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RESEARCH PAPER

Genetic variability, character association and yield potentials of twenty five accessions of cowpea (*Vigna unguiculata* L. Walp)

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Key Message: In this study, variability issues in cowpea species were addressed and reliable selection criteria for breeding in our prevailing environment were provided. Strong influence of genotype x environment interaction on productivity of cowpea was established.

Abstract: Inadequate knowledge of the level of genetic variability and genotype x environment interaction in cowpea are major constraints to its improvement in Nigeria. Therefore, study objectives were to determine genetic variability, character association and yield potential of twenty five accessions of cowpea in the field during 2014 and 2015 cropping seasons. A randomized complete block design (RCBD) with three replications was adopted in each season. Data were collected on 12 quantitative traits from 10 randomly tagged plants per accession per replicate. Analysis of variance revealed highly significant differences among accessions for all traits. Seed yield per plant fell between 0.00 g in AC19 and 134.97 g in AC18 in 2014, while the range fell between 0.00 g in AC19 and 54.09 g in AC20 in 2015. Accessions AC12, AC17, AC20 and AC18, consistently showed the highest yield, therefore these can be considered the best candidates for selection. Broad-sense heritability ranged from 48.75% (emergence) to 98.09% (pod length) in 2014 and ranged between 8.95% (number of main branches) and 94.32% (pod length) in 2015. Genetic advances as percent of mean ranged from 19.32% (emergence) to 474.89% (plant height) in 2014 and ranged from 3.43% (number of main branches) to 108.70% (days to flowering) in 2015. High positive correlations between seed yield and peduncle length (r = 0.85** and 0.84** in 2014; r = 0.55** in 2015), number of pods (r = 0.98** and 0.98** in 2014; r = 0.61** and 0.71** in 2015), seeds/pod (r = 0.57** and 0.57** in 2014; r = 0.78** and 0.68** in 2015), and seeds/plant (r = 0.97** and 0.97** in 2014; r = 0.67** and 0.75** in 2015) of these accessions will be useful in designing an effective selection program for the crop.

Keywords: Cowpea, Genetic variability, Heritability, Phenotypic and genotypic correlations, Yield potentials

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Introduction

Cowpea (*Vigna unguiculata* L. Walp; chromosome number: 2n = 22) is an important, annual herbaceous legume and a vital source of protein in the tropical and subtropical countries (Sangakkara, 1998; Ehlers & Hall, 1996). Its role as a crucial component of cropping systems in the world's tropical and subtropical areas and its importance in being a nourishment legume can never be overemphasized (Fatokun et al., 2002; Sanchez-Navarro et al., 2019). Cowpea contains 20 to 25% protein content, which makes it attractive as a source of quality nourishment for both the rural and urban poor people (Fatokun et al., 2002; Uarrota, 2010; Ajayi et al., 2014). According to Gerrano et al. (2018), protein content of cowpea ranged between 23.16% and 28.13%; crude protein was significantly positively correlated with Ca but significantly negatively correlated with Mg, Cu, K and Fe. Cowpea grows fast, curbs erosion, fixes atmospheric nitrogen (Ajayi & Adesoye, 2013) and fertilizes the soil with its decaying residues after harvest (Singh et al., 2002).

The yield of the crop in Nigeria has been inconsistent because of genotypic sensitivity to environments, as most varieties under cultivation are photo-periodically sensitive, poor-yielding and primitive landraces (Umar et al., 2010). Several other causes of the inconsistency in yield of the crop have been linked to poor edaphic environment, inappropriate cultural practices, pests, diseases and poor genetic potential of genotypes for yield. Many improved cultivars of cowpea have been developed to cater for each of these problems, especially by research institutes, such as International Institute of Tropical Agriculture (IITA), Nigeria and others, which have the mandate for cowpea improvement. Nonetheless, more efforts are needed to achieve the desired expectations at curbing the limiting factors militating against the crop. The biggest limitations to the genetic enhancement of the crop revolves around poor knowledge of the genetic diversity of available germplasm and the fact that the crop is chosen on varietal basis depending on combination of traits for specific regions (Ajayi, 2019).

