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Yield and Yield Component Assessment of Some African Yam Bean Genotypes (*Sphenostylis stenorcarpa* Hochst Ex A. Rich) Harms in Lowland Humid Tropics of South Eastern Nigeria

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Abstract: African yam bean (AYB) vary greatly depending on physiological, genetic and environmental factors, which indicates that there is inadequate information about the yield of this very important but little known tuber/seed legume crop. Therefore, the objectives of this study were to evaluate some AYB genotypes for seed yield in acid ultisols. The field experiments were conducted at Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria in 2009 and 2010 cropping seasons. Ten (10) *Sphenostylis stenocarpa* genotypes collected from different locations were sown into plots of 3.5 m x 4.5 m at 1.0 m x 0.5 m inter and intra-row spacing, respectively. The experiment was fitted into a randomized complete block design with three replications. The results revealed significant yield variations among the genotypes studied. In the two cropping seasons, AYB-03 consistently gave the highest significant ($P<0.05$) seed yield compared to the other genotypes, except AYB-04 and AYB-09. It could be due to superior genetic make-up of the genotype and its adaptability to the environment. Principal component analysis showed that the four components studied contributed 83.13 % of total variability, while the other principal components (PC1, PC2, PC3 and PC4) contributed 29.52, 27.18, 17.33 and 9.10 %, respectively while PC1, PC2 and PC3 with eigen values that were greater than unity accounted for 74.03 % of the total variability among the seed yield components. Correlation showed very strong positive ($P<0.05$) relationship between number of pods per plant and seed yield (kg/ha) with correlation coefficients of $r = 0.873$. The results revealed the importance of number of pods per plant and the other yield traits such as number of days to flowering, pod filling period, pod length and 100-seed weight in determining increased yield, hence they require appropriate attention during breeding and selection targeted at increasing the seed yield of *Sphenostylis stenocarpa*.

Key words: Principal Component Analysis · Variability · Correlation · Breeding and Selection

INTRODUCTION

The legume, African yam bean (AYB), which is usually cultivated for its edible seeds and tubers [1, 2] in most Sub-saharan Africa countries is one of the underutilized crops with high nutritional value (21-29 % crude protein in the seed and 11-19 %) protein content in the tuber on dry weight basis and its protein contains lysine and methionine levels that are equal to or better than those in soybean [3]. Other researchers [4] who evaluated the nutritional content of 44 genotypes of AYB reported that the crop is well balanced in essential amino acids and has higher amino acid content than pigeon pea, cowpea and bambara groundnut. Culturally and economically, AYB is the most important of the seven species of the genus *Sphenostylis* [5]. The crop is of minor importance [6] and has long been used as a traditional dual seed grain and tuber food crop in Africa [7, 8]. [9] as well as [10], reported that AYB is a crop that is well domesticated, cultivated and distributed within the confines of tropical Africa where it has exhibited a high percentage of diversity. Genetic

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Resources Information Network [11] submitted that AYB originated and can be found only within these areas in Africa: West tropical Africa (Nigeria, Ghana, Côte d'Ivoire, Togo, Guinea, Mali and Niger), West-Central tropical Africa (Burundi, Central African Republic and Democratic Republic of Congo), South-tropical Africa (Angola, Malawi, Zambia and Zimbabwe), as well as East and Northeast tropical Africa (Kenya, Ethiopia, Tanzania and Uganda).

According to [12], grain legumes can produce high seed yields under favourable conditions in the humid tropics. AYB is one of the lesser known legumes that is adapted to lowland tropical weather conditions and grown in mixed association with yam and cassava [13, 14]. According to [15], intercropping AYB with appropriate structural crops that would serve as life stakes such as kenaf, high seed yields are achieved than in sole cropping. Furthermore, [16] revealed that *Sphenostylis sternocarpa* can be intercropped with yellow yam (*Diosorea cayenensis*) using the same staking operational techniques applicable to yam. The essence is to ensure good interception of solar radiation by the leaves of the crop.

Sphenostylis sternocarpa responds well to organic and inorganic nutrient application. [17] reported that grain yield production of AYB can be enhanced with the application of potassium fertilizer. Also, [18] reported that *Sphenostylis sternocarpa* has a big potential to contribute to national food security, however there is dearth information on its genetic materials, production and utilization. This study was therefore, initiated to assess yield and yield component performance of some AYB genotypes on advancing breeding programmes of this little-known but highly nutritious legume crop.

