PHENOTYPIC VARIABILITY AND DIVERSITY OF SOME AFRICAN YAM BEAN ACCESSIONS BASED ON FLORAL, POD AND SEED TRAITS

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Abstract
Understanding intra-specific variability of quantitative traits which determines grain yield in African yam bean (AYB) is necessary for a guided germplasm classification. Fifty-five AYB accessions were obtained from the Genetic Resources Centre, International Institute of Tropical Agriculture, Ibadan, Nigeria. The accessions were evaluated at the Teaching and Research farm of the University of Port Harcourt, Nigeria in a randomized complete block design with three replications. Data were collected on: days to flower bud initiation (DFBI) and flowering (DTF), individual pod weight, pod length, number of seeds/pod, shell weight, seed weight/pod, seed length and width. Data were subjected to analysis of variance and means separation by Tukey honestly significant difference. The 55 x 9 mean data matrix were subjected to Pearson correlation, principal component (PC) and cluster analysis. The accessions differed significantly ($p \leq 0.01$) for the nine phenotypic traits. Pod weight had positive and significant ($p \leq 0.001$) correlation with: shell weight ($r=0.70$), pod length ($r=0.64$), seed weight ($r=0.84$) and seeds/pod ($r=0.68$). Positive correlation ($r = 0.45^{***}$) existed between DFBI and DTF. The first three PC axes explained 78% of the total variation among the 55 AYB accessions. The 55 accessions were grouped into five distinct clusters. Accessions in cluster IV had the highest mean value for pod and seed traits and accessions in cluster V initiated flower buds and flowered much earlier. The present result presents a reliable platform for trait-based selection of AYB for grain yield and earliness in flowering improvement.

Key words: African yam bean, accession, breeding, diversity, pod, seeds

Introduction

The age long agricultural goal has been to produce sufficient quantities of food, feed, and biofuel crops on limited land resources in a sustainable way (Ebert, 2014) for the daily teeming population which is expected to hit nine billion by 2050 (Bedoussac *et al.*, 2015). To attain this, a comprehensive approach that should involve the production of all kinds of food crops is necessary. Development of strategies to use less expensive and available local resources that could combine optimum nutritive value to replace expensive and exotic food resources would be a way forward (Iwe *et al.*, 2016).

African yam bean (*Sphenostylis stenocarpa* (Hocht Ex. A. Rich) Harms) is a traditional and indigenous crop of the rain forest belt of tropical Africa. African yam bean presents two edible and economic products (pulse and tubers) with significant nutritional profile which outweighs most of the contemporary legumes and tubers (Adewale and Nnamani, 2022). Konyeme *et al.* (2020), further highlighted many important proximate content in the tubers, which is the most neglected product of the crop in West Africa. Although the crop is still grossly neglected and underutilized, the research attention on it is increasing in recent time (Adewale, 2023).

The speculation by Pardey and Pingali (2010) that restoring crop genetic diversity and conservation may be difficult to achieve in the next few years because of the very slow pace of traditional crops' utilization. The poor tracking pace to rescuing underutilized crops indirectly informs that more plant genetic resources erosion is ongoing and their progressive losses will continue. Disproportionate consideration of all crops endangers the genetic resources of the crops lacking research attention, life and living balance on earth.

Among the listed constraints in African yam bean by Adewale and Nnamani (2022) are: long gestation period and poor pod and seed productivity. The present study seeks to identify potentials and promises for earliness to flowering and pods and seed productivity with 55 sourced accessions. Identified variability and diversity from the study will therefore become a platform for trait-based selection of accession(s) for improvement and promotion for other utilization.

Materials and Methods

Fifty-five accessions of African Yam Bean (AYB) were obtained from the Genetic Resource center (GRC), International Institute of Tropical Agriculture (IITA). Field experiment was conducted in the teaching and research farm Faculty of Agriculture, University of Port Harcourt, Port Harcourt, Nigeria. The treatments (55 AYB accessions), were laid out in a randomized complete block design with three replications. Two seeds were sown, number of plants per stand was reduced to one by thinning at two weeks after planting.

