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Growth and Yield Variance and Heritability Estimates among Some Local and Improved Varieties of Bambara Groundnut (*Vigna subterranean* L. Verdc)

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Highlights

- The paper focuses on the growth of certain localized and enhanced germplasms of Bambara groundnut.
- The productivity of various localized and enhanced types of Bambara groundnut.
- Also, heritability estimates for the localized and enhanced varieties of the legume considered.

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Abstract

The current investigation demonstrated that all the seeds taken into consideration generally had different varietal characteristics with the exception of several growth characteristics, notably the stem girth where the improved varieties outperformed the local Bambara nuts. The local Bambara nut varieties (Jan Iri) had the highest parameters measured compared to others. The huge variation in yield component recorded for this variety made the promise it displayed astounding. Due to the importance of the genotype-by-environment interaction on the expression of all the examined characters, the phenotypic coefficients of variation for each character were all more significant than the genotypic coefficients of variation. Three examined features, including number of pods per plant, number of pods per plot, and number of seeds per plot, all had high heritability estimates (84.96, 99.24, and 99.35, respectively). The quantity of seeds produced by each plant and the dried weight of each plot were moderately recorded at 32.48 and 38.63, respectively. Number of pods per plot (140.01) and number of seeds per plot (176.83) both showed strong genetic advance and with high heritability also. However, fresh weight per plot (109.12) revealed low heredity along with high genetic advance. Looking at the number of seeds per plant, the number of pods per plant, and the number of seeds per plant, a substantial positive association was found.

1. INTRODUCTION

The Bambara groundnut (*Vigna subterranean*, L. verdc) is of the Fabaceae subfamily Papilonoideae by [1] and [2]. Behind groundnut and cowpea, it is the third most significant seed or underutilized legume spread across northern Africa regions [3]. Pods derived from Bambara groundnut are the main reason it is grown and cultivated [4]. These pods are high in protein and serve to treat nutritional disorders in both humans and livestock [5]. Poor emergence of seeds and bad nodulation, unstable feed and yield index, and other factors, are some of the constraints on the development of Bambara groundnut in Nigeria. Although Bambara groundnut seeds are not traded on international markets, they are a key component of the diets of many West African nations, where they rank third in terms of importance only behind groundnut and cowpea; according to national production and consumption figures [6].

The effective use of the Bambara groundnut accessions in breeding programs, research on evolution, and for the purpose of sustainability depends on the knowledge of their genetic variabilities. The morphological, physiological, and agronomic features of Bambara groundnut exhibit a high degree of variability. The assessment of variance within and between populations of species is a useful method for assessing the

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genetic structure of crop germplasm [7]. This current work, therefore, is aimed at evaluating the growth and yield variance and heritability estimates among some local and improved Bambaranuts germplasms.

2. MATERIALS AND METHOD

The research was conducted at the Research Garden, Department of Plant Science and Biotechnology, Federal University of Lafia, Nasarawa State. Nasarawa State has a tropical climate with alternating periods of heat and cold. Its annual rainfall ranges from 131.31cm to 148cm, and its average temperature is between 60°F and 80°F. Lafia falls within the Southern Guinea Savannah by virtue of its location in the northern half of the Benue valley. The vegetation is mainly grassland with sparsely populated trees that are characterized by discontinuous canopy, shrubs, and grasses. The natural fertility of the soil makes agricultural activities the prominent economic pre-occupation of the people; some of the major food products are yams, maize, cassava, guinea corn, groundnut, rice, and beans, [8], Lafia is situated between latitude 709°N, Longitude 709°E [9]

2.1. Experimental Design

Randomized Complete Block Design (RCBD) was adopted with three replications.

2.2. Collection of Planting Materials

The seeds used for this study were obtained from IITA Ibadan, Oyo State and Nasarawa Eggon market, Nasarawa State. The improved varieties obtained from IITA Ibadan were TVSU-335, TVSU-287, TVSU-1533, TVSU-640 and TVSU-1321. While the local seeds obtained from Nasarawa State markets were Farin Iri (FI), Jan Iri (JI) Mai Zane (MZ), Gaza Gaza (GG) and Bakin Iri (BI).

