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Bambara Groundnut (*Vigna subterranea* L. Verdc.) Yield as Influenced by Phosphorus and Cultivars in the Semi-Arid Savanna of Nigeria

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Abstract: Field experiments were conducted in 2002 and 2003 at the Usmanu Danfodiyo University Teaching and Research Farm, Sokoto to determine effects of phosphorus (P) on the yield of bambara groundnut cultivars. Treatment consisted of factorial combinations of two cultivars (Ex-Tangaza and Pategi black), three levels of phosphorus (0, 15 and 30 kg ha^{-1}) and three intra-row spacing (15, 20 and 25 cm) laid out in a Randomized Complete Block Design replicated three times. Results of P and cultivar are presented in this study. Results revealed significantly ($p<0.05$) higher stover yield in Ex-Tangaza than Pategi Black cultivar both in 2002 and 2003. While, kernel yield was higher in Pategi black (530.7 kg ha^{-1}) than Ex-Tangaza (516.5 kg ha^{-1}) in 2003 only. P had significant effect on stover yield in the two trials with higher stover yield with 30 kg P ha^{-1}. Similar results were obtained with kernel yield in the two seasons where 30 kg P ha^{-1} resulted in higher kernel yield. Both the cultivars responded significantly to the applied P at both 15 and 30 kg ha^{-1} but higher response was obtained with Pategi black than Ex-Tangaza. Therefore, in this study, it was concluded that Ex-Tanzaga may be used for stover yield while, Pategi black would be better for kernel yield in the semiarid tropic of Nigeria. Application 30 kg P ha^{-1} (382 kg SSP ha^{-1}) gave highest yield with both cultivars. Further yield increment could be obtained by increasing the P levels from 30 kg upwards.

Key words: Bambara groundnut (*Vigna subterranea* (L.) Verdc.), phosphorus, cultivars, semi-arid savanna, Nigeria

INTRODUCTION

Bambara groundnut (*Vigna subterranea* L. Verdc.) is an indigenous African legume that has been cultivated in Africa for centuries. It is highly nutritious plant, which plays a crucial role in peoples diet. It is the third most important pulse crop in Africa after groundnut (*Arachis hypogaea)* and cowpea (*Vigna unguiculata*) (Duke *et al*., 1977). The center of origin of bambara groundnut is Africa, in Madagascar. The wild forms are found in Jos, Yola, Ogoja in cross River State (Hepper, 1970; Giller and Wilson, 1991). However, bambara groundnut remains one of the crops that is most neglected by scientific community. It is regarded as a poor mans crop as such the plant has not been accorded with a large-scale breeding and research program (Hepper, 1970).

Bambara groundnut is cultivated primarily for home consumption with excess quantities sold in local markets. Bambara groundnut considered as an African pulse is a rare example in which nature provides a complete food. Although its seeds have about 6.5% oil, 18% protein (Baudoin and Mergeai, 2001). The protein is of good quality, having a surplus of lysine (7.0%) methionine (1.4%) and moisture (10%) to complement cereal in the diet. The crops contain more carbohydrate or starch (33-45%) and make a well balanced food with a calorific value equal to that of a high-quality cereal

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grains. The seed taste good and Africans prefer it to most pulse crops. The grains are consumed either immature or when fully ripe (Rassel, 1960; Carsky *et al*., 1997). It can also be boiled, roasted either with shell or without shell after which they are either eaten alone or mixed with immature groundnut or green maize. Immature seeds are consumed fresh or grilled. Usually they are either pounded to flour and boiled to a stiff porridge, or soaked and then boiled. The porridge keeps well and is traditionally used on journeys. Ripe/dry seeds are also roasted, broken into pieces, boiled, crushed and eaten as a relish with sadza (maize-meal porridge). In restaurants in Angola and Mozambique, boiled salted seeds are often served as appetizers. Commercial canning of bambara groundnut in gravy is a successful industry in Ghana (Swanevelder, 1998).

