Response of Bambara Groundnut (Vigna Subterranea (L) Verdc.) Varieties to Plant Spacing in South Eastern Zone of Anambra State

Obidiebube E. A[1*], Akparaobi S.O[2], Eruotor P. G.[2], Okolie H.[1], Obasi C. C[1], Iwuagwu C. C.[1]

[1]*Department of Crop Science and Horticulture, Faculty of Agriculture, Nnamdi Azikiwe University, Awka, Nigeria*
[2]*Department of Agronomy, Faculty of Agriculture, Delta State University, Asaba, Nigeria*
**Corresponding author*

Abstract: **A field experiment to study the effects of plant spacing (45x30cm, 35x30cm, 25x30cm and 15x30cm) on the growth and yields of Bambara groundnut varieties (EXMFI, EXMF4, IITA165 and ENZK1) was conducted in the School Farm of Ogbaru High School, Ogbakuba in Anambra State. The experiment was designed with split-plot in a randomized complete block design replicated three times. The main plots were assigned to Bambara groundnut varieties (EXMF1, EXMF4, IITA165 and ENZK2), while sub-plots were assigned to plant spacing (45x30cm, 35x30cm, 25x30cm and 15x30cm) with population densities of 7,407, 9,524, 13,333 and 22,222 plants/ha respectively. Results showed that the number of pods per plant, pod weight and grain yields of Bambara groundnut increased with decrease in plant spacing. Plants with spacing 45x30cm had the least yield of 2455 kg/ha, where as the best yield results were from plants spaced at 15x30cm with the mean value of 3939 kg/ha. Furthermore, variety EXMF4 had the highest yield of 3384 kg/ha but was not significantly different (P<0.05) from the other varieties. Then variety x spacing interaction effects was significant for some growth and yield parameters evaluated. Thus, variety EXMF4 should be recommended for planting at high density of 22,222 plants/ha or spacing of 15x30cm in this locality.**

Keywords**: densities, experiment, interaction, replication significant.**

I. INTRODUCTION

Bambara groundnut *(Vigna subterranea* (L.) Verdc.), is an annual drought resistant leguminous crop grown mainly for its pods. It is one of the most important grain legumes after groundnuts, cowpeas and soya beans in Africa and Nigeria in particular ((Mkandawire, 2007; Omoikhoje, 2008).). Bambara groundnut is a self-pollinating annual legume crop and is an African indigenous crop that has been grown for centuries. It is an important grain legume, which is mainly grown by subsistence farmers in sub-Saharan Africa in a wide range of agro-ecological zones (Ntundu, *et al.,* (2004). The Bambara groundnut is rich in protein and helps to alleviate nutritional disorders in human and livestock lives (Massawe, *et al.,* 2003). Bambara groundnut like other legume fixes atmospheric nitrogen through symbiosis with *rihrzobium* bacteria and therefore beneficial in crop rotation and mixed cropping system. Bambara groundnut is grown for its edible seeds for protein content and shows complementary advantage when consumed with cereal crops. The fruits become very hard at maturity and also not eaten fresh without boiling. In Africa, bambara ground is popular because of its resistance to drought, pests and can adapt in a poor soil (Obidiebube *et al.,* 2019). At Nigeria, the fresh pods are boiled with salt and eaten as a snack. Additionally, the dry seeds are ground and made into a dough paste delicacy (popularly known as 'okpa') wrapped in banana leaves before cooking which can be consumed for breakfast, lunch or supper by families with average income, although it is generally enjoyed by many. Caroline (2003) and Omoikhoje (2008) in their findings described nutritional value of Bambara groundnut as follows: carbohydrates (54.4-69.3%), protein (17-24.6%), and fat (5.3 -7.8%), while calories are 367 - 414 cal per 100g. It is a good source of fiber, calcium, iron and potassium; usually high in methionine. Bambara groundnut *(Vigna subterranea)* is one of Africa's minor crops receiving growing interest from governments, plant genetic resources institutions and researchers. This is because of its numerous agronomic attributes, particularly, its yield and yield potential, relatively high resistance to diseases, and adaptability to poor soils and low rainfall (Mwale, *et al.*, 2007; Massawe *et al*, 2003). Planting density of Bambara groundnut varies from one location to another in both Eastern and Western Africa. Mkandiwire and Sibuga (2002) had reported a spacing of 30 cm x 30 cm in Tanzania and 60 cm x 30 cm in West Africa.