2.3. Parameters Measured

On the field, growth and yield parameters were assessed. They included height of plant, leaves number, area of area, lenght of leaf, diameter of stem, amount of pods in each plant, amount of pods in each plot, amount of seeds in each plant, amount of seeds in each plot, wet weight of each plant, wet weight of each plot, dry wet for each plant and dry weight for each plot were all observed in the field at 120 days after sowing (DAS).

2.4. Data Analysis

Given that experimental treatments were randomized about the plot, a one-way Analysis of Variances (ANOVA) was used to analyze the data obtained using a licened Statistical Analysis System (SAS) package [10]. Means were termed significant at $p < 0.05$. Differences between treatment means were infered using the Duncan Multiple Range Test (DMRT) at $p < 0.05$. Association established between the plant parameters studied for both estimations of genetic and physical coefficient of variance as well as the estimation of heritability.

3. RESULTS AND DISCUSSION

It is critical to state that the utilization of variability in selected plant parameters and their variables enable breeders to determine how the environment affects such plant parameter. This is due to the fact that these quantitative characters are affected by environments [11]. Results from this present study revealed variation in growth parameters among the local and improved varieties considered (Table 1). TVSU-1321 accession was observed to have the highest height (18.90 cm) and was significantly different from the Maizane variety which was found to have the lowest height (15.00 cm). As for the number of leaves, TVSU 1533 accession was found to have the highest (165.33) which was significantly different from TVSU-287 and TVSU-1321 accessions with the lowest number of leaves of 123.33 and 123.67 respectively. The leaf area and stem girth of the TVSu-1533 accession were observed to have the highest leaf area (88.67cm) and Bakin iri variety had the lowest leaf area (70.00cm) and was not significantly different. As for the stem girth, the TVSu-335 accession and Jan iri variety were found to have the highest (3.40cm) respectively; whereas

Gaza variety was found to have the lowest (2.77cm) but there were no significantly difference between the other varieties. The outcome of this work corroborates with work done by [12] who observed variations in growth parameters in Bambara nut considered. Varietal difference in terms of growth parameters was also seen among various groundnut cultivars, according to [13]. While the improved varieties performed better in terms of the growth components, it is observed that the local varieties of Bambara nut in this study compete favorably with the improved ones especially in parameters like stem girth. The trend seen in the plant height for example indicated significant difference among the improved varieties which is in agreement with the work done with groundnuts, in which it was observed significant difference existed in the height of plant of the groundnuts landraces considered. This may be attributed to different environmental conditions as well as varying climatic conditions of the study area where it had reduced amount of nitrogen available (0.18% T.N.) and is major determinant for normal growth/ development in Bambara nut and groundnut [14].

Table 1. *Mean performance for growth traits of Bambara groundnuts varieties*

Variety	Height of Plant(cm)	Leaf Number	Area of Leaf	Stem Diameter
Maizane	$15.00^{a} \pm 2.08$	$153.00^{ab} \pm 16.65$	70.67 ± 8.51^{a}	3.23 ± 0.48^{a}
Farin Iri	$15.80^{ab} \pm 0.30$	$143.33^{ab} \pm 9.61$	80.00 ± 6.11^{a}	2.77 ± 0.12^{a}
TVSU-287	$15.87^{ab} \pm 0.38$	$123.33^{a} \pm 8.76$	72.00 ± 13.11^{a}	3.03 ± 0.23^{a}
TVSU 1533	$16.47^{ab} \pm 0.74$	$165.33^{b} \pm 22.58$	88.67 ± 3.53^{a}	3.30 ± 0.50^{a}
Gaza Gaza	$16.60^{ab} \pm 0.44$	$131.00^{ab} \pm 3.61$	84.00 ± 7.02^{a}	2.73 ± 0.12^{a}
Jan Iri	$16.93^{ab} \pm 1.18$	$151.00^{ab} \pm 19.55$	78.00 ± 5.29^{a}	3.40 ± 0.59^{a}
TVSU 335	$17.00^{ab} \pm 0.06$	$142.00^{ab} \pm 8.08$	80.67 ± 4.67^{a}	3.40 ± 0.31^{a}
Bakin Iri	$17.17^{ab} \pm 1.42$	$130.67^{ab} \pm 2.03$	70.00 ± 4.00^{a}	2.87 ± 0.47^{a}
TVSU-640	$17.33^{ab} \pm 1.30$	$129.67^{ab} \pm 4.84$	74.67 ± 5.93^{a}	2.93 ± 0.07^{a}
TVSU-1321	$18.90^{b} \pm 1.15$	$123.67^{a} \pm 9.84$	87.33 ± 4.06^{a}	3.20 ± 0.65^{a}