MATERIALS AND METHODS

Field experiments were conducted at Micheal Okpara University of Agriculture, Umudike, during the 2009 and 2010 growing seasons. The soils were sandy loam having physical and chemical properties as shown in Table 1. Soil samples (0-30 cm) were collected prior to planting during both seasons. The samples were thoroughly mixed to form a composite soil sample. A sub-sample was taken from the bulk, air-dried, gently crushed with a porcelain pestle and mortar, sieved through a 2 mm sieve and used for soil physical and chemical analysis following standard laboratory procedures. Particle size analysis was determined by hydrometer method [19]. The pH (1:2.50; Soil:Water ratio) of the soil was measured electrometrically using glass electrode pH meter, Jenway model 3510 [20] whereas organic matter was estimated using wet oxidation method through chromic acid digestion as outlined by [21]. Total nitrogen per cent content was determined by the semi-micro kjedahl digestion procedure using sulphuric acid and copper sulphate and sodium sulphate catalyst mixture as described by [22]. Avaliable phosphorus was determined by the molybdenum blue colorimetry method [23]. The soil exchangeable K, Na, Ca and Mg were extracted using ammonium acetate extraction method. The extracts of K and Na were read on flame photometer using FP 8800 model, with acetylene of propane burner. Ca and Mg were determined by the ethylenediaminetetraacetic acid (EDTA) titration method with the model 8089-A2 [23].

The experimental location is characterized by two distinctive seasons {wet (May to October) and dry (November to April)}, which are typical of southern part of West Africa.

Table 1: Physico-chemical properties of the soil of the experiment site used in 2009 and 2010

Physical properties	2009	2010
Sand (%)	78.14	78.12
Silt (%)	7.40	7.60
Clay (%)	14.46	14.28
Textural class	Sandy loam	Sandy loam
Chemical properties		
pH	5.54	5.14
Available phosphorus	22.00	15.20
Total Nitrogen (%)	0.05	0.10
Organic matter (%)	1.75	1.07
Exchangeable bases		
Calcium (cmol/kg)	2.80	2.20
Magnesium (cmol/kg)	1.60	1.40
Potassium (cmol/kg)	0.12	0.14
Sodium (cmol/kg)	0.09	0.09

Source: Soil science laboratory, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria

Table 2: Agro-meterological data on rainfall, temperature and relative humidity of Umudike in 2009 and 2010

	Rainfall	Temperature (oC)		Relative humidity (%)	
Mouth	Amount (mm)	Max	Min	09.00hrs	15.00hrs
2009					
May	306.10	32.4	23.0	78.9	70.0
June	237.50	31.5	22.5	84.0	73.7
July	300.90	29.9	22.3	87.3	78.7
August	287.40	29.4	22.4	87.6	76.6
September	205.30	30.3	29.0	85.3	71.6
October	305.30	30.4	22.5	82.3	73.3
November	23.70	32.0	22.2	75.0	58.9
Mean	238.03	30.84	23.41	82.91	71.83
2010					
May	138.5	32.2	24.2	83.3	70.3
June	427.0	30.1	23.6	86.3	78.3
July	310.2	29.6	23.0	86.4	76.8
August	376.7	29.5	23.0	87.7	77.8
September	303.3	29.5	22.8	88.4	75.6
October	349.0	30.8	22.8	86.3	78.0
November	77.8	31.8	23.4	87.9	70.6
Mean	283.21	30.39	23.26	86.41	75.34

Source: National Root Crops Research Institute agro-meteorologicalstation, Umudike

Table 3: Genotypes, seed coat colour, place of collection and agro-ecological zone of *Sphenostylis stenocarpa* used in the study

Accessions number	Colour	Place of collection	Ecological zone
AYB - 01	White	Ankpa, Benue State	Derived Savanna
AYB – 02	White	Eha-Alumona, Enugu State	Derived Savanna
AYB – 03	White	Ekwashi, Benue State	Derived Savanna
AYB – 04	Dark Brown	Giver, Benue State	Derived Savanna
AYB – 05	Dark Brown	Ikwuano, Abia State	Rainforest
AYB – 06	Dark Brown	Ilaro, Ebonyi State	Rainforest
AYB – 07	Brown	Isiukwuato, Enugu State	rainforest
AYB – 08	White	Nsukka, Enugu State	Derived Savanna
AYB – 09	Brown	Tarka, Benue State	Derived Savanna
AYB – 10	Dark Brown	Umuahia, Abia State	Rainforest

