned, cropping systems (rotations or mixtures) including a legume is reported to have shown in many cases, very significant benefits for the yields of accompanying (mixed cropping) or subsequent non-legume crops (Okito *et al.*, 2004; Schilling and Masari, 1992).

Establishment of sole groundnut crop using unsuitable varieties in low fertility soils often lead to lower yields ha^{-1} as a result of sub-optimum fertilizer rates, leading to poor utilization of crop growth resources and under-utilization of scarce fertilizer inputs in the face of pressing need for cash income by the farm family. There is therefore the need to come up with groundnut varieties and optimum fertilizer rates that will enable farmers in different agro-ecological zones to produce the crop without significant increase in production cost. This is expected to increase groundnut production nationally without decreasing the annual production of cereal.

As part of the objective of N2Africa Project to select multi-purpose legumes providing food, high quality crop residues for enhanced BNF and integrate improved varieties into our resource-poor farming systems, response of groundnut variety SAMNUT22 to five fertilizer input combinations (No fertilizer application at 0 kg ha^{-1} , Sole SSP fertilization at 30 kg P ha^{-1}, Sole Rock Phosphate fertilization at 30 kg P ha^{-1},Combination of SSP at 30 Kg P ha $^{-1}$ and Urea at 20kg N ha^{-1}, and a Combination of SSP at 30kg P ha^{-1} and Agrolyzer at 900g ha^{-1}) was evaluated in a field experiment. The aim was to select the best input or input combinations that will ensure good growth and yield performance of SAMNUT22 cultivated on an Alfisol in Minna, Southern Guinea Savanna Zone of Nigeria.

MATERIALS AND METHODS

Study Area and Location

The study was carried out at the research farm of the School of Agriculture and Agricultural Technology, Federal University of Technology Minna, permanent site located at kilometer sixteen (16 km) along Minna-Bida road from the month of August to December 2010. Minna lies within the Southern Guinea

Savanna of Nigeria (Latitude 9˚49N and Longitude 6˚30E).

It has a sub-humid tropical climate with a mean annual rainfall of 1200mm. 90% of this rainfall is between the month of July and August), the temperature is below 22˚C; the peak is 40˚C, **i.e.** in the month of (February and March) and 36˚C in the month of (November to December) (Juo, 1981).

Soils from Minna are derived from the basement complex rock. They are shallow to very deep soils overlying deeply weathered gneisses and magnetite. Some of these soils are underlain by iron pan to a varying depth. The soils are strong brown to a red sandy clay or clay with gravely loamy sand or sandy surface soil layer (FDALRI, 1990). In Minna, the most predominant soil type is the ferruginous tropical soil which is basically derived from the basement complex rocks, and also from the old sedimentary rocks. These ferruginous tropical soils are ideal for the cultivation of Maize (*zea mays*), Millet (*panicum miliaceum*) and ground nut (*Arachis hypogeal*). The vegetation in Minna is characterized by tall grasses, wood land which is interspersed with tall dense species.

