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YIELD RESPONSE OF GROUNDNUT (*ARACHIS HYPOGAEA* L.) VARIETIES TO GYPSUM AND RHIZOBIA INOCULATION IN THE NIGERIAN SAVANNA

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Abstract

Yield and yield parameters of two groundnut (*Arachis hypogaea* L.) varieties under varying rates of gypsum and rhizobia inoculation levels were studied under field condition in 2012 wet seasons and 2012/13 dry season at the Institute for Agricultural Research Farm, Ahmadu Bello University, Samaru and Irrigation Research Station of the Institute for Agricultural Research, Kadawa respectively. The treatments consisted of factorial combinations of two varieties of groundnut (SAMNUT 22 and SAMNUT 23), five levels of gypsum (0, 50,100,150 and 200kg ha^{-1}) and two levels of rhizobiainoculation (inoculated and uninoculated). The treatments were arranged in a randomized complete block design and replicated three times. Results of the experiment from the two locations showed that application of gypsum and rhizobia inoculation had no significant effect on the parameters examined. However, SAMNUT 22had a significantly higher values of 100 kernel weight, shelling percentage, kernel yield plant^{-1}, pod yield plant^{-1} in Samaru and harvest index in Kadawa compared to SAMNUT 23. Significant interactions wererecordedbetween; gypsum rates andrhizobiainoculation in 100 kernel weight at Samaru and between gypsum rates and variety on the pod yield in Kadawa. Based on the results obtained from the two locations, gypsum fertilization and rhizobia inoculation did not influence the yield and yield parameters, while SAMNUT 22 performed better than SAMNUT 23. In conclusion, application of gypsum may not be necessary on soils high in calcium while further inoculation studies should be carried out on groundnut with the right strains of bacteria and SAMNUT 22 can produce better yield in both seasons.

Keywords: Gypsum, Rhizobia Inoculation, SAMNUT 22 and SAMNUT 23.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an annual herbaceous, self-pollinating legume belonging to the family*Leguminosae* and sub-family *Papilionaceae*.It is native to South America and is one of the world's most popular and universal crops. It is grown in diverse environments in more than 100 countries on 6 different continents (Nwokolo, 1996; Sharma and Mathur, 2006).

Groundnut has high economic and nutritional potential and is an important cash crop for peasant farmers in poor tropical countries including Nigeria. Industrially, the oil produced from the kernel is used in the manufacture of lubricants and other items ranging from shaving cream and soap to plastics. The seed cake is used as livestock feed and fertilizer, and shells are utilized as filler for wallboards and insulators (Onwueme and Sinha, 1991). Groundnuts also play an extremely important agronomic role in the traditional farming system as a nitrogen fixer in crop rotation (Ustimenko-Bakumovsky, 1993).Being a Leguminous crop, it can fix atmospheric nitrogen in soils through root nodule bacteria and thus improves soil fertility.

Calcium is among the most critical elements in the growth and development of groundnut seeds and is the major limiting factor to groundnut production in many parts of the world. The insufficient soil calcium in the root zone has been associated with low productivity of some soils in Nigeria (Osemwola *et al.*, 2003). Declining soil fertility, particularly calcium, has been implicated as one of the possible causes of the low yield problem in groundnut; the deficiency result in lower yield and reduces percentage of sound mature kernel. Calcium requirement of groundnut plant is quite high and it is more during the pod filling stage and to get good quality groundnut pods, adequate amount of calcium should be present in the soil from early flowering of the crop onwards. Gypsum which is calcium sulphate is the cheapest source of calcium and sulphur and it is a fertilizer obtained as a by-product of fertilizer factories. For these reasons, it will be of relevance if gypsum can be used to increase the quality of groundnut kernels and as such improving groundnut production.