Seedlings were staked three weeks after planting. Manual weeding was employed to keep the field free from weeds. Reproductive pests were controlled with Laraforce (*Lambda cyhalothrin*) applied at the rate of 60 ml in 20 litres of water at two weeks intervals during the flowering period.

Quantitative characters were obtained from the sampling units by measurement using meter rule, vernier caliper, weighing balance etc. following the African Yam Bean descriptors by Adewale and Dumet (2011). Data collected were subjected to statistical analysis in SAS (version 9.4, 2011). Among the statistical analysis employed were: descriptive statistics, Pearson correlation coefficient analysis, principal component and clustering analysis.

Results

In Table 1, significant ($p \leq 0.01$) variation existed among the 55 African yam bean accessions for the nine floral, pod and seed traits. The coefficient of variation in the study was ≤ 20% for eight out of the nine traits except pod weight (Table 1). The mean lowest number of seed/pod and seed weight/pod in the study were respectively 4.0 and 0.5 g in TSs109, TSs2 which equally had four seeds/pod had the least pod length (11.48 cm) and 0.48 g shell weight (Table not shown). Furthermore, the mean highest number of seeds/pod in the study was 15, this was observed in TSs441 but the same accession had the least mean value for seed length (6.54 mm) and width (4.92 mm), but the highest seed length (10.48 mm) and width (6.75 mm) was respectively observed in 157A and TSs3. TSs98 had the longest pod (22.82 cm), seed weight/pod (3.91 g) and shell weight of 2.1 g (Table not shown). The respective earliest accessions to initiate flower bud (49 days) and flowered (68th day after planting) were TSs119A and TSs22, however, flower bud initiation and flowering respectively occurred latest in TSs39A and 2015_12 at 65th and 95th days after planting.

Table 1: The variance components, coefficient of variation and the mean of the nine traits

Sources of variation	DF	Shell Wt. (g.)	Pod Length (cm)	Seed Wt. (g.)	Seed length (mm)	Seed Width (mm)	Seeds/ pod	Pod Weight (g.)	Days to bud Initiation	Days to Flowering
Rep	2	0.02	0.85	0.03	0.11	0.07	0.85	33.27	24.81	21.11
Accessions	54	0.33***	14.64***	1.38***	1.14***	0.50***	19.55***	2.76***	56.75***	110.11**
Error	108	0.04	1.86	0.12	0.15	0.04	2.41	0.90	22.41	54.97
CV (%)		17.64	8.46	19.51	4.58	3.31	18.17	26.29	8.84	9.47
Mean		1.13	16.11	1.81	8.33	5.95	8.50	3.61	53.55	78.26

Table 2: Correlation coefficients showing relationship among reproductive traits

	Shell weight.	Pod Length	Seed weight.	Seed Length	Seed Width	Seeds/pod	Pod weight	DFBI
Pod length	0.75***							
Seed weight.	0.70***	0.77***						

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Seed length	0.22	0.01	-0.02					
Seed width	0.44***	0.27*	0.53***	0.15				
Seeds/pod	0.51***	0.79***	0.79***	-0.35	0.26			
Pod weight	0.70***	0.64***	0.82***	0.08	0.57***	0.68***		
DFBI	0.13	0.13	0.14	0.04	0.17	0.13	0.31*	
DTF	-0.01	-0.11	0.07	-0.01	0.20	0.01	0.18	0.45***

DFBI = Days to flower bud initiation, DTF = Days to flowering

In all, 36 correlation coefficients were generated for the nine quantitative traits, 16 were positive and significant at $p \leq 0.05$ and four of the remaining 20 were negative but not significant (Table 2). Significant ($p \leq 0.05$) correlation existed among the following traits: pod length, pod weight, seed weight, shell weight, seed width and number of seeds/pod. The correlation between days to flower bud initiation and days to flower ($r = 0.45$) was significantly ($p \leq 0.001$) positive (Table 2).