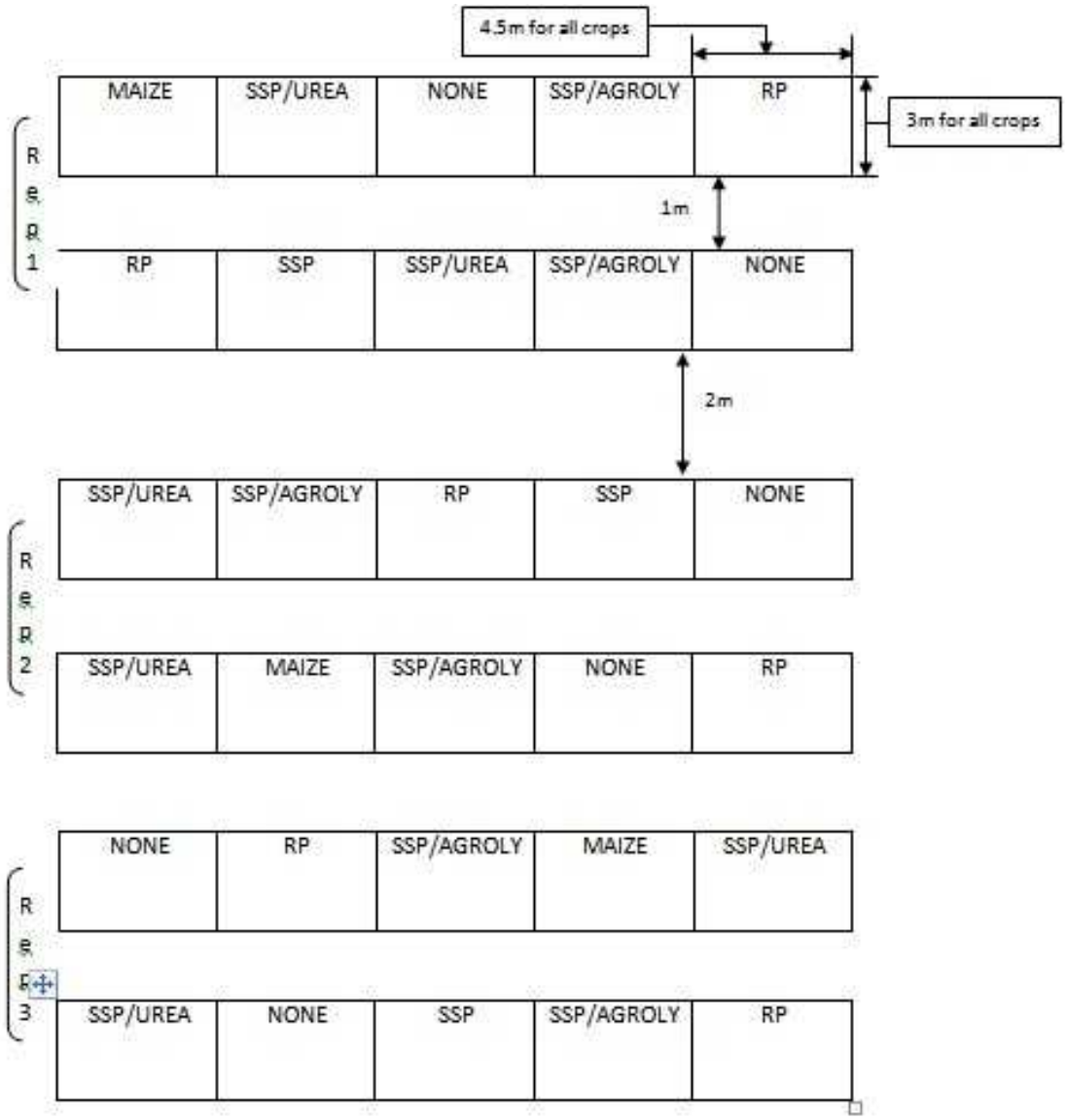
Soil Sampling and Analysis

The soil samples were collected at random on the field at a depth of 0 to 20cm, using a soil auger. A total number of 20 soil samples were collected and air dried. The soil samples were crushed and sieved with 2mm and 0.5mm sieve mesh, after which the sub-samples were taken from the composite sample for the determination of physico-chemical properties as follows; determination of soil p^H in water and 0.01M$CaCl_2$ solution using p^H meter, determination of soil particle size using hydrometer method (Bouyoucous, 1962), organic carbon in the soil was determined by dichromate oxidation and titration with ferrous ammonium sulphate (Walkey, 1947), available P was extracted by bray-1 extraction and it was determined using colorimeter. The exchangeable base was determined after the extraction with neutral 1N NH_4OAC, Ca^{2+} and Mg^{2+}, using Na-EDTA titration method (Agbenin, 1995), Exchangeable acidity was also extracted with 1NKCl,

Land Preparation, Experimental Design and Treatment

During the research, the total land area of 24.5m by 25m was cleared, after which it was harrowed and ridged. The land was then marked out and divided into three replicates out of which each replicate contained two blocks. There were a total number of six blocks in all. Each of this block was divided into sub-plots of 4m by 3.5m, maintaining a space of 1m between each block and a space of 2m between each replicates.