Replenishment of nitrogen in agricultural soils has depended largely on the addition of inorganic fertilizers or by the activity of biological nitrogen fixation (BNF) systems. The prolonged applications of large quantity of N inorganic fertilizers are manifesting themselves in environmental degradation such as leaching of nitrates into the ground water and development of soil acidity (Agbenin and Goladi, 1997; Ridley *et al.*, 2004).The economic and environmental costs of inorganic nitrogen fertilizers in agriculture are a global concern and makes it mandatory for alternatives to be urgently sought. Biofertilizers are the source of microbial inoculants, which have brought hope for many countries both economically and environmentally. Therefore, in a developing country like Nigeria, biofertilizers can solve problems of high costs of fertilizers and thussave the economy. Biofertilizers are cultured micro organisms packed in some carrier material for easy applications are used in crop production (USA, 2003). Some identified biofertilizers that are used in crop production include: *Rhizobium*, *Azobacter*, *Azospirillium*, phosphate solubilizers, blue algae and *Mycorrhiza*(NBDC, 2000). Rhizobia inoculation is a cheaper and usually more effective agronomic practice for ensuring adequate nitrogen supply. Thus, yields of grain legumes have been increased substantially by inoculation with the right strains of rhizobia. However, smallholder farmers in Africa have not taken full advantage of free atmospheric nitrogen input by biological nitrogen fixation to enhance legume productivity and soil health. In recognition of this, a project known as N_2Africa which is being led by the Wageningen University, Netherlands is currently being executed in eight countries in sub-saharan Africa (including Nigeria) to put nitrogen fixation to work for smallholder farmers through identification of niches for nitrogen fixing legumes and support of inoculums production. This project introduced a commercial inoculant (legume fix) to farmers in Kano state for soybean production. When farmers observed that this inoculant was very effective on soybean, they started using it on groundnut (personal communication). It is of interest to investigate the response of groundnut to this inoculant as some workers have shown the possibility of cross inoculation. Moreso, as commercial groundnut inoculant is not presently in Nigeria.

Improved seed is a necessary vehicle for achieving high groundnut yields among the farming communities. SAMNUT 22 and SAMNUT 23 are new improved groundnut varieties released by the Institute for Agricultural Research, Samaru as at when this research was carried out. For proper adoption of these varieties, more researches as regards the agronomic information will be required including their response to gypsum and rhizobial inoculation. The use of appropriate varieties for a particular ecology is very important in groundnut production and it is in this light that this work also aims to determine the performance of these varieties in two agro-ecological zones.

The objectives of this study are therefore, to determine the optimumgypsum level and the effect of rhizobial inoculation as well as the variety that is better adaptable to either of the ecological zones on the yield and yield attributes of groundnut varieties.

MATERIALS AND METHODS

Field trials were conducted in the wet season of 2012 at the experimental farm of the Institute for Agricultural Research, Samaru (lat 11^0 $11^{'}$N; long 7^0 38' E and 686m above sea level) which is located in the Northern Guinea Savannah ecological zone of Nigeria and in the 2012/2013 dry season at the Irrigation Research Station, Kadawa (lat 11^0 $39^{'}$N; long 08^0 27' E, 500m above sea level) of the Institute for Agricultural Research which is located in the Sudan Savannah ecological zone of Nigeria. Prior to the establishment of the trial in each location, a composite soil sample of the experimental unit was taken randomly at depths of 0-30 cm using a soil auger. The soil samples were analyzed in the laboratory for physical and chemical properties.

Soil Analysis

The physical and chemical properties of the soils of the experimental sites are presented in Table I. The soil textural class was loam and sandy loam in Samaru and Kadawa respectively and had the characteristics of high nitrogen content, medium and low organic carbon in Samaru and Kadawa respectively. Soils from both Samaru and Kadawa had high calcium content and the pH of the soils from both locations was slightly acidic.

The treatments consisted of factorial combinations of two varieties of groundnut (SAMNUT 22 and SAMNUT 23), five levels of gypsum (0, 50, 100, 150 and 200 kg ha^{-1}) and two levels of rhizobia inoculation (inoculated and uninoculated). These treatments were arranged in a randomized complete block design (RCBD) and replicated three times. The gross plot size of $18m^2$ which consisted of 6 ridges, each 4m long and the net plot size of $6m^2$ which consisted of 2 ridges, each 4m long was used. The seeds of the two groundnut varieties, SAMNUT 22 and SAMNUT 23 were sourced from the Seed Unit of the Institute for Agricultural Research, Samaru. Uninoculated seeds were first planted manually at the rate of two seeds hill^{-1} at a depth of about 5 cm and intra-row spacing of 20 cm. Then, for the inoculated treatments, 100 g of the commercial inoculant (legume fix) was evenly mixed with 25 kg of seeds. The inoculants was made into a slurry form using water and the seeds thoroughly mixed with it to ensure proper coating and planted as soon as it was mixed. Three weeks after sowing (WAS), the crop was thinned down to one seedling hill^{-1}. The experimental area received 54 kg P_2O_5(23.8 kg Pha^{-1}) and 30 kg K_2O (24.9 kg Kha^{-1}) as Single superphosphate (18 % P_2O_5) and Muriate of potash (60 %K_2O) respectively which was carried out at planting. Gypsum was applied as per the treatment, 40 days after sowing (peak flowering stage) (Daughtry and Cox, 1974); and earthening up was done. Weeds were controlled by using glyphosate (round up) at the rate of 4 L ha^{-1} (1.4 kg a.i ha^{-1}) a forthnight prior to land preparation. Also, butachlor at 4 L ha^{-1}(1.4 kg ai ha^{-1}) as a pre-emergence herbicide was applied a day after sowing and two hoe-weeding was carried out 3 and 6 weeks after planting. The following parameters were assessed: pod yield plant^{-1}, kernel yield plant^{-1}, shelling percentage, 100 kernel weight, harvest index, pod yield ha^{-1}. The data collected were subjected to analysis of variance as described by Snedecor and Cochran (1978). Where F-value was significant, treatment means were compared using Duncan Multiple Range Test (Duncan, 1995).