Grain yield of Bambara groundnut have been reported where the local cultivars are found (e.g., Ogoja) to be 254-500 kg ha^{-1} (Bationo *et al*., 1991) while the yield have also reported to be different from one countries to the other viz: Chad and Cameroon 800 kg ha^{-1}, Benin 450-650 kg ha^{-1}, Congo 350-650 kg ha^{-1}, Ghana 714-1100 kg ha^{-1} (Kari-Kari and Lavoe, 1977; Linnemann, 1987). According to Begemann (1987) the yield potential of Bambara groundnut in Nigeria is higher than any African country. The yield ranges from 500-2600 kg ha^{-1}. He reported that the production of Bambara groundnut is almost close to that of groundnut averaging 750 kg ha^{-1} in Nigeria while Africa average is about 850 kg ha^{-1} (Stanton *et al*., 1996; Purseglove, 1968).

The yield obtained by the farmers in the Sudano-Sahelian zone is generally low due to deficiency of P in the soil (Sinaj *et al*., 2001) and bambara groundnut being a leguminous crop helps in the fixation of nitrogen to the soil. Therefore phosphorus becomes important in the savanna soil to enhance N-nutrition and fixation of nitrogen to the soil. Bambara groundnut is observed to fix about 100 kg N ha^{-1}. According to Sauchelli, (1967), P is essential to plant for the fixation of essential nuclei acids and proteins cells division, formation of fats, responsible for grain germination, pod and root development and useful during respiration process since it is present in the cell nuclei. Tanimu *et al*. (1990) in his green house experiment reported that Bambara groundnut is an efficient phosphorus absorber in its free state. P is needed more by pulse crops in the savanna environment (Gueye and Bordeleau, 1988; Somasegaran *et al*. (1990). Thus, application of P could be one of the means by which yield could be increased through nitrogen fixation. Therefore, this study was undertaken to determine the optimum P level and select suitable cultivar for maximum yield in the semiarid tropics.

MATERIALS AND METHODS

The experiment was conducted in 2002/2003 rainy reasons at Usmanu Danfodiyo University Teaching and Research Dry land farm, Sokoto, Nigeria. Sokoto is located in the Sudan savanna. Agro-ecological zone of Nigeria on Latitude of 13° 01 N, Longitude 5° 15 E, at an altitude of about 350 m above sea level (m.a.s.l). The mean annual rainfall for 2002/2003 cropping season (Fig. 1). Relative humidity ranges from 52.2 and 83.8% and minimum and maximum temperatures were 21 and 32.5°C during the rainy season in 2002/2003. The area is characterized by long dry season with cool air during harmattan (November-February), dry air during hot season from March-May, followed by short rainy seasons (Davis, 1982). The physico-chemical analysis of the soil in the study area revealed that the soil was predominantly sandy in texture (Table 1). The soil reaction was slightly acidic with values of 6.02 and 6.05 for 2002 and 2003, respectively. Organic carbon and available P was generally very low and total N, CEC, K and exchangeable bases (Na, Ca and Mg) were low in content.

The treatment consisted of factorial combinations of three levels of phosphorus 0, 15 (34.4 kg P_2O_5) and 30 (68.7 kg P_2O_5) kg P ha^{-1}), three intra-row spacing (15, 20 and 25 cm) and two cultivars (Ex-Tangaza (local) and Pategi Black) making 18 treatment combinations. These treatment combinations were laid out in a Randomized Complete Block Design (RCBD) replicated three times, but only the results of effect of cultivars and phosphorus is presented in this study.

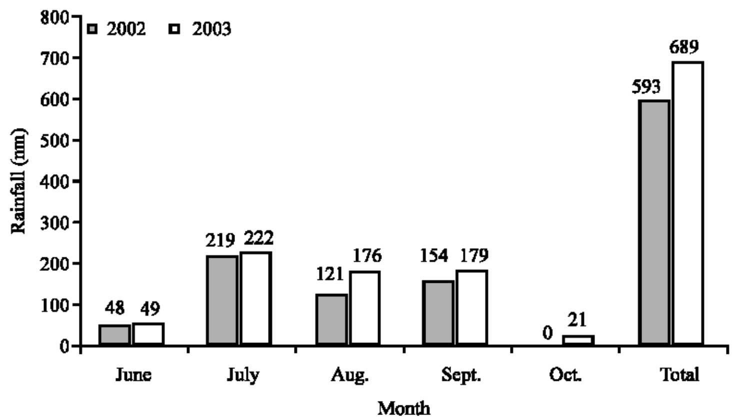

Fig. 1: Monthly and total annual rainfall at the experimental site in 2002 and 2003 cropping seasons

