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Phosphorus Rates, Intra-Rowing Spacing and Variety of Bambara Groundnut (*Vigna subterranean* (L.) Verdc) in Makurdi Ecological Zone

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Authors' contributions

This work was carried out in collaboration between all authors. Author MME carried out the experimental field work and drafted the manuscript. Author JNE performed the statistical analysis. Author TOA managed the analyses of the study and managed the literature searches. Author MOO supervised the work. All authors read and approved the final manuscript.

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ABSTRACT

Field experiments were conducted in 2012and 2013 at the teaching and research farm of the Federal University of Agriculture, Makurdi, Benue State, Nigeria to determine growth and yield components of Bambara groundnut as influenced by phosphorus rates, intra-row spacing and variety of Bambara groundnut in Southern Guinea Savanna zone of Nigeria. Treatment consists of factorial combinations of two varieties (Petegi Black and Ogoja White), three levels of phosphorus (0, 20 and 40 kg/ha) and three intra-row spacing (10, 20 and 30 cm) replicated three times. This was laid out in a Factorial randomized Complete Block Design to test the interaction of three factors (variety of Bambara nut, P-level and intra-row spacing). The results of variety, intra-row spacing and p-level applications revealed a significantly (p< 0.05) higher pods/plant, pod weight and harvest index in Pategi Black in a spacing of 30 cm and 40 kg/ha was applied gave (618.7 and

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631.5 kg/ha). While Ogoja White recorded a significantly ($p<0.05$) higher plant height, stover yield (606.0 and 615.2 kg/ha), days of 50% flowering, days of 50% maturity and shelling percentage at intra-row spacing 20 cm and 20 kg/ha across the two cropping seasons. Further growth and yield increment could be obtained by testing p-level above 40 kg /ha.

Keywords: Bambara groundnut; phosphorus; spacing; growth; yield components.

1. INTRODUCTION

Bambara groundnut (*Vigna subterranean (L.) verdc*) is considered as an indigenous African legume that has been grown in Africa for several years. It belongs to the family of Fabaceae and sub-family faboidea. It is one of the most under exploited leguminous crops that is still grown under subsistence level of production due to little research attention is given to the crop [1,2]. It is the third most important leguminous crops in Africa after groundnut (*Arachis hypogaea*) and cowpea (*Vigna unguiculata*) that is delicious and very nutritious as well as play a crucial role in human diet and animal ration [3,4]. The crop contains 18% protein, 65% carbohydrate, 6.5% fat and rich in essential amino acid such as 180 leucine, leucine, lysine, methionine, phenylalanine, threonine and valine. The fatty acid content is predominantly linoleic, palmitic and linolenic acids [5,6].

The central of origin of Bambara groundnut is Africa in Madagascar while the wild forms are found in Jos, Yola, Ogoja (Bakor) in Cross river state [7]. It is regarded as poor man's crop. It can be eaten raw, boiled, roasted, fried and grinded into flour for Bambara groundnut cake, bean porridge ("moimoi") and other delicacy [8,9].

The production potentials per year vary from one to country to the other which could be due to differences in their cropping pattern, genetic constituents, soil type and variations in the cultivars. The total world production is estimated to be 450, 000 metric tonnes, 320, 000 from Africa with more than 50% of its production from West Africa (Nigeria, Ghana, Cote d'voire, Burkina Faso, Niger, Mali) as well as in Chad and Cameroon. In 2007 and 2008, it was reported that 120, 000 and 169, 300 metric tonnes were produced in a land area of 15530ha, with 55% and above its production from Ogoja in Cross River State [2,10]. Bambara groundnut does well in a warm condition of 20-30°C with high sunshine in a hot and windy environment. It further tolerates temperature up to 15°C. It grows well in rainfall between 500-1200 mm per annum. It also thrives well in nutrient poor soils, with light texture where most crops would not thrive. It is tolerant to drought and is relatively disease free [11,12]. The black type is early maturing, more resistant to pathogenic micro-organisms, erect or determinate, short canopy spread, low stover yield, more grain yield while the white is late maturing, less resistance to pathogenic infections, long canopy height, high stover yield and less grain yield.