Notes:Value represents mean ± standard error
Means followed by same superscripts within same column are not significantly different (P>0.05).

In terms of the number of pods produced per plant, TVSU-287 accession was found to have the highest yield (64.33) which was not significantly different from other accessions and varieties. On the other hand, Jan Iri variety, which is a local variety, recorded the most number of seeds on each plant (83.33), and showed significant different from TVSU- 1533 accession (improved variety), having the lowest number (48.67) (Table 2). Also, Jan iri variety recorded the highest fresh weight per plant (189.33 g) and was significantly different from TVSU 1533 (114.00 g) and TVSU 287 (117.00 g). As far as farmers are concerned, grain yield is the most crucial factor they consider in crop production and thus this research [15]. Yield is said to be a very important factor that relates closely with other parameters and is said to be polygenic [13,16]. This investigation revealed that the local Bambara nut varieties outperformed the improved varieties in terms of yield component at 12WAP. This is however not expected but it is evident in the study; as the results clearly showed Farin Iri variety recorded more superior yield components like number of seed per pod, wet weight and so on compared to the improved ones. Physiological factors like the rate of water available and the rate at which plants manufacture their food may be the reason why there is a minimal correlation between plant biomass and seed weight [17]. Varietal differences in groundnut showed varying yield components in groundnuts [13]. İn the past, growth parameters in plants in relation to the yield have been what breeding programs watch out for as the most crucial factor to be considered; especially in an atrtempt to improve legumes like Bambara nuts [17,18]. The size and quantity of the seeds determine the size and quantity of the pods; the weight of the seed should be proportional to its number. Then, independent of the pattern of constriction in the pod, breeders attempting to enhance seed yield can focus only on increasing pod yield and size. Consequent to that, moisture content of plants is intrinsically tied to the biofuel of the plant, which is associated with the quantity of the plant weight. Consequemtly, the plant needs abundant amount of moisture for maximum crop yield. Bambara nut yield are connected to the root system of the plant, which is where water is absorbed, and are buried underground. Different pod yields may result from inheritance or due to external factors like the surrounding. Some localized crop types shows supremacy above the improved plant varieties on pod yield in potted experiment as reported by [12]

working with Bambara nuts. This could imply that different genotype can have the tendency to change ATP and photosynthates into viable components when given similar leverage of resources. The somewhat high thriving of this variety disagrees with the findings of a [19] who opined that varieties that were improved could take advantage of cotyledonary reserve (CR) in higher quantity thereby resulting in the elongation of stem, as well as ensuring that the underground parts of the plant as well as the above the ground moistureless mass is more than in the rest [19]. İt has been reported that the yield of grain especially in leguminous plants depends on some obvious factors, of which, seed weights are chief [20].

