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Studies on the Adaptation of Bambara Groundnut [*Vigna subterranea* (L.) Verdc] in Owerri Southeastern Nigeria

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Abstract: Field experiment was conducted on the adaptability of bambara groundnut in humid rain forest tropical zones with six local accesssions in a randomized complete block design with three replications. Data was collected on the yield and yield attributes and analysed with Analysis of Variance (ANOVA) and means separated by Least Significant Difference (LSD p = 0.05). Correlation studies were carried out to determine the relationshipbetween yield and yield attributes. Results of analysis of variance showed significant differences in plant height, canopy diameter and petiole length and no significant differences in number of stem and dry matter weight (biomass) among accessions. Correlation analysis between yield attributes and fresh pod weight indicated positive correlation in all cases. However, plant height and number of stems had a near perfect positive correlation signifying that the higher the height of the plant the greater the yield. The performance ranking of the accessions showed that AC-01 had the best overall performance while AC-05 had the least. Conclusively, the crop is apparently adaptive to the study area (especially, tall growing accessions) and can contribute immensely in food and nutritional security in this agroecological zone.

Key words: *Vigna subterranea*, bambara groundnut, adaptability, humid rain forest zone, accessions, Nigeria

INTRODUCTION

The expansion of crop production has been to increase and stabilize yield to meet the various need of man; first to ensure that food supply is at pace with ever increasing human population so as to reduce or eradicate hunger if possible, next to produce feed for livestock and then raw materials for industries. In addition, crop production in recent times is diversified to satisfy varying human taste, cure certain ailments of man and even to beautify human environment.

Consequently, research on ways to improve crop production is on the increase especially now that global food crisis and nutritional insecurity is threatening human existence. It has been reported that about 1.2 billion people in the world do not have enough food to meet their daily food requirement and a further 2 billion people are deficient in one or more micro-nutrients (Williams and Haq, 2003), necessitating exploration of other ways to increase crop production. One of the major challenges of crop production in present time is crop failure consequent on climate change. It has been observed that the overall effect of climate change is poor performance and low adaptation of crops even in their natural environment of origin. Invariably, this will lead to an upsurge reduction in global crop production and supply, increase in food price, risk of exposure to hunger, malnutrition and food insecurity (IPCC, 2007).

Writing on the same issue, WFP (2009) projected that there will be a 9-11% decrease in crop performance, 25-50% increase in food price and 10-60% increase in hunger, consequent on climate change in the near decades in most developing countries of the world.

It is also estimated that the number of people at risk of hunger as a result of climate change will increase by 10-20% in the near future and Africa will be most affected especially, the semi-arid regions North and South of the equator. Apparently, this problem of global food crisis and nutritional insecurity demands that crops be grown outside their usual growing environment, especially hardy crops that can adapt to a wide range of environmental conditions.

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Several researchers observed important attributes of bambara groundnut to include; tolerance to drought, high temperature and rainfall (Linnemann and Azam-Ali, 1993; Azam-Ali *et al*., 2001), reasonable resistance to pest and disease (Uguru and Ezeh, 1997; Ntundu *et al*., 2004), high yielding potentials (Swanevelder, 1998; Collinson *et al*., 2000) and nutritional values (Amarteifio *et al*., 2006; Makanda *et al*., 2008).

Unfortunately, there is scarcely any report on the evaluation of this crop in the humid rainforest zone of Nigeria irrespective of its important agronomic and nutritional potentials.

In fact most farmers in this agroecological zone have not seen the crop. Hence, the need to evaluate the adaptability of bambara groundnut in this zone is the primary target of this study with a view to identifying suitable line(s) for cultivation of bambara groundnut in humid rain forest zone of Nigeria.

MATERIALS AND METHODS

The materials used in this study comprise of six local lines of bambara groundnut (AC 01-06) characterised by different seed coat colour, seed eye colour and seed size as shown in Fig. 1 and Table 1. Other materials are meter rule and vernier calliper.