Genetic diversity study in cowpea genotypes would facilitate cultivar development for specific production constraints. However, more reliable data about the level of genetic variability obtainable within accessible world gene pools from which to exploit heterosis and additional valued traits are desirable (Mneney et al., 2011) for a successful cowpea improvement program. Therefore, magnitude and nature of variability in the current cowpea material and the combination of the different characteristics are a prerequisite for improving its yield (Ajayi & Adesoye, 2013). Hence, initiation of cowpea improvement plan requires that a thorough knowledge regarding the level of genetic variability existing in the species for various characters (Gerrano et al., 2015), and their association with yield be known as a prerequisite for effective yield-enhancement programs. Environments, genetic make-up and interactions between the genotypes and environments are the chief factors that control phenotypes in crop species (Jones et al., 2019; Seyoum et al., 2019; Fasoula et al., 2020). However, plants do possess inherent capacity to alter their phenotypes depending on the environment, and this attribute is referred to as phenotypic plasticity. The variation in this plasticity is controlled by the gene and is popularly referred to as genotype by environment interaction (Rahman et al., 2019). Therefore, it is essential to divide the phenotypic differences into heritable and non-heritable components with appropriate parameters, such as phenotypic and genotypic coefficients of variation, heritability and genetic gain. Thus, it is essential for breeders to be equipped with the knowledge of genetic variability, heritability and genetic gain in cowpea for selection of best genotypes for effective improvement.

In crop species, recombination and mutation are the most important sources of genetic variability. The genetic part is most important in crop improvement programs, as it is transmitted to the subsequent generation. Heritability in broad sense is a consequence of the proportion of the genetic variance to phenotypic variance. Estimates of heritability offer plant breeders the chance to select the best genotypes from countless gene populations as reported by many workers (Verma, 2010; Anandrao et al., 2011; Singh et al., 2011; Neji et al., 2019). Heritability estimates alone may not give an insight into anticipated genetic gain in the succeeding generation; therefore, it must be considered in combination with estimates of genetic gain for efficient selection. A number of workers (Ubi et al., 2001; Omoigui et al., 2006; Osekita & Ajayi, 2013; Ajayi et al., 2014; Osekita, 2014; Osekita et al., 2015) have assessed genotypic and phenotypic components of variance, heritability and genetic advance for different traits and yield qualities in cowpea and other crops and have shown that selection was effective for a population with extensive genetic variability and traits with high heritability. Such information would be useful for effective cowpea breeding in Akungba-Akoko environment and the whole southern area of Nigeria.

Correlation studies provide knowledge regarding association of traits among themselves and with economic traits on which indirect selection could be made for improvement. It helps to simultaneously select for more than one character of importance at a time. Meanwhile, total correlation is inadequate to explain the true association between traits, as yield is dependent on many components characters. The relative magnitude of several traits is therefore more desirable to be considered in order for a stronger representation of yield components for effective breeding programs (Ajayi et al., 2014; Sadras et al., 2019). In line with these, significant correlations among several traits and seed yield of different genotypes of cowpea across several locations are valuable in planning an effective selection and breeding program for the crop. The amount of relationship between two traits that is observed directly is the phenotypic value (Falconer, 1993), and according to Gomez and Gomez (1976), Osekita et al. (2000), emphasis was laid on the fact that a greater association results from greater magnitude of correlation coefficient. Many works (Adewale et al., 2010; Ajayi et al., 2014) on cowpea have shown significant variability and degree of association of traits among yield and yield contributing traits in cowpea. But detailed studies regarding this have not been done in Akungba-Akoko and its environment. Therefore, information on association of traits among cowpea genotypes will be a valuable tool in the Akoko environment in the breeding program of cowpea.

The objective of this study was to assess the level of genetic variability and character association among accessions of cowpea from different origins of Africa (Benin, Burkina Faso, Ghana, Niger, Nigeria, Sudan, South Africa, and Tanzania) and United States of America.

Materials and Methods

Site for research and cowpea materials

The research was done in two seasons: 2014 (March through June) and 2015 (May through October) cropping seasons. The planting season of 2014 fell within the beginning of the rainy season, while the planting season of 2015 fell in the middle of the rainy season. The site of the study was in the Plant Breeding plot, Plant Science and Biotechnology Department, Adekunle Ajasin University, Akungba-Akoko, Ondo State, Nigeria between Latitude 7.2^0 N, Longitude 5.44’ E, and Altitude 423 m above the sea level. This achieved two investigation environments for the study. The details of the 25 accessions of cowpea utilized in the study are described in Table 1. These accessions were made available by the Genetic Resources Centre of the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.