Five different fertilizer treatments were applied as follows; single super phosphate at 30kg Pha^{-1}, Rock phosphate 30kg Pha^{-1}, Single Super Phosphate at 30kg Pha^{-1} and Urea at 20kg Nha^{-1}, Single Super Phosphate at 30kg Pha^{-1} and Agroliser at 900gha^{-1} and zero fertilizer treatment. The reference groundnut variety was SAMNUT22 obtained from N2 Africa Project. The experiment was arranged in a randomized complete block design as shown overleaf.



Planting and crop management

Groundnut variety SAMNUT22 was planted on 2nd of August 2010. Two seeds were planted per hole at intra row spacing of 25cm and inter row spacing of 75cm. Manual weeding was also done twice before Harvesting; the first weeding was at 2weeks after planting while the second weeding was before flowering.

Biomass sampling and Harvesting

The shoot biomass weight, plant height, days to 50% flowering and podding, nodulation, leaf number were taken at 50% flowering by destructively sampling four plants within the

two inner ridges. Harvesting was done after the groundnut had fully matured, by pulling the plants from the soil, plucking the pods, sun drying and threshing. Yield data was collected after harvesting.

Determination of Phosphorus in Plant Tissue (Dry Ashing)

Determination of Tissue P (Dry Ashing method)

Procedure

0.5g of finely grounded and oven dried ($60^{o}C$) plant material was weighed into a 30ml porcelain crucible. The sample was placed in a muffle furnace for 6-8 hours at a temperature

of 450°C until it was turned to a grayish white ash. The sample was cool on top of asbestos sheet, and then 20ml of 20% HCl was added and placed on a hot plate at low heat under ventilation to evaporate to dryness. Then 10ml of 0.1N HCl was added and filtered into a 50ml volumetric flask and made up to volume with 0.1N HCl solution. 1ml of the sample solution was pipetted into a test tube, followed by 5ml of distilled water and then 4ml of vanado-molybdate to a yellow coloration. The percentage transmittance was then determined at 400µm by plotting it against the standard curve for P pipetted 0, 2, 4, 6, 8 and 10ml. 25ml P standard solution was then pipetted into a series of 100ml volumetric flasks and colour developed according to the same procedure stated.

Data collection and statistical Analysis

Growth, nodulation and yield data were subjected to statistical analysis using the statistical package, statistical system Analysis version 2.2 for window copyright by SAS inc. (2002) to determine treatment effect at 5% level of significance. Duncan multiple tests were used to separate means. Pearson correlation analysis was used to determine whether linear relationship exist between the parameters.

RESULTS AND DISCUSSIONS

Physico-chemical properties of soil

The results of the physical and chemical properties of the soil at 0-20cm depth are shown in (Table 3.1). The soil was classified as sandy clay loam, with sand % as 75.88, clay % as 23.42 and silt % as 0.70. The soil was slightly acidic with pH of 6.91 in water and pH of 6.41 in $CaCl_2$, and the percent organic carbon was low (6.5g Kg^{-1}). Available Phosphorus was low (9.00mg gKg^{-1}) and consequently, Total Nitrogen was low (<0.30g Kg^{-1}). The Exchangeable Ca (3.10cmol Kg^{-1}) in the Exchangeable bases was higher than others, followed by Mg and K with their values as 1.00cmol Kg^{-1} and 0.48cmol Kg^{-1} respectively and the Na was the least with the value 0.29cmol Kg^{-1}. The Effective Cation Exchange Capacity was also low (<8.0 cmol Kg^{-1}).

Table 1: Some physico-chemical properties of the soil at the Experimental Farm prior to Groundnut Cultivation

Parameter	Value
Sand (g/kg^{-1})	758.8
Silt (g/kg^{-1})	7.00
Clay (g/kg^{-1})	234.2
Textural class	Sandu clay loam
pH in $Cacl_2$	6.41
pH in H_2O (1:2:5)	6.91
available P (mg/kg^{-1})	9.00
total Nitrogen (g/kg^{-1})	0.28
Organic C (g/kg^{-1})	6.50
Exchangeable cations (cmol kg^{-1})	
Mg^{2+}	1.00
Ca^{2+}	3.10
K^{+}	0.48
Na^{+}	0.29
Exchangeable Acidity (cmol kg^{-1})	
$Al^{3+} + H^{+}$	1.38
ECEC (cmol $kg^{=1}$)	6.25

Correlation Coefficient between the pairs of Growth and nodulation of yield parameters of groundnut

Table 2 is the table of coefficient between the parameters measured. Plant height showed a positive correlation ($p<0.05$) with shoot biomass and number of leaves. The shoot biomass shows a positive correlation ($p<0.05$) with number of leaves. Number of leaves also showed a positive correlation with leaf P value.