Table 2. *Mean performance for yield traits of Bambara ground varieties*

Variety	No. of Pods/Plant	No. of Seeds/Plant	Fresh Weight/Plant	Dry Weight/Plant
Maizane	55.00 ± 8.08^{a}	60.33 ± 7.88^{ab}	149.33 ± 17.94^{ab}	49.33 ± 5.46^{ab}
Farin Iri	52.00 ± 14.57^{a}	53.33 ± 14.43^{ab}	128.67 ± 23.25^{ab}	48.67 ± 8.57^{a}
TVSU-287	64.33 ± 6.44^{a}	67.33 ± 5.49^{ab}	117.00 ± 19.69^{a}	43.67 ± 1.33^{a}
TVSU 1533	46.67 ± 11.09^{a}	48.67 ± 12.72^{a}	114.00 ± 31.53^{a}	41.00 ± 11.79^{a}
Gaza Gaza	54.00 ± 7.09^{a}	60.33 ± 7.36^{ab}	172.67 ± 12.35^{ab}	55.33 ± 5.36^{ab}
Jan Iri	63.67 ± 10.37^{a}	83.33 ± 16.86^{b}	189.33 ± 38.39^{b}	93.67 ± 40.68^{b}
TVSU 335	40.34 ± 6.36^{a}	55.33 ± 8.76^{ab}	148.00 ± 8.39^{ab}	54.33 ± 6.89^{ab}
Bakin Iri	60.67 ± 12.12^{a}	63.67 ± 12.12^{ab}	163.33 ± 12.35^{ab}	52.00 ± 6.66^{ab}
TVSU-640	55.67 ± 10.93^{a}	66.67 ± 8.82^{ab}	163.33 ± 21.18^{ab}	70.33 ± 13.35^{ab}
TVSU-1321	57.33 ± 10.49^{a}	58.00 ± 10.69^{ab}	137.33 ± 13.98^{ab}	53.00 ± 8.96^{ab}

Notes: Value represents mean ± standard error
Means followed by same superscripts within same column are not significantly different (P>0.05).

Table 3 lists the estimated coefficients of variation for the 10 Bambara groundnut genotypes tested in the Federal University of Lafia Botanical Garden. The sum of the observable and genetic constituents that brings about variations (PCV and GCV) demonstrated that the observable traits shown were significantly different than the one caused by the genetic constituents. The amount of pods for each plant (84.96), amount of pods in each plot (99.24), as well as the amount of seeds in each plot (99.35) all showed high level of heritability. Amount of pods in each plot (140.01) as well as the amount of seeds in each plot (176.83) both showed strong measure of how much gain you may get from the phentypic selection for traits together with incresed inheritable components. However, fresh weight per plot (109.12) showed low heredity together with increaed genetic advance. The observable traits (Phenotypic) was higher than theone thats as a result of genes, pointing to the fact that there is impact from the surrounding on the kind of chatracter that would be expressed. This finding corroborates with work done by [20] working with cowpea in Ghana. This finding contrasts with work done by [20], who opined that all the traits studied in cowpea revealed increased variations caused by the gene expression rather than variation from the surrounding and therefore had a high broad sense heritability. The results indicated, environment had minimal effects on the character traits [21], hence, cowpea could thrive confortably around Northen Ghana regions. From this study, some parameters, such as the amount of pods in each variety, amount of pods in each plot, as well as the amount of seeds in each plot have high heredity whereas other parameters have low heritability.

From this current results, it is an indication that those parameters are influenced by the gene rather than the environmental factors and it is in agreement with work done by [12] on cowpea. Also, according to [22], it

could be relatively easy if there is a heritability that is beyond 70 %. However, it is crucial to mention that, the fact that one has higher heritability only is not a good reason to conclude that it is a successful parameter or indices in further progenies except more genetic advance is implored that is substancial [23]. Because most of the yield components have substantial genetic advance and high heritability, lines of genes that shows promise may be sellected so as it could be subjected to more analysis, chosen and be made be made known to farmers for use. The most favorable conditions for selection in this study can be found in the high genetic advance and high heritability estimations observed in the amount of pods for each plot as well as the amount of seeds in a plot.