RESULTS AND DISCUSSION

Response to Gypsum Fertilization

The results of this study have shown that the two groundnut varieties did not respond significantly to gypsum in the two locations. The non significant response of the parameters to the application of gypsum could be attributed to the high soil calcium (6.0 cmolkg^{-1} and 5.3 cmolkg^{-1} in Samaru and Kadawa respectively) as indicated in Table I, and as such, the addition of extra calcium may have not been necessary. This is in line with the proposition of Robert (2011) who noted that soil calcium is an important factor when evaluating the need for calcium fertilization, as additions of lime and gypsum do not show improvements in yield or seed quality when the soil has adequate calcium. In addition to this, gypsum application may have risen the pH of the soil above the requirement of groundnut as the pH of the soils in both locations were within the pH range for groundnut production before gypsum application.

Response to Rhizobia Inoculation

The lack ofsignificant response of some of the yield parameters of the two groundnut varieties to inoculation in this research may be due to several factors which include; adequate nodulation by indigenous rhizobia, unfavorable conditions for survival of introduced rhizobia strains and inability of inoculant strains to compete with indigenous strains for nodule sites, the use of the strains of bacteria that are incompatible with groundnut or even the high nitrogen content of the soils in both locations (4.00g kg^{-1} in Samaru and 6.30 g kg^{-1}in Kadawa).

Varietal Response

Where there was a significant response on the varieties, SAMNUTT 22 performed better than SAMNUT 23 by having higher values for pod yield plant^{-1}, shelling percentage, 100 kernel weight and Harvest index. This could be attributed to the higher leaf area ratio and leaf area duration for SAMNUT 22 than SAMNUT 23 as such, the higher capacity for interception of sunlight and therefore assimilate production. SAMNUT 22, a Virginia bunch is morphologically classified as semi-spreading whose branches trail partially on the surface of the soil. They are usually heavier yielding and later maturing than the bunch varieties (Jasani, 2009). SAMNUT 23, genetically a Spanish type is morphologically classified as erect bunch with few branches and leaves that gives it an open appearance (Mukhtar, 2009).

Interaction

The interaction between gypsum and inoculation on the 100 kernel weight (g) showed a haphazard responsetrend. Although, the control + uninoculated produced the highest mean (48.92). Interaction between gypsum and variety on the pod yield (kg ha^{-1}) showed that 150 kg ha^{-1} of gypsum+ SAMNUT 22 produced the highest pod yield (1000 kg ha^{-1}).

Conclusion

Application of gypsum may not be necessary on soils high in calcium, further inoculation studies should be carried out on groundnut with the right strains of bacteria and SAMNUT 22 can produce good yield both in the rainy and dry seasons.

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Table 1: Physico-chemical properties of soils at experimental fields during the 2012 rainy season in Samaru and 2012/2013 dry season in Kadawa.

Location	**Samaru**	**Kadawa**
Soil depth(cm)	**0-30(cm)**	**0-30(cm)**
Soil characteristics		
Physical composition (g kg^{-1})		
Sand	440	600
Silt	360	320
Clay	200	80
Textural class	Loam	Sandy Loam
Chemical composition		
pH in H_2O (1:2.5)	6.41	6.98
pH in 0.01M $CaCl_2$ (1:2.5)	6.23	6.49
Organic carbon (g kg^{-1})	11.2	5.90
Available phosphorus (mg kg^{-1})	1.42	3.82
Total nitrogen (g kg^{-1})	4.00	6.30
Exchangeable bases(cmolkg^{-1})		
Ca	6.00	5.30
Mg	2.00	0.12
K	0.11	0.21
Na	1.60	0.54
CEC	6.60	4.30

Soil samples as analyzed in Agronomy Department, Ahmadu Bello University, Samaru, Zaria.