II. MATERIALS AND METHODS

*Experimental site***:** The study was conducted on the School Farm of Ogbaru High School, Gbakuba in Anambra State. Ogbaru Local Government Area is located in the south western part of Anambra State and lies between latitudes 5°42' and 6°08'N and Longitudes 6°42' and 6°50'E. The climate is hot wet equatorial with average maximum temperature of 30°C and the average minimum of 24°C depending on the season of the year. Rainfall is experienced for 7 months of the year; with a total annual value of about 1,900mm (Ezenwaji, *et al.,* 2014).

*Experimental design and planting***:** Four varieties of Bambara groundnut (EXMF1, EXMF4, IITA165 and ENZK2) were sown to examine the effects of plant spacing (15x30cm, 25x30cm, 35x30cm and 45x30cm) on them. The experiment was a factorial (split - plot layout) in a randomized complete block design (RCBD) replicated three times. The main plots were assigned to four varieties of Bambara groundnut, while the sub – plots were assigned to the four plant spacing. The experimental site was cleared, ploughed and the debris was gathered, bundled out and the site measured, marked and divided into three portions (blocks) as replicates. Forty-eight plots were used and each one measured 2m x 2m separated by 0.5m between plots and 1m between blocks. The marked out plots were filled and made into beds using hoes. The seeds were sown in July at a depth of 5cm in each plot at the rate of one seed per hole, with spacing of 45x30cm, 35x30cm, 25x30cm and 15x30cm. The plants were weeded and sprayed with insecticides at appropriate times during the experimental periods.

*Data collection and analysis***:** A tubular sampling augur was used to collect soil samples which were bulked and composited for the analysis of the physico – chemical parameters of the soils for the research. The analysis was conducted at the Soil Science Laboratory of University of Nigeria Nsukka following the standard routine procedures. Data were collected from the thirty randomly selected plants in the middle from each plot. Since destructive analysis was involved, five different plants were uprooted from each plot for data collection. With regard to growth parameters, canopy width, fodder freshness and dry weights at 4, 8, 12 and 16 weeks after sowing were measured from the five randomly selected plants within middle rows. Canopy width (cm) was taken by measuring the horizontal distances of canopies from one end to another using meter rule; fresh and dry weights (g) of leaves were measured using TANITA KD 200 sensitive scale. The fresh fodder weight was taken when the fodder were still fresh, while the dry fodder weight was taken after air drying for eight days and showed constant weights. On yields, number of pods per plant, pod and seed weight (gm) per plant and seed yield kg/ha were collected. On number of pods, pods were counted at harvest per plant. Pods per plant were measured and shelled to get seed weight per plant. Total seed yield kg/ha was taken after harvest and the dried pods shelled and seeds weighed using sensitive scale then converted to yield kg/ha. Data collected were subjected to Analysis of Variance (ANOVA) and treatment means were separated using Duncan Multiple Range Test (DMRT) SAS (2010).