The growth of Bambara groundnut varied from one location to another. The growth obtained by the farmers is generally low [13,14]. Therefore there is a need to select suitable improved varieties, good management practices and adequate and appropriate fertilizer rate to increase growth, development and yield of the crop. The plant to plant spacing of 30 x 20 cm and the application of P. fertilizer rate of 30 kg/ha in a plot size of 2684.5 m^2 Sudan Savanna of Nigeria produced above 15% of the total production in Nigeria. [11] and [15]. The study aimed to investigate the growth and yield components of Bambara groundnut as influenced by variety phosphorus and intra-row spacing in Guinea savanna zone of Nigeria.

2. MATERIALS AND METHODS

A field experiment was carried out in Teaching and Research farm of the Federal University of Agriculture, Makurdi, Benue State, Nigeria in both years 2012 and 2013. The experimental field was situated at 07°41'N, 08° 37'E at an altitude 106.4 m above sea level [16].

Meteorological data for the period of study was collected from Nigerian Air Force Base Meteorological station 300 km away from the experimental field. The location falls within the Southern Guinea Savanna of Nigeria. The mean annual rainfall for 2013 was 1100-1350 mm. The relative humidity ranges from 52.2% and 83.8% and minimum and maximum temperatures were 33° and 31°C during the rainy season in 2012/2013.

The area is characterized long rainy season from March- October with cool air during harmattan (November–January), dry and hot air during February, being the month preceding rainy season [17]. The core samples of soil were collected from different parts of the experimental field from a depth of 0 – 30 cm and bulked into a composite sample and used for the determination of physico-chemical properties of the soil. The soil in the study area revealed that the soil was predominantly sandy in texture. The soil reaction was slightly acidic with values of 6.02 – 6.08 for 2012 and 2013 respectively. Organic carbon and available p were generally very low and total N, CEC, K and exchangeable bases (Na, Ca and Mg) were also low.

Table 1. Physical and chemical properties of soil at the experiment site

Chemical composition	2013	2014
pH	6.02	6.08
Organic matter	1.98	0.99
Total N	0.09	0.08
Available p(Mg/kg)	2.94	0.64
Exchangeable bases composition		
Ca (cmol/ kg)	5.4	4.4
Mg(cmol /kg)	1.3	2.0
Ma (cmol/ kg)	0.11	0.09
Exchangeable acidity		
Al3+ (cmol/kg)	0.94	0.64
ECEC (cmol/ kg)	6.4	6.68
Base Saturation	82.2	81.0
Micro nutrients		
Mn (mg/kg)	84.4	82.5
Cu (mg/kg)	33.0	32.1
Zn (mg/kg)	82.0	81.2
Fe (mg/kg)	141.3	121.0
Particle size analysis		
Sand (%)	82.0	82.0
Silt (%)	7.0	6.5
Clay (%)	5.5	4.6
Soil textural class	Sand	Sand

The treatment consists of factorial combinations of two varieties (Pategi Black (improved) and Ogoja White (local) three levels of phosphorus (0. 20 and 40 kg/ha) and three intra-row spacing (15, 20 and 30 cm) laid out in a Randomised Complete Block Design (2 x 3 x 3) = 18 treatment combinations replicated three times.

Seeds of Pategi Black were obtained from the institute for Agricultural Research (IAR), Samaru, Zaria while Ogoja White was obtained by ADP farmers from Ogoja local Government Area of Cross River State. The experiment site was manually cleared with machetes and ridged with hand hoes. Six ridges, 6 m long with 0.75 cm apart were prepared. One seed was sown per hill about 3 cm deep. P, fertilizer rate in the form of Single Super Phosphate (SSP).

(18% P_20_5) was applied below the seed (basal application). Nitrogen in the form of Urea (46%N) was applied at the rate 20 kg/ha as a starter does to all the plots at sowing. This starter does support sprouting due to heavy rainfall in the ecological zone. No disease incidence was observed and the plot was kept weed free manually. Data was collected on canopy height at 2, 4, 6, 8 weeks after planting and yield components on; Pods per plant, pod weight, stover yield (+ pod wall), days to 50% flowering, Days to 50% maturity harvest index and shelling percentage (%).

Data obtained were subjected to analysis of variance (ANOVA) procedure using the Genstat Discovery Edition 4.23 software (Genstat, 2007) and significant difference (LSD) test at 5% level of probability.