Two seeds were sown per hole which was later thinned down to one after emergence with a planting distance of 30 cm on ridges spaced 100 cm apart.

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications and was carried out in Teaching and Research Farm of School of Agriculture and Agricultural Technology, Federal University of Technology Owerri, Southeastern Nigeria.

Data was collected on days to first and 50% emergence, days to first and 50% flowering, plant height, canopy diameter, petiole length, number of stems, root and shoot dry matter (at flowering) and fresh pod weight (at harvest).

All the data collected were subjected to statistical analysis using the Analysis of Variance (ANOVA) and the Least Significant Difference (LSD) for mean separation. In addition, statistical correlation was used to determine the relationship between yield attributes and yield (Fisher, 1963).

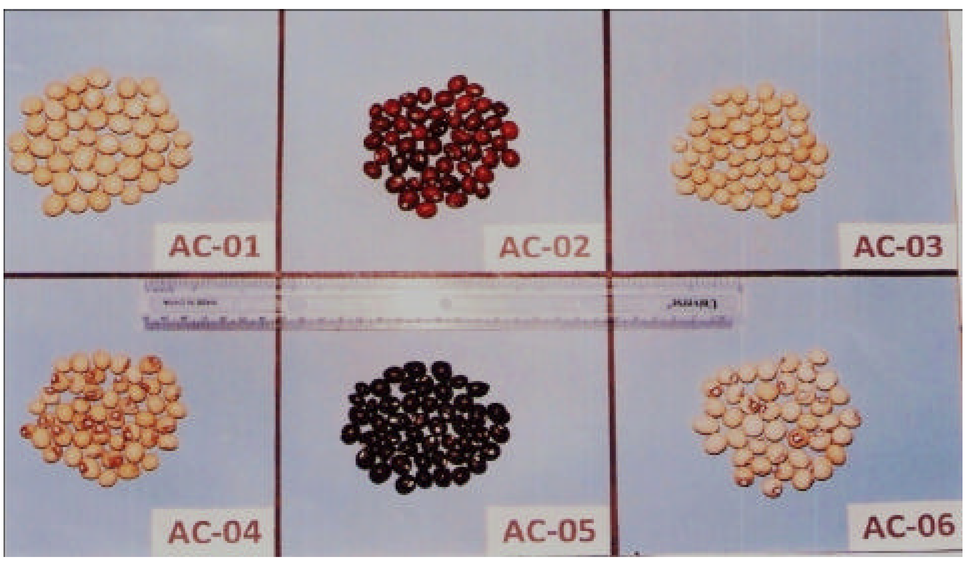

Fig. 1: Seeds of the six local lines of bambara groundnut

Table 1: Localities and seed characteristics of the six bambara groundnut accessions

Accession no.	Locality (state)	Seed coat colour	Seed eye colour	Seed size
AC-01	Mubi Adamawa	Cream	White	Big
AC-02	Dundaye Sokoto	Red	White	Small
AC-03	Dundaye Sokoto	Cream	White	Small
AC-04	Dundaye Sokoto	Cream	Purple	Butterfly eye small
AC-05	Dundaye Sokoto	Black	White	Small
AC-06	Mubi Adamawa	Cream	Purple	Butterfly eye big

RESULTS AND DISCUSSION

Three accessions (01, 03 and 06) emerged first at 6 Days After Planting (DAP) while the other three accessions (02, 04 and 05) emerged 7 DAP. The least days to 50% emergence of 8 days was recorded for accession 06 while the highest of 10 days was observed for accessions 02 and 05. On days to first flowering, two accessions 01 and 02 flowered first at 30 days while accession 04 flowered last at 34 days. The least and highest number of days to 50% flowering of 39 and 45 days were recorded for accessions 06 and 01, respectively (Table 2).