Table 3. *Estimate of Coefficient of Variability, Heritability, Genetic advance and Genetic gain of some yield components of Bambara Groundnut varieties*

Genetic parameters	No. of Pods/Plant	No. of Seeds/Plant	Fresh Weight / Plant (g)	Dried Weight/Plant (g)	No. Of pods/Plot	No. of Seeds/Plot	Fresh Weight /Plot (g)	Dried Weight /Plot (g)
(PCV):	164.92	275.37	1797.51	709.2	4690.52	7464.89	93742.6	13763.32
(GCV):	140.11	89.43	376.08	25.77	4654.82	7416.46	16218.9	5316.15
Heritability (%):	84.96	32.48	20.92	3.63	99.24	99.35	17.3	38.63
(GA):	22.47	11.1	18.27	1.99	140.01	176.83	109.12	93.35
(GG):	40.89	17.99	12.32	3.55	120.01	133.63	14.92	29.5

Notes: PCV= Phenotypic Coefficient of Variance, GCV= Genotypic Coefficient of Variance, GA= Genetic Advance, GG= Genetic Gain

Results also revealed that the growth characteristics seen in this study had no significant difference with one another (Table 4). However, there were negeative relationships between height of plant, area of leaf, diameter of stem and the leaf number. Correlation analysis helps in providing crucial information on the relationship between important agronomic traits [16,24]. The four growth traits evaluated had negative correlation between them. While there was positive correlation among the yield traits with some significance which corroborates with [20]. There were substantial positive correlations for the yield parameters (Table 5). Most interestingly, the strongest positive correlations were seen between the amount of seeds in a plant and the amount of pods in a plant (0.910) and between the amount of pods in a plant and the amount of seeds in a plant (0.973).

Table 4. *Pearson Correlation between the growth parameters*

	Plant height	Number of Leaves	Leaf Area	Stem Girth
Plant height	1	-0.321	0.244	0.217
Number of Leaves		1	0.061	0.161
Leaf Area			1	-0.012
Stem Girth				1

Table 5. *Pearson Correlation between the yield parameters*

	Number of Pods per Plant	Number of seeds per Plant	Fresh weight per Plant	Dry weight per Plant	Number of Pods per Plot	Number of Seeds per Plot	Fresh weigh t per Plot	Dry weight per Plot
Number of Pods per Plant		0.910**	0.286	0.351	0.368*	0.352	-0.131	0.142
Number of seeds per Plant			0.440*	0.579**	0.425*	0.454*	0.009	0.186
Fresh weight per Plant				0.768**	0.162	0.223	0.271	0.377*
Dry weight per Plant					0.276	0.363*	0.244	0.339
Number of Pods per Plot						0.973**	-0.022	0.325
Number of Seeds per Plot							0.034	0.350
Fresh weight per Plot								0.565**
Dry weight per Plot								

Notes: **. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed)

Plate 1: Tvsu-287 at 11 WAP

Plate 1: Bakin iri at 11 WAP

4. CONCLUSION

Present study revealed that, one as well as the other of the local as well as improved Bambara nut seeds considered generally had different varietal characteristics and responses. With the exception of several growth characteristics, notably stem girth, the improved varieties outperformed the local Bambara nut varieties. The local Bambara nut varieties (Jan Iri) had the highest recordings in most of the parameters considered. The huge variation in yield components recorded for this variety made it the most promising among others. Due to the importance of the genotype-environment association leading to the expression of all the examined characters, the traits influenced by observable or physical appearance are all bigger compared to the variations that comes as a results the genes. Three examined features, including amount of pods in each plant, amount of pods in a plot, and amount of seeds in a plot, all had high heritability estimates (84.96, 99.24, and 99.35, respectively). The quantity of seeds produced by each plant and the dried weight of each plot were moderately recorded at 32.48 and 38.63, respectively. Amount of pods in a plot (140.01) and amount of seeds in a plot (176.83) both showed strong genetic advance along with high heritability. However fresh weight per plot (109.12) showed low heredity along with high genetic advance. Between the amount of seeds in a plant, the amount of pods in a plant, and the amount of seeds in a plant, a substantial positive correlation was found.

CONFLICTS OF INTEREST

No conflict of interest was declared by the authors.

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