Table 3: Proportion of variance and the eigenvector loadings in five principal component axes

	PC1	PC2	PC3	PC4	PC5
Eigenvalue	4.207	1.539	1.268	0.744	0.492
Variance Proportion	0.467	0.171	0.141	0.083	0.055
Cumulative variance	0.467	0.639	0.779	0.862	0.917
Variables			Eigenvectors		
Shell weight.	0.401	-0.044	0.278	0.150	0.127
Pod Length	0.416	-0.232	0.009	0.325	0.099
Seed wt.	0.454	-0.075	-0.012	-0.104	0.092
Seed Length	0.008	0.264	0.775	0.284	0.177
Seed width	0.289	0.269	0.216	-0.708	-0.381
Seeds/pod	0.401	-0.237	-0.346	0.058	0.072
Pod weight	0.441	0.116	0.025	-0.071	-0.034
DFBI	0.135	0.565	-0.249	0.508	-0.568
DTF	0.056	0.639	-0.303	-0.118	0.678

DFBI = Days to flower bud initiation, DTF = Days to flowering

The proportional performances of the eigenvalues, variances and eigenvectors in five principal component (PC) axes is presented in Table 3. PC axes 1 to 3 had eigenvalues above a unit, variance proportion > 10% and a total cumulative variance of 78% (Table 3). The nine considered traits had significant (eigenvector loading > 0.2) in the first three PCs. Shell weight, pod length, seed weight, number of seeds/pod and pod weight were prominent in PC1 with eigenvector > 0.4. In PC 2 and 3, pod length, seed length and width, seeds/pod, days to flower bud initiation and flowering were significantly prominent (Table 3).