The result on plant height, canopy diameter, petiole length and number of stem is shown in Table 3. Accession 01 recorded the highest mean values; 12.88 cm for plant height, 28.86 cm for canopy diameter and 3.14 mm for petiole length while accession 05 recorded the lowest mean values; 10.08 cm for plant height, 18.13 cm for canopy diameter and 2.08 mm for petiole length (Table 3). On number of stem, accessions 06 recorded the highest mean value of 28.87 while accession 05 had the least mean value of 23.97.

Table 4 shows the result on root and shoot dry matter at flowering and fresh pod weight at harvest. On shoot dry matter weight, accession 01 had the highest mean of 2 g while the least (0.82 g) was recorded for accession 05. The highest and lowest mean root dry matter weight of 0.54 and 0.12 g were recorded accessions 01 and 02, respectively. Similarly, accession 06 had the highest mean fresh pod weight of 42.00 g (or 13.33 kg ha^{-1}) while accession 05 had the least mean value of 21.25 g (or 6.74 kg). The results on mean correlation of yield attributes and fresh pod weight shows that all yield attributes tested had a positive correlation with fresh pod weight. However, two of the parameters (plant height and number of stem) showed a near perfect positive correlation with correlation coefficient values of 0.754 and 0.924, respectively while others, canopy diameter, petiole length, shoot dry matter weight and root dry matter weight recorded a moderately positive correlation with correlation coefficient values of 0.40, 0.433, 0.40 and 0.20 in that order (Table 5).

In perfect positive correlation both variables increase and decrease in the same proportion while in moderately positive correlation the variables are positively correlated but the changes do not occur in exactly the same proportion (Fisher, 1963; Kar and Halder, 2006). The ranking of the accessions studied based on their performance on a 1-6 scale (where 1 represents the lowest value and 6 the highest value) is shown in Table 6. From Table 6, accession 01 had the overall best performance in all the parameters assessed having a ranking value of one while accession 05 had the least performance with a ranking value of six.

Table 2: Days to first and 50% emergence and days to first and 50% flowering

ACC. no.	DTFE	DT50% E	DTFF	DT50% F
AC-01	6	9	30	45
AC-02	7	10	30	42
AC-03	6	9	32	42
AC-04	7	9	34	40
AC-05	7	10	31	42
AC-06	6	8	33	39

ACC. no. = Accession number; DTFF = Days to First Flowering; DT50% F = days to 50% flowering; DTFE = Days to First Emergence; DT50% E = days to 50% emergence

Table 3: Means for plant height, canopy diameter, petiole length and number of stem

ACC. no.	PH (cm)	CD (cm)	PL (mm)	NS
AC-01	12.88	28.86	3.140	27.90
AC-02	10.16	23.22	2.530	25.67
AC-03	10.92	23.67	2.210	24.10
AC-04	10.69	24.40	2.250	25.47
AC-05	10.08	18.13	2.080	23.97
AC-06	11.98	23.49	2.440	28.87
LSD (0.05)	1.81	1.99	0.186	NS

ACC. no = Accession number; PH = Plant Height; CD = Canopy Diameter; PL = Petiole Length; NS = Number of Stems; LSD = Least Significant Difference; ns = not significant

Table 4: Means for leave, shoot and root dry matter and fresh pod weight

ACC. no.	SDM	RDM	FPW (g) S^{-1}	FPW (kg) h^{-1}
AC-01	2.009	0.54	31.67	10.054
AC-02	1.09	0.12	22.50	7.140
AC-03	1.33	0.46	22.50	7.140
AC-04	1.27	0.14	23.00	7.300
AC-05	0.82	0.16	21.25	6.740
AC-06	1.23	0.22	42.00	13.330
LSD (0.05)	NS	NS	-	-

ACC. no. = Accession number; SDM = Shoot Dry Matter; RDM = Root Dry Matter; FPW S^{-1} = Fresh Pod Weight per stand; FPW h^{-1} = Fresh Pod Weight per hectare; LSD = Least Significant Difference; ns = not significant

