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# Floral-pod efficiency and pod productivity potential among some African yam bean (*Sphenostylis stenocarpa* Hochst. Ex. A. Rich) Harms accessions

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**Abstract**
Pod and grain yield in legumes is a function of the quantity of flowers on the field. The present study explored flower and pod productivity potentials of 15 African yam bean (AYB) accessions to provide insight into their intra-specific grain yield potentials. The 15 accessions were evaluated in a randomized complete block design (RCBD) with three replicates at the Teaching and Research Farm, Federal University Oye-Ekiti (FUOYE), Ikole-Ekiti Campus, Nigeria. Data were collected on: number of flowers/peduncle (NOFP), number of filled pods/peduncle (NOFPP), number of unfilled pod/peduncle (NOUPP), number of pods/plant (NOPP) and pod weight/plant (PWP). Data were subjected to analysis of variance and genetic estimates were estimated from the variance components. Pearson correlation coefficient analysis was done using means of the data and ratios of flower to pod were estimated for each accession. Significant (≤0.001) variation existed among the 15 accessions for the five traits. Average NOFP, NOFPP, NOUPP, NOPP and PWP from the 15 accessions were 14.51, 2.06, 0.97, 32.36 and 174.44g respectively. DSs4B and DSs4C had above average NOFP, NOPP and PWP with NOUPP less than the average while TSs69A and DSs4A had above average for the five traits. NOPP had the highest (91.32%) broad-sense heritability. Mean proportion of pod to flower in this study was 21%, seven accessions had above this average, the highest (29%) occurred in DSs4A. African yam bean accessions had different flower-pod ratio efficiencies and pod productivity potential. This study unfolds a platform for pod productivity selection in AYB.

**Keywords:** Accessions, African yam bean, flower-pod ratio, heritability, variability

## Introduction

Nigeria, akin to many developing nations, faces a critical challenge in meeting its nutritional needs, particularly concerning protein deficiencies, aggravated by escalating population growth. In the past decade, over three million children have grappled with inadequate protein intake, resulting in severe stunted physical growth and development [1]. This nutritional shortfall not only affects the young but also detrimentally impacts the health and economic productivity of the adult populace.

In light of escalating population pressures and the rapid depletion of natural resources, the exploration of novel plant resources has become an imperative pursuit. This quest is especially relevant given the disproportionate reliance on a limited array of plant resources, encompassing less than 30 crops, among which the African yam bean (AYB), a leguminous crop, holds prominence [1].

Legumes, renowned for their adaptability to adverse ecological conditions and nutritional richness, present an avenue for bolstering the sustainability of dry subtropical and tropical agricultural systems [2, 3]. Among these legumes, the African yam bean stands out as an underutilized yet nutritionally potent crop, comparable in nutritional value to widely-consumed legumes [4]. However, despite its nutritional promise, comprehensive awareness of its productivity and nutritional significance remains conspicuously deficient, particularly in regions where it thrives.

AYB, classified as a vigorous climbing herbaceous vine indigenous to West and East Africa, exhibits robust growth patterns under specific ecological prerequisites [5].

This leguminous crop, thriving in well-drained sandy and loamy soils with adequate rainfall and temperatures, emerges as a crucial reservoir of protein, carbohydrates, and fats [6, 7].

Nonetheless, despite its nutritional prowess, AYB continues to be overlooked, partly attributed to the presence of anti-nutritional compounds and the paucity of comprehensive research devoted to its enhancement [8, 9].

Understanding the genetic diversity encapsulated within AYB is foundational to effective breeding programs and the development of superior cultivars [10, 11, 12]. However, despite strides in understanding its genetics, detailed investigations into the pod productivity potentials of AYB peduncles and variations in testa colors between planted and harvested seeds remain conspicuously scant in contemporary research.

Hence, this study endeavors to investigate the pod productivity potentials across diverse AYB accessions and elucidate variances in testa colors between planted and harvested seeds, aiming to contribute valuable insights to the enhancement of this underutilized yet nutritionally promising crop.