Mean monthly rainfall of the experimental site between May and November was 238.03 mm and 283.21 mm in 2009 and 2010, respectively (Table 2), while the minimum and maximum temperatures of the area are 23.41°C and 30.84°C, respectively (2009) and 23.26 °C and 30.39 °C, respectively (2010). The mean relative humidity in both years at 09.00 hours and 15.00hours was 84.66 % and 73.59 %, respectively.

Seeds of ten (10) AYB genotypes were collected from different locations where they are usually cultivated and identified accordingly (Table 3). The AYB were sown into plots of 3.5 m x 4.5 m (15.75 m^2) at inter-row and intra-row spacing of 1.0 m x 0.5 m to give a plant population of 20,000 plants/ha. The experiment was laid out in randomized complete block design (RCBD) with three replications. Three hand weeding were carried out at 4, 8 and 12 weeks after planting (WAP). The plants were staked with long dry sticks. The plants were allowed to use the nutrients from the ambient environment as no fertilizer (organic or inorganic) was applied to the crop. Insect pests were controlled with the application of Cypermethrin EC [24] at 2.5 ml/litre with a knapsack sprayer.

Yield and yield component data were collected from six randomly selected plants, from the inner rows of the plots on days to flowering, pod filling period, days to physiological maturity, pod length, number of pods per plant, number of seeds per pod, 100-seed weight, seed yield per plant, dry matter yield per plant and seed yield per hectare.

The data collected were subjected to statistical analysis for a single factor experiment using SAS software [25]. F-LSD was used to determine significant mean difference following the procedure outlined by [26].

Principal component analysis (PCA) was carried out to identify genotypes according to yield aimed at obtaining reliable information on groups of genotypes that have desirable yield traits that could be used to improve AYB breedings [27]. According to [28], statistically, PCA is a method of data reduction, to clarify the association between two or more traits of a crop and to divide the total variance of the original traits into a limited number of uncorrelated new variables. The analysis allows for good visualization of the differences among the individuals and identify possible groups [27] while the reduction is achieved by linear transformation of the original variables into a new set of uncorrelated variables, known as Principal Components (PCs). They are orthogonal and independent of each other with each PC revealing different properties of the original data and may be interpreted independently. The total variation in the original data set may therefore be broken down into components that are cumulative in nature [29]. Also, the analysis helps to identify the genetic distance between crop genotypes. Our data was analyzed according to PRINCOMP procedure using SAS software [25]. Pearson correlations were calculated to examine inter-character relationships among the traits using SPSS for windows version 16.0 (2004) following the procedure outlined by Miller *et al*. (1958). The degree of significance of genotypic correlation coefficients was tested by referring to the standard table (Snedecor and Cochran 1980) with n-2 degrees of freedom, where, n is number of African yam bean (AYB) genotypes evaluated.'

RESULTS AND DISCUSSION

Significant (P<0.0.5) mean year effect on number of days to flowering and pod filling period was recorded in 2009 (Table 4). Averaged over the two cropping seasons, number of days to flowering and pod filling period ranged between 88.11 (AYB-10) to 100.97 (AYB-02) and 46.64 (AYB-02) to 57.83 (AYB-05), respectively. The interaction between year and genotype was not significant in the yield component parameters. Similarly, [7] reported that lower number of days to flowering and a higher seed set percentage are desirable traits that influence the yield of AYB positively.

In both cropping seasons, number of days to physiological maturity was significant and showed strong variation among the AYB genotypes evaluated (Table 5). The mean physiological maturity ranged from 151.89 to 159.44 with AYB-09 genotype exhibiting the longest maturity days. AYB-04 significantly (P<0.01) produced the highest mean number of pods per plant (31.20) compared to the other genotypes studied (Table 6), while number of seeds per pod was highest in AYB-10 (15.67) and lowest in AYB-08 (12.05). The findings corroborate previous works by [30] in their studies on reproductive mechanism and pollen characterization in some accessions of an underutilized legume (AYB) in which they reported that number of pods and number of seeds per pod produced from the legume plant are good indices of high yield. Also, [13] as well as [31] stated that yield parameters such as number of pods per plant, number of seeds per pod and 100-seed weight strongly influence grain yield of AYB, hence efforts should be directed in improving them for high and stable yield. Year by genotype interactions in the parameters were not significantly (P>0.05) different.