Table 2: Effect of gypsum and rhizobia inoculation on the pod yield plant^{-1} (g), kernel yield plant^{-1} and shelling percentage of Groundnut varieties during the 2012 rainy season in Samaru and 2012/2013 dry season in Kadawa

	Pod yield plant^{-1}(g)		**Kernel yield plant^{-1}(g)**		**Shelling percentage (%)**	
Treatment	**Samaru**	**Kadawa**	**Samaru**	**Kadawa**	**Samaru**	**Kadawa**
Gypsum(kgha^{-1})						
0	30.50	39.15	16.32	24.69	54.04ab	63.78ab
50	29.92	33.47	16.09	19.07	53.84ab	58.90ab
100	32.20	38.87	17.74	24.62	55.28a	64.42ab
150	27.99	42.56	14.34	21.63	51.39b	53.89b
200	28.97	40.21	14.99	27.55	51.91ab	68.64a
SE±	2.062	5.203	1.179	3.422	1.174	4.241
Rhizobia Inoculation						
Uninoculated	31.21	38.51	16.59	24.13	53.49	65.02
Inoculated	28.61	39.19	15.20	22.89	53.09	58.83
SE±	1.304	3.291	0.746	2.164	0.742	2.682
Variety						
SAMNUT 22	32.25a	38.32	16.03	23.69	58.13a	63.18
SAMNUT 23	27.57b	39.38	15.76	23.33	48.45b	60.67
SE±	1.304	3.291	0.746	2.164	0.742	2.682
Interaction						
G*I	NS	NS	NS	NS	NS	NS
G*V	NS	NS	NS	NS	NS	NS
I*V	NS	NS	NS	NS	NS	NS
G*I*V	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of
probability using DMRT. NS= Not Significant.

Table 3: Effect of gypsum and rhizobia inoculation on the 100 kernel weight (g), harvest index(%) and pod yield(kg ha^{-1}) of Groundnut varieties during the 2012 rainy season in Samaru and 2012/2013 dry season in Kadawa

	100 kernel weight(g)		**Harvest index(%)**		**Pod yield (kg ha^{-1})**	
	Samaru	**Kadawa**	**Samaru**	**Kadawa**	**Samaru**	**Kadawa**
Treatment						
Gypsum(kg ha^{-1})						
0	36.70	46.37	16.56	15.18	871a	1647
50	37.05	42.93	16.57	14.82	724ab	1518
100	35.12	44.18	17.35	15.90	686b	1481
150	34.20	43.47	15.04	14.47	776ab	1571
200	36.17	44.76	15.31	17.49	690b	1716
SE±	1.010	1.246	0.903	1.562	52.8	151.8
Rhizobia Inoculation						
Uninoculated	36.13	44.05	17.14a	17.15a	726	1604
Inoculated	35.57	44.63	15.19b	13.10b	773	1569
SE±	0.639	0.788	0.571	0.988	33.4	96.0
Variety						
SAMNUT 22	38.27a	44.99	15.72	17.69a	760	1521
SAMNUT 23	33.42b	43.69	16.60	13.46b	738	1652
SE±	0.639	0.788	0.571	0.988	33.4	96.0
Interaction						
G*I	NS	*	NS	NS	NS	NS
G*V	NS	NS	NS	NS	*	NS
I*V	NS	NS	NS	NS	NS	NS
G*I*V	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a treatment group are not significantly different at 0.05 level of probability using DMRT. *=Significant, NS= Not Significant.

Table 4: Interaction of gypsum and inoculation on the 100 kernel weight (g) of Groundnut varieties during the dry season of 2012/2013 in Kadawa.

Rhizobia Inoculation	**Gypsum(kg ha^{-1})**				
	0	**50**	**100**	**150**	**200**
Uninoculated	48.92a	39.32c	44.25abc	43.88bc	43.87bc
Inoculated	43.82bc	46.55ab	44.10abc	43.05bc	45.65ab
SE±			1.762		

Means followed by the same letters within a treatment group are not significantly different at 0.05 level of probability using DMRT.

Table 5: Interaction of gypsum and variety on pod yield (kg ha^{-1}) of Groundnut varieties during the rainy season of 2012 in Samaru.

Variety	**Gypsum(kg ha^{-1})**				
	0	**50**	**100**	**150**	**200**
SAMNUT 22	772bc	734cd	661cd	1000a	635cd
SAMNUT 23	971ab	713cd	711cd	553d	745bc
SE±			74.7		

Means followed by the same letters within a treatment group are not significantly different at 0.05 level of probability using DMRT.