## Materials and Methods

An experiment was carried out at the Teaching and Research farm, Department of Crop Science and Horticulture, Federal University Oye-Ekiti (FUOYE). Ikole-Ekiti campus, Ikole-Ekiti, Ekiti state, Nigeria. The land area was ploughed, harrowed and ridged. The experimental layout was randomized complete block design with three replicates. The treatment was 15 African yam bean (AYB) genetic materials obtained from the Genetic Resources Centre (GRC), International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria and AYB Breeding program FUOYE, Ikole-Ekiti Campus, Nigeria (List in Table 1).

Planting was done at 1m by 1m, thinning and staking was done between weeks two and three after planting. A row plot of six plants were maintained and 15 plots were maintained in a replicate. Five peduncles were tagged on the primary branches of two middle plants in each plot per replicate. The number of flowers, number of pods and number of filled pods were recorded. Number of unfilled pods/peduncle were estimated as: total pods/peduncle – total number of filled pods/peduncle. Furthermore, mean number of flowers/peduncle, flowers to filled and unfilled pod ratios were estimated. Other data include: number of pods/plant and pod weight/plant. Data were submitted to analysis of variance (ANOVA), means of the treatments for each data were separated by Tukey Honestly significant differences. Trait relationships was estimated by Pearson correlation coefficient analysis. Above analyses were conducted in SAS, version 9.4. (SAS, 2011). Genetic estimates such as: phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV) and broad sense heritability (Hbs) were estimated from the variance components as follows, following [13].

$$PCV = 100*\sqrt{\frac{\sigma p2}{X}} \quad \text{Eq. 1}$$

$$GCV = 100*\sqrt{\frac{\sigma g2}{X}} \quad \text{Eq. 2}$$

$$Hbs = \frac{\sigma g2}{\sigma p2} \quad \text{Eq. 3}$$

Where: $\sigma_g^2$ and $\sigma_p^2$ are genotypic and phenotypic variance components from ANOVA, $\sigma_g^2$ -genotypic mean square – error mean square)/number of replications and $\sigma_p^2$ - genotypic mean square $_+$ error mean square)/number of replications. X is the mean of each trait.

Different proportions of the pods, filled and unfilled pods to the total numbers of flowers per pod were estimated.

**Table 1:** List and sources of the 15 African yam bean accessions used in the experiment

| S/N | Accessions | Sources |
|---|---|---|
| 1 | TSs84A | GRC, IITA, Ibadan |
| 2 | TSs58W | GRC, IITA, Ibadan |
| 3 | TSs69A | GRC, IITA, Ibadan |
| 4 | TSs69B | GRC, IITA, Ibadan |
| 5 | TSs217AA | GRC, IITA, Ibadan |
| 6 | TSs217AB | GRC, IITA, Ibadan |
| 7 | TSs217AC | GRC, IITA, Ibadan |
| 8 | TSs217AD | GRC, IITA, Ibadan |
| 9 | TSs357AA | GRC, IITA, Ibadan |
| 10 | TSs357AB | GRC, IITA, Ibadan |
| 11 | TSs357AC | GRC, IITA, Ibadan |
| 12 | DSs4A | FUOYE Breeding program |
| 13 | DSs4B | FUOYE Breeding program |
| 14 | DSs4C | FUOYE Breeding program |
| 15 | DSs4D | FUOYE Breeding program |

## Result

The 15 genotypes differ significantly ($p \leq 0.001$) from each other for all the traits in Table 2 except in the number of unfilled pods per plant. All other traits had coefficient of variation < 15% except number of unfilled pods per plant whose CV was 46.79% (Table 2).