Experimental procedure

Three replications of a Randomized Complete Block Design (RCBD) layout were adopted for the experiments in each of the seasons. In each replicate, there were 25 plots (with two rows each), each of which was of 5 m in length and 1 m in width comprising accessions sown at 30 cm intra row and 50 cm inter row spacing. Spacing between plots (accessions) within each replicate was 1 m and spacing between replicates was 2 m. Twenty (20) plants were contained per plot (10 plants per row, in two rows) sown at two seeds per hill at approximately 2.5 cm depth, and thinned to one plant per hill after full establishment. Total number of plots for the 3 replicates was 75; the total number of plants in each replicate was 500, while the total number in the study field was 1500 plants. Hand weeding was done as required. Cypermethrin 10% EC was used at flowering and podding stages to control insect pests. No fertilizer application was done during the study.

Data collection

Data were collected on twelve quantitative traits of 10 randomly tagged plants per accession per replicate, and their means calculated. Data on emergence percentage were collected at 20 days after planting. Data on plant height (measured from the base of each plant to the terminal bud of the main stem), number of main branches (by counting branches directly attached to the main stem of each tagged plant) and number of leaves per plant (by counting the total leaves per tagged plant) were collected at 5 weeks after planting. Data on days to first flowering were recorded as each tagged plant flowered by counting from the day of planting. Data on peduncle length (10 best peduncle per tagged plant were selected and means recorded), number of pods per plant (by counting all pods on each tagged plant), pod length (10 chief pods for every marked plant were selected), number of seeds per pod (from 10 pods randomly selected from tagged plants), number of seeds per plant (this was done as the product of number of pods per plant and number of seeds per pod from the tagged plants), 100-seed weight (done from the weight of 100 randomly selected dried seeds in 10 places per rep and means recorded in grams) and seed yield per plant (determined as the product of total number of seeds per plant and weight of 1 seed per plant) were collected at maturity.

Data analysis

Data for all quantitative traits were subjected to a combined analysis of variance (ANOVA) using the Statistical Package for Social Science (SPSS) version 20 (SPSS Inc., Chicago IL). Means were separated using Duncan Multiple Range Test (DMRT) at $P \leq 0.01$ level of significance. Data for each environment were utilized for estimates of genetic parameters. Genotypic and phenotypic variances (GV and PV) were estimated according to Prasad et al. (1981); Wricke & Weber (1986). The phenotypic and genotypic coefficients of variation were determined in line with Burton (1952) and Johnson et al. (1955), and classified according to the procedure of Sivasubramanian & Madhavamenon (1973) as: low = 0 – 10%; moderate = 10 – 20%; and high = above 20%. Broad sense heritability (H^2B) was conveyed as described by Allard (1960) as the proportion of VG to VP and categorized in line with the method of Robinson et al. (1949) as: low = 0 – 30%; moderate = 0 – 60%; and high = above 60%. Genetic advance (GA) was estimated according to Fehr et al. (1987), and same utilized for calculating genetic advance as percent of the mean (GAM) in line with Johnson et al. (1955) and grouped as: low = 0 – 10%; moderate = 10 – 20%; and above 20% = high. Data were used for genotypic and phenotypic correlations using the Plant Breeding Tools, version 1.4 (PBTools, version 1.4. 2014). Genotypic and Phenotypic correlation coefficients were compared against the "t" table r (n – 2) degrees of freedom at the probability levels of 0.05 and 0.01 for significance testing (Fisher & Yates, 1963).

Results

Genetic variation of 25 accessions of cowpea for 2014 and 2015 and combined cropping seasons

The mean squares from analysis of variance for the quantitative traits of the 25 accessions for combined 2014 and 2015 planting seasons are presented in Table 2. Combined ANOVA showed high significant differences ($P \leq 0.01$) among accessions. Season had a significant effect for all traits, except for the number of leaves per plant, peduncle length and pod length. Accession by Season interaction was highly significant for all traits. Replication was also highly significant for all traits except for plant height, days to first flowering and total number of seeds per pod. The most variable trait and the least variable trait in 2014 were plant height (CV = 22.73%) and pod length (CV = 3.30%) respectively. In 2015 season, the most variable trait and the least variable trait were seed yield, with CV of 53.01% and days to first flowering (CV = 7.30%); while the combined seasons had CV of 26.68% for number of pods per plant and number of days to first flowering had CV of 5.70% as the most variable and least variable traits respectively. The mean values of quantitative traits of the 25 accessions of cowpea for 2014 are presented in Tables 3 and 4, 2015 in Tables 5 and 6, while the combined cropping seasons are presented in Tables 7 and 8.