The mean of pod length and 100-seed weight in both cropping seasons were highly (P<0.01) significant as shown in Table 7. AYB-10 gave the longest pod length (28.07 cm), while AYB-04 had the highest 100-seed weight (33.52 g) compared to the other genotypes. The strong variations among the AYB genotypes were due to genetic variability associated with location and environmental factors of the place of location prior to the collection and

Table 4: Number of days to flowering and pod filling period of African yam bean (*Sphenostylis stenocarpa* L. Hosch) on 2009 and 2010 cropping seasons

	Number of days to flowering			Pod filling period		
Genotype	2009	2010	Mean	2009	2010	Mean
AYB - 01	101.22	97.50	99.36	50.61	50.22	50.42
AYB – 02	103.17	98.78	100.97	47.06	46.22	46.64
AYB – 03	96.22	94.50	95.36	49.89	48.11	49.00
AYB – 04	97.11	96.06	96.58	48.56	47.17	47.86
AYB – 05	89.72	89.17	89.44	58.39	57.28	57.83
AYB – 06	89.55	89.11	89.33	56.33	54.78	55.56
AYB – 07	94.39	94.44	94.41	51.56	49.78	50.67
AYB – 08	99.83	98.17	99.00	48.84	46.61	47.72
AYB – 09	101.55	99.95	100.75	51.17	49.89	50.53
AYB – 10	88.61	87.61	88.11	58.55	55.00	56.78
Mean	96.14	94.53		52.09	50.51	
LSD0.05	Year	1.327*		1.383*		
		Genotype = 3.968,***		5.405,***		
		Year x Genotype = ns		ns		

Table 5: Number of days to physiological maturity in the African yam bean (*Sphenostylis sternocarpa* L. Hosch) in 2009 and 2010 cropping seasons

	Number of days to physiological maturity		
Genotype	2009	2010	Mean
AYB - 01	158.83	158.39	158.61
AYB – 02	157.22	156.11	156.67
AYB – 03	153.33	151.95	152.64
AYB – 04	152.67	151.28	151.97
AYB – 05	153.28	151.78	152.53
AYB – 06	154.94	153.72	154.33
AYB – 07	152.72	151.06	151.89
AYB – 08	155.17	154.66	154.92
AYB – 09	159.83	159.06	159.44
AYB – 10	154.22	152.56	153.39
Mean	152.22	154.06	
LSD0.05	Year = ns		
	Genotype = 2.776		
	Year x Genotype = ns		

Table 6: Number of pods/plant and number of seeds/pod of African yam bean genotypes (*Sphenostylis sternocarpa* L. Hosch) in 2009 and 2010 cropping season

	Number of pods/plant			Number of seeds/pod		
Genotype	2009	2010	Mean	2009	2010	mean
AYB - 01	14.39	13.00	13.70	15.60	13.67	14.64
AYB – 02	14.00	10.45	12.22	14.50	12.68	13.79
AYB – 03	23.89	20.61	22.25	14.47	12.51	13.49
AYB – 04	33.45	28.94	31.20	14.50	12.29	13.39
AYB – 05	19.17	15.94	17.55	16.17	13.75	14.96
AYB – 06	14.28	11.89	13.08	14.37	12.21	13.29
AYB – 07	17.11	12.89	15.00	14.73	12.86	13.79
AYB – 08	10.34	9.39	9.87	12.87	11.23	12.05
AYB – 09	25.89	22.67	24.28	13.63	11.94	12.78
AYB – 10	16.56	16.00	16.28	16.30	15.05	15.67
Mean	18.91	16.18		14.71	12.82	
LSD0.05	year	ns		0.763		
		Genotype = 6.90,***			1.606	
		Year x genotypes =ns			ns	

Table 7: Pod length (cm) and 100-seed weight (g) of African yam bean genotypes (*Sphenostylis sterncarpa* L. Hosch) in 2009 and 2010 cropping season