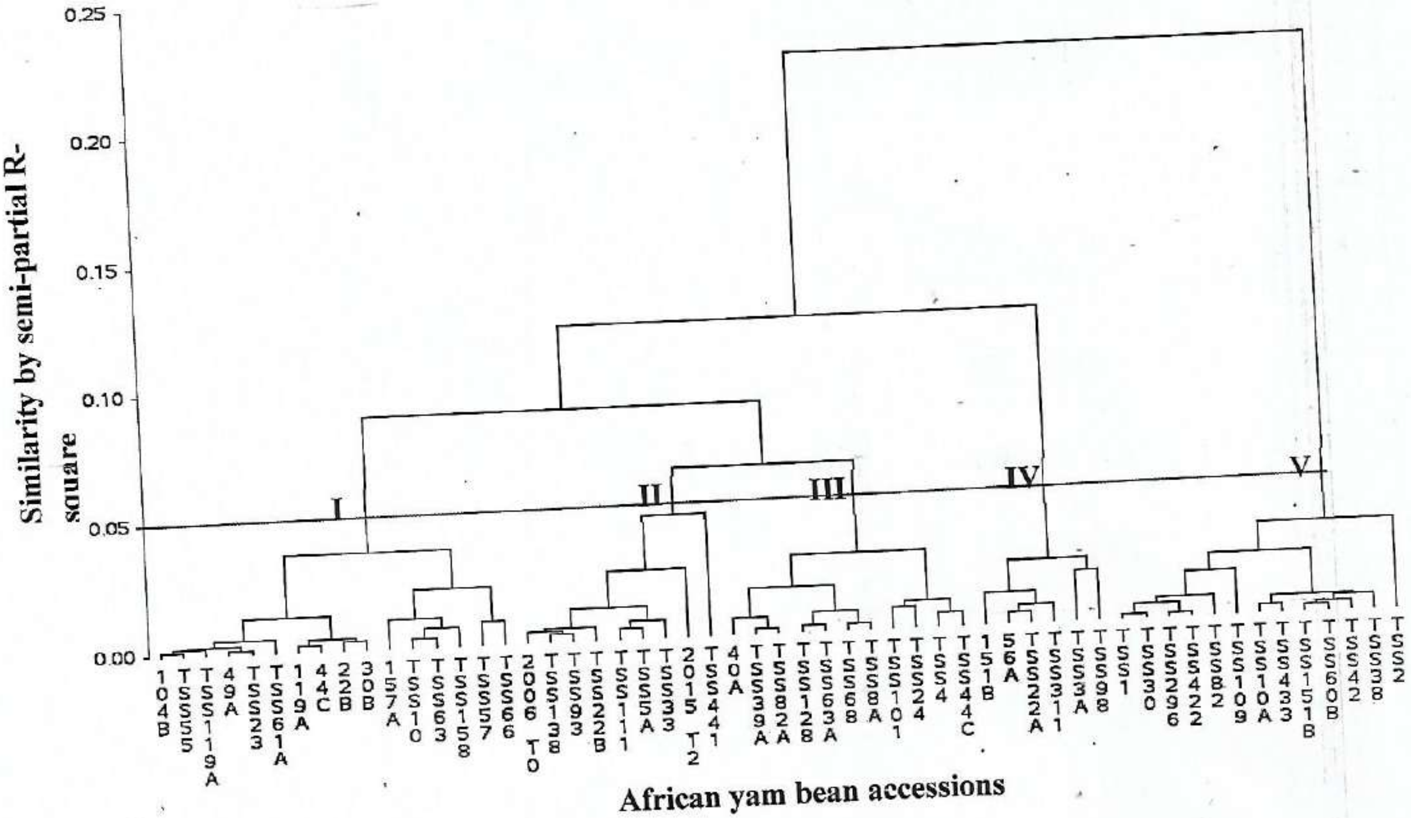

Figure 1: A dendrogram showing the clustering pattern of the 55 African yam bean accessions based on similarities for nine agronomic traits.

In Figure 1, choice of the inflection point of 0.05 was made to be able to capture the distinctiveness of the membership of the various clusters; only five clusters were visible at the point. The genetic similarities among the 55 accessions based on the nine traits was 0.77 (Table not shown). In the Figure, the number of accessions within each clusters were: 16 (I), 9 (II), 11 (III), 6 (IV) and 13 (V), each with the respective genetic similarities of 0.85, 0.80. 0.85, 0.78 and 0.86 (Table not shown).

Discussion

The significant variation observed among the 55 African yam bean accessions for the nine traits seem to depict that the various genetic materials differ phenotypically. The less than 20% coefficient of variation observed in most of the studied traits fall in the low and medium categories as remarked by Sivasubramanian and Menon (1973). Low CV determines uniformity of the sample and hence ensures reliability of the traits as trustworthy characters for characterization and selection for specific genotype based on the traits in question. The variations in the performances of the different African yam bean accessions for the nine quantitative traits was an indication of differences in the inherent genotypic potentials as aided by the environment.

The results present a platform for selection of good genetic materials, thus reiterating the assertion by Bernado (2010) and Sofi *et al.* (2014) that variability assessment is a prerequisite for selection of genetic materials. Therefore, from this study, TSs119A and TSs22 are choicest for early maturity since they attained flower bud initiation and flowering less than 50th and 70th day after planting respectively. It could therefore be inferred that flower bud initiation and blooming happens within 20 days in African yam bean. Furthermore, promising accessions such as TSs98 can be selected having the highest pod length, weight and seed weight, TSs2 could also be promising for shell weight, for having the lowest value in this study and TSs3A and 157A which respectively had the highest value for seed width and length could be promising accessions for seed size.

Correlation analysis is novel for revealing association of traits, positive and significant association is mostly appreciated by the plant breeders, as this eases selection of different genotypes for multiple traits and equally reveals dependency of one trait on the other. From this study, pod weight of African yam bean is a function of: Shell weight, pod length, seed weight and width and the number of seeds in a pod because the relationships were positively significant. However, negative correlations among desired traits usually pose challenges to plant breeders.

The nine phenotypic traits employed in this study for characterization explained 78% of the total variation among the 55 African yam bean. This seems to identify them as good quantitative descriptors for African yam bean along with some vegetative, floral pod, seeds and grain yield parameters identified lately by Aina *et al.* (2020), Animasaun *et al.* (2021), Adjei *et al* (2023).

Grouping of genotypes by dendrogram is meant to enhance the discovery of distinctiveness for similarity of genotypes for specific traits. Generally in each of the clusters, there is very high uniformity among the accessions for each of the nine traits. This seems to certify them as heterotic groups with unique performances to enhance selection of outstanding genotype(s) for specific traits. The present result concurs with the norm that characterization can lead to the identification of unique genotypes or groups of genotypes in a germplasm (Baenziger *et al.*, 2006; Carena, 2009; McCouch *et al.*, 2020). Clusters IV and V host accessions with the mean extreme values for most nine traits. Cross breeding between selected accessions within the two will lead to the generation of F1 and foster the discovery of the inherent gene action for the various traits through generation mean analysis.

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