**Table 2:** ANOVA Table showing the source of variation showing the floral and pod traits

| | | Mean Squares | | | | |
|---|---|---|---|---|---|---|
| SOV | DF | NOFP | NOFPP | NOUPP | NOPP | PWP(g.) |
| Rep | 2 | 1.70 | 0.07 | 0.03 | 4.91 | 234.71 |
| Gen | 14 | 10.38*** | 0.49*** | 0.34*** | 221.80*** | 3983.5*** |
| Error | 28 | 0.97 | 0.03 | 0.03 | 7.72 | 659.41 |
| Mean | - | 14.51 | 2.06 | 0.95 | 32.36 | 174.44 |
| CV (%) | - | 6.80 | 8.14 | 18.95 | 8.59 | 14.72 |

*, ** and *** - significant probabilities at $p \leq 0.05$, 0.01 and 0.001. Number of flowers/peduncle (NOFP), number of filled pods/peduncle (NOFPP), number of unfilled pod/peduncle (NOUPP), number of pods/plant (NOPP) and pod weight/plant (PWP).

Among the 15 studied African yam bean accessions, the highest mean of flowers/peduncle was 17.15, and it occurred in TSs217AC, the genotype with the least (10.85) number of flowers/peduncle was TSs217AD (Table 3). Highest number of filled pods/peduncle was 2.73 in DSs4A, the least (1.30) was observed in TSs217AA, the same genotype had the least (106.72g) weight of pods/plant but DSs4C was the genotype with the highest (254.46 g) pod weight in this study (Table 3). While DSs4D and DSs4B respectively had the highest value for unfilled pod and number of pods/plant, the least values for the same traits were respectively recorded in TSs357AC and TSs357AA (Table 3).

Among the five traits, ten correlation coefficients ensued, eight were positive, two were negative and only three were significant (Table 4). Number of flowers/plant positively and significantly ($p \leq 0.05$) correlated with: number of pods/plant (r = 0.56) and pod weight/plant (r = 0.68). Correlation coefficient between number of pods/plant and pod weight/plant was high (r = 0.91) and highly significant (Table 4).

From Table 5, the PCV were higher than the GCV in all the traits. The highest PCV and GCV occurred in the number of unfilled pods, the same trait had the least broadsense heritability of 31.23%. Moreover, very high magnitude was observed in the differences between phenotypic and genotypic coefficient variation values (Table 5). Broadsense heritability was > 70% in the number of pods/plant (91.32%), number of flowers/peduncle (72.11%) and number of filled pods (77.97%)

**Table 3:** Mean performances of the 15 accessions for floral and pod traits

| Accessions | Means | | | | |
|---|---|---|---|---|---|
| | NOFP | NOFPP | NOUPP | NOPP | PWP (g.) |
| TSs84A | 12.03d-f | 1.39ef | 0.85b-f | 19.89f | 124.34cd |
| TSs84W | 11.55ef | 1.81c-e | 0.72d-f | 26.17d-f | 154.4b-d |
| TSs69A | 15.66a-c | 2.28a-c | 1.31a-c | 25.24f | 143.38b-d |
| TSs69B | 15.59a-c | 2.42ab | 0.49f | 41.24ab | 185.75a-c |
| TSs217AA | 14.52a-d | 1.30f | 0.57ef | 25.62ef | 106.72d |
| TSs217AB | 16.44ab | 1.67d-f | 1.13a-d | 21.67f | 141.5b-d |
| TSs217AC | 17.15a | 2.14c-d | 1.36ab | 35.57a-c | 196.29a-c |
| TSs217AD | 10.85f | 2.07c-d | 0.71d-f | 32.52c-e | 178.11a-d |
| TSs357AA | 13.79b-f | 1.7d-f | 1.34a-c | 34.48b-d | 191.3a-c |
| TSs357AB | 14.62a-d | 2.44ab | 0.80c-f | 19.73f | 188a-c |
| TSs357AC | 13.41c-f | 2.11b-d | 0.45f | 41.53ab | 198.13a-c |
| DSs4A | 14.65a-d | 2.73a | 1.14a-d | 36.07a-c | 181.51a-d |
| DSs4B | 15.63a-c | 2.27a-c | 1.09a-e | 43.47a | 204.45ab |
| DSs4C | 15.65a-c | 2.32a-c | 0.82b-f | 39.59a-c | 254.46a |
| DSs4D | 16.14a-c | 2.22a-c | 1.50a | 42.56ab | 168.18b-d |

Number of flowers/peduncle (NOFP), number of filled pods/peduncle (NOFPP), number of unfilled pod/peduncle (NOUPP), number of pods/plant (NOPP) and pod weight/plant (PWP)

*Mean comparison is along each column; means with the same alphabet are not significantly different from each other.