	Pod length (cm)			Pod seed weight (gm)		
Genotype	2009	2010	Mean	2009	2010	Mean
AYB - 01	25.50	24.60	25.05	23.07	20.57	21.82
AYB – 02	23.83	23.23	23.53	22.80	22.27	22.53
AYB – 03	25.07	24.47	24.77	33.43	28.90	31.17
AYB – 04	21.00	20.47	25.73	36.97	30.07	33.52
AYB – 05	27.83	27.13	27.48	25.20	21.13	23.17
AYB – 06	25.17	22.90	24.03	28.20	20.10	24.15
AYB – 07	26.53	25.20	25.87	53.93	29.43	31.68
AYB – 08	24.83	24.17	24.50	25.83	22.27	24.05
AYB – 09	21.27	20.53	20.90	31.10	23.80	27.45
AYB – 10	28.67	27.47	28.07	31.60	25.57	28.58
Mean	24.97	24.02		29.21	24.41	
LSD0.05	Year = ns			ns		
		Genotype = 2.048,***			4.598,***	
		Year x genotype = ns			ns	

Table 8: Seed yield (kg/ha) and dry matter yield (g/plot) of African yam bean genotypes (*Sphenostylis sternocarpa* L. Hosch) in 2009 and 2010 cropping seasons

	Seed yield (kg/ha)			Dry matter yield (g/plot)		
Genotype	2009	2010	Mean	2009	2010	Mean
AYB - 01	396	326	361.00	41.80	32.0	36.90
AYB – 02	249	224	236.50	67.90	52.70	60.30
AYB – 03	781	622	701.50	45.10	32.20	38.65
AYB – 04	771	569	645.00	41.40	27.50	34.45
AYB – 05	382	284	333.00	44.20	32.90	38.55
AYB – 06	391	296	343.50	51.20	18.10	34.65
AYB – 07	385	329	357.00	39.60	23.00	31.30
AYB – 08	234	244	239.00	37.90	28.30	33.10
AYB – 09	686	515	600.50	52.30	37.70	45.00
AYB – 10	360	316	338.00	61.00	22.80	41.90
Mean	458.00	372.00		48.20	30.70	
LSD0.05	Year = ns			ns		
		Genotype = 138.80,***		13.01,**		
		Year x genotype = ns		ns		

Table 9: Principal component analysis of yield and yield associated fruits in the African yam bean genotypes (*Sphenostylis sternocarpa* L. Hosch)

Attributes	PC1	PC2	PC3	PC4
100 seed weight	-0.39319	0.22474	0.12112	0.22204
Days to flowering	-0.10110	0.59294	-0.16951	0.21610
Dry matter yield (g/plot)	-0.28932	-0.09669	-0.58605	0.48078
Days of physiological maturity	-0.00799	0.30073	-0.66544	-0.36298`
Pod filling period	0.09673	-0.50316	-0.32976	-0.52922
Pod length (cm)	0.17632	-0.48504	-0.23314	0.43880
Number of pods/plant	-0.59731	-0.08532	0.05377	-0.16291
Seed yield (kg/ha)	-0.59313	-0.04914	0.06390	-0.20478
Latent axis	2.361	2.174	1.386	0.728
Percentage variation	29.52	27.18	17.33	9.10
Cumulative	29.52	56.52	74.03	83.13

planting of the genotypes at the study site. Year by genotype interaction effects on pod length and 100-seed weight were not significant (P>0.05).

Seed yield and dry matter yield of African yam bean were not significantly (P>0.05) affected by year (Table 8). The same trend was observed in interaction between year and genotype. However, there was strong genotypic variability among the genotypes studied with AYB-03 significantly giving the highest seed yield (701.50 kg/ha) while AYB-02 had the lowest seed yield (236.50 kg/ha) but gave the highest mean dry matter yield per plot (60.30 g). Similarly, [7] and [13] reported that yield components such as length of pod, number of pods per plant, number of seeds per plant, 100-seed weight, among others are desirable characters that positively influence grain yield of AYB.