III. RESULTS AND DISCUSSION

The results of the growth parameters are presented in Table1. The results on canopy width showed significant effect with ENZK2 having the largest canopy width across the sampling periods with mean values of 25.6, 43.5, 54.1 and 55.1 at 4, 8, 12 and 16 respectively (for variety). On spacing, there were significant differences at all the sampling periods. Spacing of 45 x 30cm had the largest canopy width across the sampling periods with the mean values of 27.8, 36.8, 47.8 and 60.2cm at 4, 8, 12 and 16 respectively; while spacing 15 x 30cm had the least canopy width with the mean values of 22.8, 31.0, 42.9 and 53.0cm at 4, 8, 12 and 16 respectively. Canopy structure is important for the display of leaves for light interception for photosynthesis in crop plants. The canopy width of the four Bambara groundnut varieties used were similar which could be attributed to their bunched type and not spreading. This is similar to the findings of Alhassan, *et al.,* (2012) and Akpalu (2013) who reported that spreading type of Bambara groundnuts could have canopy width up to 120cm or more while that of bunched could be on the average between 24.67cm and 45cm. It was observed that in this study the plants on large spacing had wider canopy width which can be traced to the reduced competition for sunlight and available nutrient. This is in consonance to the findings of Obidiebube *et al* (2019); Malami and Sama'ila (2012), who found that Bambara groundnuts on spacing 45 x 30 cm had the largest canopy of 63cm at 16 weeks and on Cowpea that the intra - row spacing of 50 and 75cm had the widest canopy spread respectively. The results from fodder fresh and dry weight showed that significant effects were recorded at 4 and 16WAS for variety. At 8 and 12WAS, ENZK1 alone was significantly different ($P<0.05$) from other varieties both on fodder fresh and dry weight with the mean values of 62.7 and 70.8. On plant spacing, it was observed that the fodder fresh and dry weight of spacing 45x30 cm had greater fodder fresh and dry weights and could be attributed to their struggling over environmental and edaphic materials. This competition also might have reduced weed interference. This agrees with findings of Obidiebube *et al* (2019); and Ibrahim (2012) who indicated that there is intense competition for light and nutrient by closely spaced crops compared to widely spaced crops. This is in contrast to the findings of Shiyam (2010) who reported that above ground biomass yield like the number of branches/plant was not influenced by plant spacing. The variety x spacing interaction effects were significant for some growth parameters evaluated (Table 1).

Table 1: Effects of variety and plant spacing and their interactions on canopy width (cm), fodder fresh and dry weight (g) of Bambara groundnut at different sampling periods.

Variety/ Spacing	Weeks after sowing 4 CW	4 FFW	4 FDW	8 CW	8 FFW	8 FDW	12 CW	12 FFW	12 FDW	16 CW	16 FFW	16 FDW
EXMF1	24.2^{b}	11.1^{b}	2.00^{b}	34.2^{ab}	49.8^{c}	15.0^{b}	43.9^{b}	58.7^{a}	19.8^{a}	65.6^{b}	26.1^{c}	12.3^{d}
EXMF4	28.0^{a}	13.7^{a}	2.91^{a}	33.6^{ab}	56.0^{b}	20.0^{a}	44.4^{b}	61.9^{ab}	19.8^{a}	62.8^{ab}	62.5^{a}	27.8^{a}
IITA165	25.0^{ab}	11.3^{b}	2.33^{ab}	36.5^{ab}	58.1^{ab}	14.9^{b}	47.5^{ab}	68.8^{a}	24.9^{a}	56.4^{ab}	50.5^{b}	23.3^{b}
ENZK2	25.6^{ab}	10.3^{a}	2.08^{b}	43.5^{a}	62.7^{a}	18.5^{a}	55.1^{a}	70.8^{a}	22.8^{a}	74.8^{a}	27.1^{c}	15.0^{c}
Spacing (cm)												
15 X 30	22.8^{b}	13.7^{a}	2.83^{a}	31.0^{b}	70.3^{a}	19.1^{a}	42.9^{b}	74.2^{a}	24.2^{a}	53.0^{b}	54.0^{a}	26.5^{a}
25 X 30	25.1ab	11.8^{ab}	2.42^{ab}	31.9^{b}	64.8^{ab}	18.9^{a}	43.3^{b}	71.3^{a}	24.0^{a}	58.8^{a}	51.1^{b}	22.8^{b}
35 X 30	27.1^{a}	11.2^{a}	2.08^{a}	35.9^{a}	48.2^{b}	13.9^{b}	46.9^{ab}	65.3^{ab}	23.8^{a}	58.5^{a}	47.1^{c}	19.0^{c}
45 X 30	27.8^{a}	9.83^{b}	2.00^{a}	36.8^{a}	39.5^{b}	12.3^{b}	47.8^{a}	49.4^{b}	15.2^{b}	60.2^{a}	38.6^{d}	17.8^{d}
Spacing	NS	*	NS	*	*	NS	*	NS	*	NS	NS	NS
Variety	*	*	*	NS	NS	NS	NS	NS	NS	NS	*	*
Sp x Var	NS	NS	*	*	NS	NS	NS	NS	NS	*	*	NS

Legend * = significant at 0.05 level of probability, NS = not significant, Sp = spacing, Var = variety. CW = canopy width, FFW = fresh fodder weight, DFW = dry fodder weight (g). Means with the same letter(s) in the same column and under same heading are not significantly different at P>0.05 using Duncan Multiple Range Test (DMRT).