The number of days to 50% flowering showed a positive correlation with 50% pudding ($p<0.01$) and nodule weight ($p<0.05$). 50% pudding was positively correlated with nodule weight while % leaf damage was negatively correlated with yield Kg ha^{-1} ($p<0.01$).

Table 2: Correlation Coefficient between Growth and Nodulation Parameters.

	Plt hgt (cm)	Leaf No. (plt^{-1})	Shoot bio ($gplt^{-1}$)	Leaf dam (%)	DF 50%	DF 50%	Nod No. (plt^{-1})	Nod wgt ($gplt^{-1}$)	Pod No. (plt^{-1})	Yield ($kgha^{-1}$)	%P (seed)	%P (leaf)	%N (seed)	%N (leaf)
Plt hgt (cm)	1													
Leaf No. (plt^{-1})	0.69**	1												
Shoot biom ($gplt^{-1}$)	0.84**	0.73**	1											
Leaf dam (%)	0.60*	0.26	0.60*	1										
DF 50%	0.22	0.37	0.22	-0.17	1									
DF 50%	0.08	0.12	0.32	0.17	0.27	1								
Nod No. (plt^{-1})	0.80**	0.78**	0.81**	0.63*	0.11	-0.03	1							
Nod wgt ($gplt^{-1}$)	0.76**	0.82**	0.91**	0.57*	0.15	0.26	0.92**	1						
Pod No. (plt^{-1})	0.71**	0.87**	0.76**	0.50	0.09	-0.02	0.89**	0.86**	1					
Yield ($kgha^{-1}$)	0.98**	0.59*	0.83**	0.68**	0.16	0.08	0.80**	0.76**	0.68**	1				
%P (seed)	0.30	0.02	0.16	0.48	0.17	-0.01	0.38	0.19	0.25	0.41	1			
%P (leaf)	0.54*	0.49	0.42	0.66**	-0.07	0.12	0.59*	0.51	0.44	0.54*	0.33	1		
%N (seed)	0.17	0.09	0.19	0.34	-0.08	0.08	0.26	028	0.40	0.24	0.32	-0.01	1	
%N (leaf)	0.36	0.30	0.47	0.55*	-0.29	-0.19	0.70**	0.64**	0.57*	0.43	0.27	0.22	0.21	1

P < 0.05 not significant *p < 0.05 significant ** p < 0.01

Table 3: Growth, Nodulation and yield parameter of Groundnut as affected by various Fertilizer inputs

Inputs	Plant height (cm)	Shoot biomas ($gplt^{-1}$)	Leaf number	Nodules number	Nodules weight ($gplt^{-1}$)	% leaf damage	Days to 50% flowering	Days to 50% podding	Pod number	% P in leaf	% P in seed	Yield ($kgha^{-1}$)
None	36^{c}	32^{b}	211^{c}	8^{a}	0.4^{b}	50.7^{b}	32^{a}	58^{a}	6^{c}	0.011^{a}	0.031^{a}	339.8^{a}
SSP	41^{bc}	55^{a}	205^{c}	8^{a}	0.4^{b}	50.7^{b}	32^{a}	58^{a}	6^{c}	0.011^{a}	0.031^{a}	339.8^{a}
RP	39^{bc}	61^{a}	266^{bc}	7^{a}	0.4^{b}	53.3^{ab}	32^{a}	58^{a}	7^{bc}	0.010^{a}	0.030^{a}	266.7^{b}
SSP & Urea	47^{a}	59^{a}	452^{a}	8^{a}	0.4^{a}	51.7^{b}	32^{ab}	58^{ab}	8^{abc}	0.014^{a}	0.041^{a}	393.8^{a}
SSP & Agro	43^{ab}	61^{a}	388^{ab}	8^{a}	0.4^{a}	56.3^{ab}	31^{bc}	58^{ab}	10^{ab}	0.011^{a}	0.028^{a}	344.4^{ab}

Means with different letters indicated in the columns are significantly different ($P<0.05$).