Accessions AC25, AC17, AC10 and AC01 had the highest emergence in 2014 (100%), AC19, AC17 and AC13 had the highest in 2015 (100%) while AC17 had the highest (100%) for the combined seasons. Accessions AC13, AC14, AC01 and AC17 had consistently above 90 percent emergence values across seasons. In 2014, 2015 and combined seasons, AC20 (39.96 cm), AC17 (35.21 cm) and AC20 (34.93 cm) had the highest plant height respectively. Furthermore, AC18, AC17, AC14, AC19 and AC20 had consistent high plant height (above 20 cm) across seasons. In 2014, AC22 and AC25 had the highest value each (9.67) for the number of main branches. In 2015, AC22, AC13 and AC23 had the highest means ranging from 6.06 and 6.25; the combined seasons had AC22 having the highest mean value. AC22 consistently had highest number of branches across seasons. The number of leaves in 2014, 2015 and combined seasons respectively was highest in AC01 (48.37), AC19 (35.58) and AC01 (38.28), respectively.

Table 1 List of the 25 accessions of cowpea evaluated for genetic variability in 2014 and 2015 cropping seasons

S/N	Accession	Country of origin	Biological status	Growth habit	Code
1	TVu-7362	Ghana	Landrace	Erect	AC01
2	TVu-185	Nigeria	Landrace	Semi-erect	AC02
3	TVu-199	USA	Breeding material	Intermediate	AC03
4	Tvu-207	USA	Breeding material	Intermediate	AC04
5	Tvu-218	USA	Breeding material	Prostrate	AC05
6	Tvu-224	USA	Breeding material	Semi-erect	AC06
7	Tvu-235	Ghana	Breeding material	Semi-erect	AC07
8	Tvu-236	Ghana	Breeding material	Intermediate	AC08
9	Tvu-239	South Africa	Breeding material	Intermediate	AC09
10	Tvu-241	USA	Breeding material	Intermediate	AC10
11	IT98K-205-8	Nigeria	Unknown	Unknown	AC11
12	IT98K-555-1	Nigeria	Unknown	Unknown	AC12
13	Tvu-4886	Niger	Landrace	Semi-prostrate	AC13
14	Tvu-4866	Niger	Landrace	Semi-prostrate	AC14
15	Tvu-8660	Benin	Landrace	Intermediate	AC15
16	Tvu-9225	Tanzania	Landrace	Semi-erect	AC16
17	Tvu-11986	Sudan	Landrace	Semi-erect	AC17
18	Tvu-9256	Burkina Faso	Landrace	Semi-prostrate	AC18
19	Tvu-9252	Burkina Faso	Landrace	Semi-prostrate	AC19
20	Tvu-11979	Sudan	Landrace	Unknown	AC20
21	IT97K-568-18	Nigeria	Landrace	Unknown	AC21
22	IT89K-288	Nigeria	Unknown	Unknown	AC22
23	IT96-610	Nigeria	Unknown	Unknown	AC23
24	IT81-994	Nigeria	Unknown	Unknown	AC24
25	IT89K-391	Nigeria	Unknown	Unknown	AC25

Table 2 Mean squares for quantitative traits of 25 accessions of cowpea for individual seasons and combined 2014 and 2015 seasons