Table 1: Physical and chemical properties of the soil at the experiment site in 2002 and 2003 rainy season

Physical and chemical characteristic	2002	2003
Physical properties		
Sand (g kg^{-1})	950	940
Silt (g kg^{-1})	40	40
Clay (g kg^{-1})	10	20
Textural class	Sandy	Sandy
Chemical properties		
Organic carbon (g kg^{-1})	7.1	7.2
Total nitrogen (g kg^{-1})	3.6	3.5
Available P (mg kg^{-1})	2.5	2.4
Exchangeable K (cmol kg^{-1})	4.2	5.2
CEC (cmol kg^{-1})	3.5	3.6
pH (water)	6.02	6.05
pH ($CaCl_2$)	5.90	5.92

Seeds of Ex-tangaza were obtained from the farmers while Pategi black was obtained from Institute for Agricultural Research (IAR), Samaru, Zaria. Experimental site was plough and harrowed using a tractor at the onset of the rainy season in 2002 and also 2003. Six ridges 3 m long were prepared at 0.75 m (75 cm) apart. One seed was sown per hill about 3 cm deep. P fertilizer in the form of Single Super Phosphate (SSP) (18% P_2O_5) was applied below the seed (basal placed) as per the treatment. Nitrogen in the form of urea (46%N) was applied at the rate of 15 kg ha^{-1} as a starter dose to all the plots at planting. The plot were kept weed free manually. No incidence of pest and disease were observed. Harvesting was done about 12 weeks after planting from the net plot area for stover and kernel yield. The plants along with pods were air dried to constant weight and threshed for kernel yield.

Data obtain were subjected to analysis of variance (ANOVA) procedure using SAS (1999) and significant differences in the treatment were further analyzed using, least significant different test (LSD).

RESULTS AND DISCUSSION

Stover Yield

Cultivar had significant ($p<0.05$) effect on the Stover yield of bambara groundnut in both 2002 and 2003 cropping seasons (Table 2). Significantly higher stover yield was recorded with Ex-Tangaza (271.9 to 293.8 kg ha^{-1}) than Pategi black cultivar (232.3 to 253.7 kg ha^{-1}) in both 2002 and 2003. This could be due to its adaptability to the local conditions like with well developed root system, high stature, ability to thrive well in low rainfall areas and also due to bushy nature of the plant that resulted

Table 2: Kernel and stover yield of bambara groundnut cultivars as influenced by phosphorus in 2002 and 2003 cropping seasons

	Kernel yield (kg ha^{-1})		Stover yield (+pod Wall) (kg ha^{-1})	
Treatments	2002	2003	2002	2003
Cultivar				
Ex-Tangaza	514.5	516.5b	271.9a	293.8a
Patigy Black	522.9	530.7a	232.3b	253.7b
SE of Mean	3.99	0.38	0.16	0.32
Significance	ns	s	s	s
Phosphorus (kg ha^{-1})				
0	491.5c	498.5c	247.7c	269.5c
15	521.6b	522.1b	252.3b	273.6b
30	543.1a	550.3a	256.5a	278.2a
SEM	4.89	0.46	0.19	0.40
Significance	s	s	s	s
Interactions				
Cultivar *Phosphorus	ns	s	s	s

Within a treatment group, means followed by similar letter(s) are not significantly different at 5% level using LSD test, s: significant, ns: Not significant

Table 3: Stover yield (+pod wall) of bambara as influenced between cultivar and phosphorus in 2002 and 2003 cropping seasons

	Stover yield (+ pod wall) (kg ha^{-1})	
Phosphorus (kg ha^{-1})	Ex-Tangaza	Pategi black
2002		
0	264.6c	230.7e
15	271.8b	232.9d
30	279.7a	233.3d
SE	0.28	
2003		
0	285.9c	253.1d
15	293.9b	253.4d
30	301.8a	254.5d
SE	0.57	

Across rows and columns means follow by similar letter(s) within a year are not significantly different at 5% level using DMRT

in higher stover yield. This agreed with the findings of Baudoin and Mergeai (2001) who reported that improved cultivars of pulse crops have less stover yield especially in the savanna or semiarid environment.