On harvest, the results are shown in Table 2. Plant spacing 15x30cm had the highest number of pods, pod and seed weight / plant and then seed yield kg/ha at harvest with the mean values of 40.2, 45.0g 34.4g and 3939kg/ha respectively from the other three plant spacings. Finally, plants on the spacing of 45 x 30cm had the least yield on number of pods/plant, pod and seed weight per plant and seed yield kg/ha with the values of 24.8, 23.4g, 22.0g and 2455kg/ha respectively. The close spacing had greater number of pods/plant; pod and seed weight per plant and seed yield kg/ha and could be due to non interference of weeds as they were suppressed by the canopy width. This is in agreement with the findings of Gunri *et al.*, (2009) who reported that plant spacing of 30cm x 10cm significantly increased both the pod and kernel yield. The increased yield of Bambara groundnut with increased plant density was similar to the findings of Asiwe and Kutu (2007); Akpalu (2010); Kouassi and Zorobi (2011). These researchers observed that increasing plant population density resulted in high pod and grain yield.

Table 2: Effects of variety and plant spacing and their interactions on yield and yield components of Bambara groundnut at different sampling periods.

Treament	Pod/plt wt/plt (g)	Pod wt/plt Yield/ha (g)	(kg)	Seed
variety				
EXMF1	31.0^{a}	31.3^{b}	27.0^{ab}	3190^{c}
EXMF4	32.3^{a}	36.3^{a}	28.6^{a}	3384^{a}
IITA165	30.4^{a}	30.7^{b}	27.0^{ab}	3215^{b}
ENZK2	30.3^{a}	30.3^{b}	26.4^{b}	3080^{d}
Spacing (cm)				
15 x 30	40.2^{a}	45.0^{a}	34.4^{a}	3939^{a}
25 x 30	31.3^{b}	33.5^{b}	28.4^{b}	3785^{b}
35 x 30	27.8^{c}	26.7^{c}	24.2^{c}	2683^{c}
45 x 30	24.8^{d}	23.4^{d}	22.0^{d}	2455^{d}
Sp	*	*	*	*
Var	NS	*	*	*
Sp x Var	NS	*	NS	*

Legend * = significant at 0.05 level of probability, NS = not significant, Sp = spacing, var = variety. CW = canopy width, FFW = fresh fodder weight, DFW = dry fodder weight (g). Means with the same letter(s) in the same column and under same heading are not significantly different at P>0.05 using Duncan Multiple Range Test (DMRT).

Also the results showed that all the varieties were not significantly different (P<0.05) with the mean values of 32.3, 31.0, 30.4 and 30.3 for varieties EXMF4, EXMF1, IITA165 and ENZK2 respectively for number of pod/plant (Table). On pod and seed weight per plant, the results indicated that variety EXMF4 had the highest mean values of 36.3g (pod weight) and 28.6g (seed weight) and was significantly higher than the other three varieties. The variety with the least pods and seed weight was ENZK2 with the mean values of 30.3g (pod weight) and 26.4g (seed weight). On the seed yield in kg/ha, EXMF4 showed superiority over other varieties by being significantly different (P<0.05) with mean value of 3384kg/ha. In this study, it was observed that the varieties exhibited similar characteristics in partitioning of the dry matter into product of more pods per plant and variety. EXMF4 had the highest number of pods, pod and seed weights per plant and seed yield kg/ha indicating that it got most of the dry matter sunk into the pod filling. The findings

are consistent with that of Akpalu (2010) and Stephen (2009) who reported significant differences between the landraces used which showed how different crop genotypes responded to diverse environmental conditions. The variety x spacing interaction effect was significant for some yield parameters evaluated (Table 2).

IV. CONCLUSION

Based on the results of this study, the four varieties exhibited similar yield characteristics, but variety EXMF4 manifested its superiority over other varieties and a plant spacing of 15cm x 30cm with a population of 22,222 plants per hectare gave better results. Therefore, EXMF4 is being recommended to farmers in the area.

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