3. RESULTS AND DISCUSSION

Result showed significantly ($P<0.05$) effect of variety on canopy height at all sampling dates (2, 4, 6 and 8 WAP) of Bambara groundnut in the two cropping season (Table 1) Ogoja White exhibited a significantly ($P<0.05$) higher canopy height of (11.16-20.6 cm) when compared to Pategi Black (10.63-20.2 cm) at all sampling period in both 2012 and 2013 cropping seasons. This could be due to its adaptability of Ogoja White to local climatic conditions. It also has well developed root system and ability to thrive well in hot and windy environment as well as survive in areas prone to low and erratic rainfall. The well-developed root systems help it to exploit nutrient excessively for its growth. This agrees with the findings of Alhassan et al. [18] and Nweke and Emeh, [19] who reported that local varieties of pulse crops are taller with higher canopy growth and development.

There was a significant increase in canopy height with an increase in plant to plant spacing up to 20 cm in both seasons. Further increase beyond 20 cm resulted in significant reduction in canopy height (Table 1). Significant canopy height was recorded in plots with 20 cm spacing than 15 and 30 cm plant to plant spacing at all sampling dates in both cropping seasons. 20 cm intra-row spacing appears to be optimum for better utilization of nutrients in the soil as a result of minimal competition for nutrients, light, moisture

Table 2. Canopy height of Bambara groundnut at 2, 4, 6, and 8 weeks after planting (WAP) as affected by variety, phosphorus levels and intra-row spacing in 2013 cropping season

	Canopy height (cm)							
Treatments	**2 WAP**		**4WAP**		**6WAP**		**8 WAP**	
Variety	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**
Ogoja White	11.16a	11.3a	14.6a	14.6a	16.7a	17.3a	19.1a	20.6a
Palegi Black	10.63b	10.9b	13.9b	14.3b	16.3b	16.8b	18.9b	20.2b
LSD (0.05)	0.02	0.01	0.06	0.05	0.03	0.07	0.01	0.04
Significance	S	S	S	S	S	S	S	S
Phosphorus (Kgha^{-1})								
0	9.9c	10.3c	13.0c	13.5c	14.7c	15.9c	18.4c	19.4c
20	10.6b	10.9b	14.2b	14.4b	16.8b	17.1b	19.1b	20.5b
40	12.1a	12.2a	15.4a	15.3a	17.9a	18.1a	19.5a	21.2a
LSD (0.05)	0.03	0.01	0.07	0.07	0.04	0.09	0.01	0.05
Significance	S	S	S	S	S	S	S	S
Intra-row spacing (cm)								
10	10.8b	11.2b	14.2b	14.6a	16.5b	17.2a	19.0b	20.6a
20	11.3a	11.4a	14.6a	14.7a	16.9a	17.3a	19.3a	20.5a
30	10.5c	10.8c	13.9c	14.0b	16.0	16.7b	18.7c	20.0b
LSD (0.05)	0.03	0.01	0.07	0.07	0.04	0.08	0.01	0.05
Significance	S	S	S	S	S	S	S	S

Within a treatment group, mean in a column followed by similar letters are of significantly different at 5% level using LSD. S = significant at 5% level of significance

and space. Therefore, closer plant to plant spacing, plant tend to compete for space, light, nutrients and exhibit taller canopy height but when it is too close. In hinders the utilization of the soil nutrients for growth. This agrees with Toungos et al. [20] and Yakubu et al. [21] that spacing of 20-30 cm gives maximum growth performance of canopy height.

Canopy height was significantly influenced by variety and plant to plant spacing interaction in both seasons for 2WAP and only 2012 for 6 and 8WAP. Pategi Black was statistically similar in all levels of intra-row spacing while it significantly increased when spacing was increased from 15 to 20cm under Ogoja White but further increased to 30 cm result to a significant reduction.

Table 3. Pods per plant, pod weight and stover yield (+pod wall) of Bambara groundnut cultivars as influence by variety, phosphorus level, and ultra-row spacing

Treatments	**Pods per plant**		**Pod weight (Kg/ha)**		**Stover yield (+ pod wall)**	
Variety	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**
Ogoja White	24.3b	24.6b	606.9b	615.2b	271.9a	293.8a
Pategi Black	26.6a	27.7a	618.7a	631.5a	232.3b	253.7b
LSD (0.05)	0.30	0.28	0.09	0.97	0.16	0.32
Significance	S	S	S	S	S	S
Phosphorus (Kgha^{-1})						
0	21.7c	22.9c	580.5c	594.1c	247.7c	269.5c
20	24.7b	25.2b	615.8b	623.0b	252.3b	273.6b
40	30.0a	30.4a	642.1a	653.0a	256.5a	278.2a
LSD (0.05)	0.37	0.35	4.90	1.19	0.19	0.40
Significance	S	S	S	S	S	S
Intra-row spacing (cm)						
10	20.8c	21.1c	580.3c	593.8c	249.8c	271.9b
20	26.5b	27.7b	615.4b	622.7b	256.1a	277.0a
30	29.0a	29.5a	64.9a	652.6a	250.6b	272.3b
LSD (0.05)	0.37	0.35	4.9	1.2	0.19	0.40
Significance	S	S	S	S	S	S