Stover yield progressively increased with increase in P level up to 30 kg P ha^{-1} in both seasons. This could be attributed to the low level of P in the soil. Higher P application resulted in better N-nutrition, which resulted in larger leaf areas, higher photosynthetic activity and thus higher dry matter production. This was in line with Fixen and Groven (1990). Sharpley (1993) reported that P enhances physiological process in plants (photosynthesis, lateral roots formation) and can lead to higher stover and kernel yield

There was significant effect of interaction between cultivar and P on stover yield of bambara groundnut. Ex-Tangaza recorded higher stover yield at all levels of P in both 2002 and 2003 season compared to Pategi black cultivar (Table 3).

Kernel Yield

The effect of cultivar on kernel yield was significant in 2003 trial. Pategi black was observed to produce significantly ($p<0.05$) higher kernel yield than Ex-Tangaza cultivar (Table 2). However, cultivar effect was noted to have no significant effect on kernel yield in 2002. The higher kernel yield produced by Pategi Black could be attributed to early flowering, more number of pods per plant and higher seeds per pods as well as higher weight (Higher harvest index). Improved cultivars are more efficient in translocating the food materials from source to the sink thus higher yield. This finding is in agreement with the work of Sereme *et al.* (1991) who reported that improved cultivars have good converting ability from source to sink (grains) resulting to higher yield. Baudoin and Mergeai (2001) also reported that average yield of dry seeds ranges between 300 and 800 kg ha^{-1} in traditional farming as compared to 3000 kg ha^{-1} for commercial farming. Similarly, Karikari (2000) in Botswana recorded a kernel yield ranging from 505-1477 kg ha^{-1} with eight landraces. However, the yield obtained by Pategi Black was less than that obtained by Tanimu *et al.* (1990) under Northern Guinea savanna conditions (1.3 t ha^{-1}).

P application had significant effect on the kernel yield of bambara groundnut in both 2002 and 2003 cropping seasons. Application of 15 kg P ha^{-1} resulted in significant increase in kernel yield in both 2002 and 2003 seasons. Further increase to 30 kg P ha^{-1} resulted in significant increase in yield compared to 15 kg ha^{-1} (Table 2). This response may be because the soils were low in P and also due to the role of P in pod development, root growth and nitrogen fixation in Bambara groundnut. This result agreed with the finding of Sharpley *et al.* (1984) and NAS (1979) that reported that soils of great plain, semiarid and arid region require phosphorus for optimum yield. However, it was contradictory to Ramolemana *et al.* (2000) that did not observe any response to applied P on the field but response to applied P was observed in pot experiment.

Kernel yield was significantly ($p<0.05$) influenced by cultivar and P in 2003 cropping season. Both cultivars responded significantly at all levels of applied P application. However, the response from Pategi black was higher than Ex-Tangaza at all levels of P. Higher kernel yield were recorded when p-levels were increased from 0 to 30 kg ha^{-1} in the two cultivars. Result showed significant increase in kernel yield of Pategi Black (558 kg ha^{-1}) than Ex-Tangaza (542 kg ha^{-1}), when 30 kg P ha^{-1} was applied in 2003. This result was similar to the findings of Tanimu *et al.* (1990) who reported that increase in P levels on improved seeds of bambara groundnut make no difference in the stover yield but could lead to increase in kernel yield in arid and semiarid environment.

CONCLUSIONS

Based on the findings of this study, bambara groundnut responded to P application and application of 30 kg P ha^{-1} gave the highest yield. However, further yield increment could be obtained by increasing the P level above 30 kg ha^{-1}. It was also observed that the local, Ex-Tangaza performed better in terms of stover yield while the improved Pategi black performed better in terms of kernel yield. The response to P application was higher in Pategi black than Ex-Tangaza and to obtain the optimum requirement more than 30 kg P ha^{-1} needs to be tested.

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