The emergence for the accessions studied was between 6 and 7 days for Days to First Emergence (DTFE), 8 and 10 days for days to 50% emergence (DT50% E) (Table 2). Three accessions 01, 03 and 06 had early emergence, emerging first at 6 Days After Planting (DAP) while other accessions 02, 04 and 05 emerged on the 7th day after planting. Apparently from Table 2, three accessions 01, 03 and 04 had their 50% emergence at 9 days after planting and two other accessions 02 and 05 had 50% emergence at 10 days after planting. Accession 06 recorded the least number of days to 50% emergence of 8 days after planting. The variation on the emergence of the crop studied has also been observed by Sesay (2009) who reported that germination or seedling emergence in bambara groundnut is often erratic and variable. However, early seedling emergence is an important agronomic trait for efficient crop management

Table 5: Correlation of yield attributes and fresh pod weight

ACC. no.	PH	CD	PL	NS	SDM	RDM	FPW(g) S^{-1}
AC-01	12.88	28.86	3.14	27.90	2.009	0.54	31.67
AC-02	10.16	23.22	2.53	25.67	1.09	0.12	22.50
AC-03	10.92	23.67	2.21	24.10	1.33	0.46	22.50
AC-04	10.69	24.40	2.25	25.47	1.27	0.14	23.00
AC-05	10.08	18.13	2.08	23.97	0.82	0.16	21.25
AC-06	11.98	23.49	2.44	28.87	1.23	0.22	42.00
(r)	0.754	0.40	0.43	0.924	0.40	0.20	-
Tc	PPC	MPC	MPC	PPC	MPC	MPC	-

r-tab (0.05) = 0.5529; ACC. no. = Accession number; PH = Plant Height; CD = Canopy Diameter; PL = Petiole Length; NS = Number of Stem; SDM = Stem Dry Matter; RDM = Root Dry Matter; FPW S^{-1} = Fresh Pod Weight per stand; PPC = Perfect Positive Correlation; MPC = Moderately Positive Correlation; r = coefficient of correlation; Tc = Type of correlation; r-tab (0.05) = coefficient of correlation tabulated at 0.05 probability level

Table 6: Performance ranking of the accessions studied

ACC. no.	DTFE	DT50% E	DTFF	DT50% F	PH	CD	PL	NS	SDM	RDM	FPW/S	Total	Rank
AC-01	2	2	5	16	6	6	5	6	6	4	55	1	-
AC-02	1	1	5	22	2	5	4	2	1	3	30	5	-
AC-03	2	2	3	2	4	4	2	2	5	5	3	39	3
AC-04	1	2	1	3	3	5	3	3	4	2	2	33	4
AC-05	1	1	4	2	1	1	1	1	1	3	1	18	6
AC-06	2	3	2	4	5	3	4	6	3	4	5	44	2
TOTAL	6	6	6	6	6	6	6	6	6	6	6	72	1-6

ACC. no. = Accession number; CD = Canopy Diameter

and production (Jefferson and Coulman, 2008; Thomas *et al*., 2009). The number of days to flowering was observed to be between 30 and 34 days for Days to First Flowering (DTFF), 39 and 45 days for days to 50% flowering (DT50% F). Two accessions 01 and 02 flowered first at 30 days while accession 05 had first flowering at 31 days after planting. Accessions 03, 04 and 06 had the highest number of days to first flowering of 32, 33 and 34 days in that order. The least number of days to 50% flowering of 39 days was recorded for accession 06, accessions 02, 03 and 05 recorded for 42 days. Accession 04 had 40 days while the highest of 45 days was for 01. This result on first and 50% flowering is in agreement with that of DPP who observed that flowering in bambara groundnut is between 30 and 45 days. Furthermore, the result on first and 50% flowering is similar to that of first and 50% emergence on the grounds of variability. The variation observed in flowering of the crop has been attributed mostly to variable temperatures and photoperiods (Linnemann, 1992; Brink, 1997).