Total variation from the principal component analysis (PCI-PC4) of the ten (10) AYB genotypes studied (Table 9) showed that the initial four components (cumulative) contributed 83.13 % (where, PC1, PC2, PC3 and PC4) contributed 29.52, 27.18, 17.33 and 9.10 %, respectively. The results further revealed that only three components (PC1, PC2 and PC3) had values that were greater than unity, hence accounted for 74.03 % of the total variability. This implies that genetic diversity plays a key role in crop yield performance. The most important traits contributing to seed yield in AYB genotypes under (PC1) were 100-seed weight (-0.39319), seed yield (-0.59313) with 29.52 % of the total variability and number of pods per plant (-0.59731) while in PC2, contributions were achieved through days to flowering, days to physiological maturity, pod length and pod filling period. In PC3, percentage total variation was 17.33. The most important traits to seed yield production were pod filling period, dry matter yield and days to physiological maturity (PC1), as well as dry matter yield, pod length, days to physiological maturity and pod filling period (PC4). The findings are in consonance with [32] who reported that length of pod, number of seeds per pod and seed weight are desirable traits in

Table 10: Yield and yield attributes of African yam bean genotypes (*Sphenostylis sternocarpa* L. Hosch) in 2009 and 2010 cropping seasons

	Pearson's correlation analysis								
	DTF	PFP	DTPM	PL (cm)	NPP	NSP	100-SW (g)	DMY PLT (g)	SYHA (t)
DTF	1								
PFP	-.608**	1							
DTPM	.477**	.078	1						
PL(cm)	-.466**	.472**	-.180	1					
NPP	.001	-.28	-.080	-163	1				
NSP	.568**	-.226	.097	.495**	.107	1			
100-SW (g)	-.134	.083	-.179	.026	.430**	.264*	1		
DMYPLT(g)	.074	.124	.279*	.196	.323*	.359**	.192	1	
SYHA (t)	.039	-.066	-.041	-.193	.873**	.092	.421**	.273*	1

DTF, Days to flowering; PFP, Pod filling period; DTPM, Days to physiological maturity; PL, Pod length (cm); NPP, Number of pods per plant; NSP, Number of seeds per pod;100-seed weight (g); DMYPLT, Dry matter yield per plot (g); Seed yield per hectare (t); *, Significant at 5 % level; **, Significant at 1% level.

genetic improvement of AYB. Furthermore, [33] evaluated fifty accessions of AYB in South west Nigeria and surmised that principal components such as pod number per plant, pod length, number of seeds per pod and seed yield contributed immensely to tuber and seed yield as well as total variation (90 %) in the crop, which was not dissimilar to the results obtained from our study in Umudike, South east Nigeria.

Combined Pearson's correlation analysis of yield and yield attributes of AYB (Table 10) showed that number of days to flowering was negatively and highly significantly ($P \geq 0.01$) correlated with pod filling period and pod length while it showed highly significant and positive correlation with number of days to physiological maturity and number of seeds per pod. The study further revealed that pod filling period, pod length, number of seeds per pod and 100-seed weight showed positive and high significant ($P \leq 0.01$) correlation with pod length with correlation coefficients (r), = 0.472**, number of seeds per pod (r = 0.495**), dry matter yield per plot (r = 0.359**) and seed yield (t/ha) (r = 0.421**), respectively. Also, number of pods per plant was highly significantly and positively correlated 100-seed weight and seed yield per hectare with correlation coefficients (r) of 0.430** and 0.873**, respectively. [30] in their study on some accessions of the underutilized legume (*Sphenostylis stenocarpa*) reported that pod length and width as well as number of seeds per pod positively influenced percentage seed set in twenty five (25) accessions. Days to physiological maturity and number of pods per plant showed positive and significant ($P \leq 0.05$) correlation with dry matter yield per plant. Also, significant and positive annunciation existed between number of seeds per pod and 100-seed weight and between dry matter yield per plot and seed yield of African yam bean. The results corroborated earlier findings of Mgbeze and [13] where they reported that correlation coefficients of AYB traits such as length of reproductive branch, plant dry weight, pod length, number of seeds per pod, number of reproductive branch and maturity period of the crop significantly and positively influenced crop seed yield.

CONCLUSION

The study showed that some promising AYB genotypes (AYB-03, AYB-04 and AYB-05) were identified with superior plant traits, such as number of days to flowering, pod filling period number of pods per plant, pod length, 100-seed weight and seed yield. These rich trait potentials could play a significant role in future AYB breeding programs through selection. Further-more, the use of PCA in the study enabled the identification of quantitative traits that best described the variations between the ten (10) AYB genotypes assessed. Also, the inter-trait relationships exhibited by the genotypes could serve as clear platform for establishing hybridization procedure that could further be used for AYB genotype selection.

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