Within a treatment group, means in a column followed by similar letters are not significantly different at 5% level using LSP, ns = not significant, s = significant at 5% level of significant

Table 4. Days of 50% flowering and maturity, Harvest index and shelling percentage as influenced by variety, phosphorus rate and intra-row spacing in cropping season

Treatment	Days to 5% flowering		Days to 50% maturity		Harvest index (%)		Shelling percentage (%)	
Variety	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**
Ogoja White	43.9a	44.0a	98.8a	98.0a	58.5b	56.8b	84.8a	83.9a
Pategi Black	38.1b	38.6b	92.4b	92.4b	61.4a	59.9a	84.5b	83.8b
LSD (0.05)	0.27	0.12	0.15	0.11	0.17	0.57	0.09	0.06
Significance		S	S	S	S	S	S	Ns
Phosphorus (kgha^{-1})								
0	42.1a	42.5a	95.0c	94.1c	59.4b	57.8c	84.7	83.9ab
20	41.4a	41.6b	95.6b	95.1b	60.1a	58.2b	84.7	83.8b
40	39.6b	39.9c	96.2a	95.6a	60.1a	59.1a	84.5	84.1a
LSD (0.05)	0.33	0.14	0.18	0.13	0.21	0.07	0.11	0.08
Significance	S	S	S	S	S	S	nS	S
Intra-row spacing (cm)								
10	40.9a	41.3b	95.6b	95.1b	59.9	58.4a	84.6	84.0
20	40.6b	40.6c	95.3c	94.2c	60.0	58.6b	84.5	83.8b
30	41.7a	41.9a	95.8a	95.6a	60.1	58.1b	84.8	83.7
LSD (0.05)	0.33	0.14	0.18	0.13	0.21	0.07	0.11	0.08
Significance	S	S	ns	S	ns	S	ns	Ns

Within a treatment group, mean in a column followed by same letter (s) are not significantly different at 5% level using LSD ns = not significant, s = significant t 5% level

Comparing the varieties and intra-row spacing ogoja white produced significantly higher canopy height than Pategi Black at 20 cm spacing in the cropping seasons (Table not presented).

The number of pods per plant was significantly influenced by variety, intra-row spacing and phosphorus, significantly (P< 0.05) higher pods/plant was recorded in Pategi Black under intra row spacing of 30 cm and 40 kgp/ha applied (26.6 and 27.7) while Ogoja White with (24.3 and 24.6) [21,20]. Also an intra-row spacing of 30 cm and 40 kgp/ha produced a significantly (P<0.05) higher pod weight and harvest index in Pategi Black (618.7 and 631.5 kg/ha) and (61.4 and 59.9% than Ogoja White (606.9 and 615.2 kg/ha and (58.5 and 56.8%) for the two cropping seasons.

Ogoja White was produced statistically higher stover yield, days to 50% flowering, Days to 50% maturity and shelling percentage (273.8kg/ha, 44.0, 98.8 and 84.8) than Pategi Black with (253.7 kg/ha, 38.6, 92.4 and 83.8) at an intra-row spacing of 20 cm and 20 kgp/ha. This could be as a result of genetic constituents, intra-plant competition for nutrients, space, light and moisture leading to higher growth rate and higher biomass production. This agreed with the opinion of Kowal and Knabe, [18] and Adamanya et al. [22] who reported that closer intra-row spacing increased canopy height and spread. It also agrees with the findings of Bamshaiye et al. [7] and Nweke and Emeh, [19] that local varieties of Bambara groundnut take higher number of days to flowering and maturity.

4. CONCLUSION

Based on the result of the findings, it can be concluded that intra-row spacing of 30 cm and 40 kgp/ha is best for the production of Bambara groundnut for both ogoja white and Pategi Black varieties. Petegi Black is recommended for grains while Ogoja White for stover/ hay yield for animal consumption.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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