**Table 4:** Correlation between a Pair Between all the Data

| | NOFP | NOFPP | NOUPP | NOPP |
|---|---|---|---|---|
| NOFPP | 0.38 | | | |
| NOUPP | 0.44 | -0.28 | | |
| NOPP | 0.56* | 0.44 | -0.08 | |
| PWP | 0.68** | 0.32 | 0.1 | 0.91*** |

*, ** and *** - significant probabilities at $p \leq 0.005$, 0.01, 0.001. Number of flowers/peduncle (NOFP), number of filled pods/peduncle (NOFPP), number of unfilled pod/peduncle (NOUPP), number of pods/plant (NOPP) and pod weight/plant (PWP)

**Table 5:** Genetic Estimates of the measured traits

| Traits | PCV (%) | GCV (%) | Broadsense Heritability (Hbs) |
|---|---|---|---|
| NOFP | 24.90 | 21.14 | 72.11 |
| NOFPP | 37.29 | 32.92 | 77.97 |
| NOUPP | 82.50 | 46.11 | 31.25 |
| NOPP | 47.31 | 45.22 | 91.32 |
| PWP | 40.04 | 33.05 | 68.15 |

Number of flowers/peduncle (NOFP), number of filled pods/peduncle (NOFPP), number of unfilled pod/peduncle (NOUPP), number of pods/plant (NOPP) and pod weight/plant (PWP).

Table 6 unfolds the differential flower: pod ratios of the 15 African yam bean accessions. Among the studied 15 accessions, mean flowers: pods, flowers: filled pods, flowers: unfilled pods and filled: unfilled pods ratios were respectively: 20.98%, 14.3%, 6.68% and 48.54 % (Table 6). DSs4A took the lead among the 15 accessions by having the highest number of converted flowers to pods, filled pods and unfilled pods (Table 6). TSs217AD had the least (29%) proportion of losses to unfilled pods, but the highest (79%) was observed in TSs357AA.

**Table 6:** Proportions of flowers to pods of the different African yam bean accessions

| Accessions | Flowers: Pods (%) | Flowers: FLD pods (%) | Flowers: UFLD pods (%) | FLD:UFLD pods (%) |
|---|---|---|---|---|
| TSs84A | 17.96 | 11.55 | 6.40 | 55.40 |
| TSs84W | 20.61 | 15.67 | 4.94 | 31.49 |
| TSs69A | 22.41 | 14.56 | 7.85 | 53.95 |
| TSs69B | 22.96 | 15.52 | 7.44 | 47.93 |
| TSs217AA | 15.15 | 8.95 | 6.20 | 69.23 |
| TSs217AB | 16.67 | 10.16 | 6.51 | 64.07 |
| TSs217AC | 18.48 | 12.48 | 6.01 | 48.13 |
| TSs217AD | 24.61 | 19.08 | 5.53 | 28.99 |
| TSs357AA | 22.04 | 12.33 | 9.72 | 78.82 |
| TSs357AB | 23.67 | 16.69 | 6.98 | 41.80 |
| TSs357AC | 21.63 | 15.73 | 5.89 | 37.44 |
| DSs4A | 28.67 | 18.63 | 10.03 | 53.85 |
| DSs4B | 20.22 | 14.52 | 5.69 | 39.21 |
| DSs4C | 19.87 | 14.82 | 5.05 | 34.05 |
| DSs4D | 19.76 | 13.75 | 6.01 | 43.69 |
| Mean | 20.98 | 14.30 | 6.68 | 48.54 |

FLD – filled, UFLD – unfilled

**Discussion**

The findings of this study unfold significant variability among 15 accessions of African yam bean for floral and pod traits. The identified variation may be suggestive of the distinctive genetic variability among the accessions for the various traits, thus offering promising avenue for direct selection of genotypes for cultivar development programs in African yam bean. The traits considered in this study are among the grain yield determinants of grain yield in legumes [14]. Many authors have identified number of flowers [15], number of pods/plant [16], number of filled pods [17], flower to pod ratios [18] as critical traits to guide selection of candidate genotypes as parental stocks for hybridization and hence advanced trial for the generation of elite cultivars.