In addition, Masindeni (2006) indicated flowering in bambara groundnut is indeterminate. However, early flowering has been recognised as a good agronomic attribute of crops for early maturity, uniformity of yield and crop production in general (Kumaga *et al*., 2003).

Similarly, poor yield in this crop has been identified as a function of delayed flowering (Makanda *et al*., 2009). Hence, lines that flower early should be considered in the production of bambara groundnut.

Significant differences in other morphological characters studied were observed among the accessions. The recorded mean values indicated that accession 01 recorded the best performance in plant height, canopy diameter and petiole length having mean values of 12.88 cm for plant height, 28.86 cm for canopy diameter and 3.14 mm for petiole length. On number of stems, accession 06 had the highest mean value of 28.87 and this was followed by accession 01 with 27.90. Other accessions 02, 03, 04 and 05 recorded slight variabilities in plant height, canopy diameter, petiole length and number of stems with mean values ranging between 10.0 and 10.9 cm for plant height, 18 and 24 cm for canopy spread and between 23 and 25 cm for number of stems (Table 3). Variability on morphological traits like plant height, canopy spread, petiole length and number of stems among accessions of bambara groundnut have been observed by several workers (Amadou *et al*., 2001; Ntundu *et al*., 2004; Massawe *et al*., 2005).

The observed mean values for root and shoot dry matter weight as shown in Table 4 indicated that accession 01 had the highest mean values of 2.009 g shoot dry weight and 0.5 g of root dry matter weight. The other accessions; 02-06 had mean values ranging between 0.8 and 1.3 g for shoot dry matter weight and 0.1 and 0.4 g for root dry matter weight. Also at p = 0.05, there were no significant differences in shoot and root dry weights among accessions. This clearly indicates that there were no differences in both root and shoot biomass for these accessions.

However, the high root and shoot biomass observed for accession 01 is an indication of good agronomic character (Makanda *et al*., 2009). On Fresh Pod Weight per Stand (FPW/S), the highest mean value of 42.00 g (or 13.33 kg ha^{-1}) was recorded for accession 06 while accession 05 had the least mean value of 21.25 g (or 6.74 kg ha^{-1}).

The other accessions 02-04 recorded mean values for fresh pod weight per stand ranging between 22.50 and 23.00 g (or between 7.14 and 7.30 kg for fresh pod weight ha^{-1}). Primarily this crop is cultivated for its fresh pods and hence, lines with greater fresh pod weight are of immense value to farmers (Table 4). A correlation of morphological components (plant height, canopy diameter, petiole length, number of stem, shoot and root dry matter weight) with fresh pod yield showed a positive correlation between these morphological parameters and pod yield. Correlation studies between characters have been observed to be of great value in determining the most effective procedures for selection of superior agronomic traits in crops (Johnson *et al*., 1955; Paroda and Hayes, 1970; Kamboj and Mani, 1983; Adebisi *et al*., 2004; Jonah *et al*., 2010). The results herein showed different forms of association between variables and pod yield. A highly significant perfect positive correlation was observed for plant height and number of stem at r-tab = 0.05 which clearly indicates a direct positive effect of both plant height and number of stem on pod yield.

On the other hand, a moderately positive correlation observed for canopy spread, petiole length, shoot and root dry weight matter indicated a moderate but positive effect of these parameters on pod yield (Table 5). The result shows that accessions with greater heights and number of stems had better yield. Ultimately, increase in yield is the major goal of crop production, hence agronomic and morphological characters that improves yield should be emphasized on. Kadams and Sajo (1998) described yield as a measure of and an indication of good agronomic and morphological characteristics in crops. Overall accession 01 had a better performance with a total score of 55 and a ranking value of one while accession 05 recorded the least performance with a total score of 18 and a ranking value of six (Table 6).

CONCLUSION

Apparently from the results obtained in this study, there is clear evidence that a great measure of adaptability was attained among the accessions studied. Therefore, the domestication of this crop will certainly improve the cropping system and nutritional status of the people in the humid rainforest agroecological zone of Nigeria.

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