Growth, Nodulation and Yield Parameters of Groundnut

Groundnut is in dire need of Phosphorus and responses to Phosphorus application has been reported by some authors (El-Habbacha *et al.*,2005). In our result, leaf number and plant height were significantly affected by Phosphorus application ($P<0.05$) (Table 3). Plants supplied with Phosphorus alone were taller and heavier than those without fertilizer application justifying the role P plays in assimilate translocation.This is consistent with the report of Agasimani and Babalab (1991) who reported response to P when the available P status in the soil was less than 35 kg P_20_5 ha^{-1} .These plants were better when inclusion of either Urea at 20 kg N ha^{-1} or Agrolyzer at 900 g ha^{-1} was supplied; the addition of Urea to Single Super Phosphate doubled the leaf number effect produced by sole Single super phosphate probably because urea at 20kg N ha^{-1} was sufficient to enhance growth of leaves. Edna Anthony et al. (2000) revealed that certain leaf indices increased with an increase in Nitrogen dose in all genotypes studied and concluded that 25 kg N ha^{-1} was necessary for optimal growth. Improved leaf growth observed in our research as a result of Agrolyzer inclusion implied that micronutrients were deficient in the soil. Although the amounts of micronutrients were not determined prior to the experiment, the possibility of micronutrient deficiency in slightly acidic soils may not be ruled out. The pH in $cacl_2$ of soil used was 6.41 and studies have shown that Groundnut grown on soils of pH 6.5 has incidences of Mn deficiency. Another micronutrient that is deficient in acidic soils is molybdenum.

Phosphorus has the ability to increase leaf area just as Nitrogen, although it does not affect the power of the leaves to translocate carbohydrates to the roots (Osunde pers.com) hence, it is expected that plants supplied with phosphorus should not be susceptible to leaf damage. However, % leaf damage obtained in our result was increased even by fertilizer application with the highest increase observed when plants were supplied with Single super phosphate . This suggests that application of Single super phosphate alone at 30 kg P ha^{-1} probably enhanced an excessive uptake of soil N which resulted to succulent leaves that were prone to damages.

Plants supplied with Single super phosphate alone and those supplied with Single super phosphate and Agrolyzer flowered earlier only by one day probably because of the P supplied. Phosphorus has been reported to enhance floral initiation and growth and to prevent the abortion of flowers (Uzoma *et al*.,2006). Agrolyzer containing Zn, Cu etc have also been reported to enhance floral initiation. Although Zn and Cu deficiencies are common in alkaline soils, slightly acidic pH of 6.41 in $cacl_2$ probably enhanced their supply to the plants.The lowest nodule number of 7 recorded by plants supplied with Rock phosphate and the lowest nodule weight of 0.3g $plant^{-1}$ produced by plants receiving Single super phosphate alone suggested that SAMNUT 22 may not need external supply of Phosphorus at 30 kg P ha^{-1} to nodulate. This might imply also that the variety was P efficient giving the prevailing condition at the time of cultivation.

Pod number per plant was high when Single super phosphate was supplied alone or in combination with Agrolyzer probably because plants had enough time to produce more pods by flowering earlier (Table 3). Aside that, Phosphorus in the soil could be limiting. Phosphorus is one of the major limiting plant nutrients in the tropical and sub-tropical soils (Rao *et al*.,2004; Agasimani and Babalad 1991) . Averagely, Rock phosphate alone and Single Super Phosphate mixed with Urea produced the best seed and leaf P values compared with the control due to a higher assimilation of the P content of these fertilizer sources alone or in mixture. The high yield of SAMNUT22 at the second best position when

no fertilizer was applied justifies the probability of the variety being P-efficient.

In conclusion, application of Phosphorus fertilizer in a single or in a combined form improved all the plant growth parameters that were observed. The application of Single Super Phosphates in a combined form with Urea gave a better yield response when applied to (SAMNUT22). Further studies should however be carried out to investigate the P- use efficiency of SAMNUT22 under various prevailing environmental conditions and management practices.

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