This study reveal that a peduncle of African yam bean situated on a primary branch of the vine can produce flowers in the range of 11 to 18 and up to three pods/peduncle. Furthermore, number of pods/plant recorded in this study for African yam bean ranged between 20 and 44 and pod weight/plant was between 107 g to 255g. Above results were relatively in consonance with that of [19, 20, 21, 22] etc.

Selection in plant breeding is a very critical procedure to advance breeding progress, the process is eased when correlation analysis reveal proportional relationship among traits. In this study, number of pods/plant had a positive correlation with the weight of pods/plant. Correlation analyses revealed intriguing relationships between certain traits. Relationship of these two traits underscores direct association of pod quantity and pod weight, this has positive inference on grain yield. Our study therefore identified DSs4B and DSs4C as the best accessions for these traits; possible cross between them can greatly lead to the generation of heterotic genotypes for this economic trait. It is noteworthy from our study that more flowers per peduncle equally translated to higher number of pods/plant and hence the pod weight/plant; meaning, low flower producing genotypes may not be recommended for higher grain yield.

The proportional differences between PCV and GCV values for number of flowers/peduncle, number of filled pod and number of pods/plant were very low, moreover the three had broad-sense heritability well above 70%. Many authors [23, 11, 24] had earlier remarked that selection based on trait with such low PCV and GCV difference and > 70% broad-sense heritability values may be very reliable. Number of unfilled pod had the widest PCV-GCV gap and the lowest broad-sense heritability value. Environmental factors are suspected to be playing a very significant role in its expression, thus selection based on the trait may not be reliable. Practically, factors which enhances pod filling in legumes include water, assimilates, temperature etc. [25, 26].

We postulate floral-pod ratio as a measure of efficiencies of the conversion of flowers to pods among different accessions of African yam bean in this study. While mean flower to pod ratio among the 15 accessions was 21%, pod from flower production efficiency may be as low as 15% in TSs217AA and as high as 29% in DSs4A. According to [27, 28] flower-pod ratio varies within species and it is mostly determined by assimilate partitioning pattern and other environmental factors. From the results the number of flowers produced per peduncle does not actually determine the productivity of the pod, for example, TSs84W, produced the highest number of flowers while TSs217AD had the lowest. Identifying the most relevant factor determining flower-pod efficiency ratio in African yam bean is key to eventual recommendation. We therefore recommend assessment of physiological role in the determination of flower-pod ratio for African yam bean as a further study gap.

**Conclusion**

In conclusion, the study revealed significant variability among 15 African yam bean accessions for floral and pod traits, with distinct genetic variability observed. This diversity provides promising opportunities for direct selection of genotypes in cultivar development programs. Traits such as number of flowers, pods per plant, and pod weight were identified as crucial determinants of grain yield, essential for guiding selection of parental stocks for hybridization. Correlation analyses highlighted positive associations between traits, particularly between number of pods per plant and pod weight, indicating their direct influence on grain yield. Notably, accessions DSs4B and DSs4C showed potential for enhancing these traits, suggesting the possibility of generating heterotic genotypes through crosses between them. However, caution is advised in selection based on the number of unfilled pods, given its wide variation influenced by environmental factors. Furthermore, the study introduced floral-pod ratio as a measure of conversion efficiency, emphasizing the need for further investigation into the physiological determinants of this ratio in African yam bean. Overall, these findings contribute valuable insights for optimizing breeding strategies and enhancing productivity in African yam bean cultivation.

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