Source of variation	DF	EM (%)	PH (cm)	NMB	NL	PEDL (cm)	DFF
2014 cropping season							
Replication	2	17.33ns	26.67**	0.27**	36.45**	0.09ns	3.38**
Accession	24	537.56**	128.46**	9.33**	293.25**	268.11**	377.82**
Error	48	139.56	14.12	0.2	15.02	7.43	3.39
CV (%)		13.78	22.73	7.83	14.51	11.24	3.79
2015 cropping season							
Replication	2	457.33**	14.79**	5.69**	290.86**	166.38**	1.50^{ns}
Accession	24	966.89**	61.79**	1.12**	84.84**	122.93**	84.73**
Error	48	100.39	15.49	0.87	50.87	12.17	11.43
CV (%)		12.82	15.43	18.08	27.72	13.92	7.30
Combined seasons							
Replication	2	316.67**	10.32^{ns}	3.67**	157.58**	84.44**	0.19^{ns}
Accession (Acc)	24	1007.89**	106.72**	5.93**	201.63**	217.72**	352.22**
Season (S)	1	2166.00**	3029.77**	11.67**	36.09^{ns}	24.06^{ns}	185.28**
Acc × S	24	496.56**	83.53**	4.53**	176.46**	173.32**	110.33**
Error	98	120.75	15.14	0.57	35.74	11.27	7.65
CV (%)		12.82	23.84	13.22	22.38	13.83	5.70

AC11 and AC17 had the longest peduncles ranging between 39.22 cm and 39.52 cm in 2014, AC23 had the longest peduncle (35.70 cm) in 2015, while AC11 had the longest peduncle (35.04 cm) in the combined seasons. In 2014, AC02 flowered first (at day 40.00). Accessions AC15 and AC01 were first to flower between day 38.50 and 38.92 respectively in 2015. AC02 was the earliest to flower at day 40.25 for the combined seasons. In 2014, the highest number of pods per plant (74.11) was observed in AC18; AC05 had the highest number of pods per plant (26.33) in 2015, while AC18 had the highest number of pods per plant (46.93) for the combined seasons. AC20, AC17, AC12 and AC18 were consistently above average across seasons for total number of pods per plant. The longest pod (19.34 cm) was observed in AC20 in 2014; in AC03 (20.33 cm) and AC20 in 2015 and combined seasons respectively. Pod length was consistently high in AC20 across seasons. AC20 had the highest number of seeds per pod in all seasons (19.67 in 2014, 18.67 in 2015 and 19.27 in combined seasons). AC16 and AC18 had the highest number of seeds per plant with values ranging between 1186.40 and 1200.03 in 2014; the highest number of seeds per plant (461.25) was obtained in AC05 in 2015, while the highest number of seeds per plant in the combined seasons ranged between 710.45 and 748.08 in AC20 and AC18 respectively. AC18 and AC20 were consistent for higher number of seeds per plant across seasons. AC03 had the highest seed weights in all seasons (20.00 g in 2014, 17.42 g in 2015 and 18.71 g for the combined seasons). Highest seed yield ranged between 123.99 g and 134.96 g in AC16 and AC18 respectively in 2014. The highest seed yielder in 2015 was AC20 (54.09 g), while the highest seed yielder in the combined seasons was AC18 (83.29 g). Accessions AC20 and AC18 had consistently higher yield across seasons.

Estimates of genetic parameters of quantitative traits for 2014 and 2015 cropping seasons

The results of estimates of variances, Coefficients of Variation (Genotypic, GCV and Phenotypic, PCV), Heritability in the Broad sense (H^2B), as well as Genetic advance as percent of mean (GAM) for the quantitative traits of cowpea accessions for 2014 and 2015 cropping season respectively are presented in Tables 9 and 10. Phenotypic variances for all traits were higher than genotypic variances in both seasons. The difference between genotypic and phenotypic coefficients of variation was low for all traits except in number of leaves per plant in 2014; number of main branches, number of leaves, and number of pods per plant, seeds per plant and seed yield in 2015. GCV and PCV were high for all traits in 2014 except for emergence percentage; the range fell between 13.44% in emergence percentage and 347.21% in number of leaves per plant for GCV and between 19.24% (emergence percentage) to 403.44% (number of leaves per plant) for PCV. But in 2015, GCV was high for all traits, except for plant height, number of main branches, number of leaves per plant and number of days to first flowering, and the range lied between 5.65% in number of main branches and 43.82% in seed yield per plant. PCV was also high for all traits except for number of main branches and days to first flowering, with range between 12.93% in days to first flowering and 68.78% in seed yield. Heritability was high for all traits in both seasons, except for emergence percentage in 2014 (and ranged between 48.75% in emergence percentage and 98.09% in pod length); except for plant height, number of leaves per plant, number of main branches, number of pods per plant, number of seeds per pod and seed yield per plant in 2015 (and ranged between 8.95% in number of main branches and 94.32% in pod length). It was also high for all traits in 2015. High GAM was observed in all traits in both seasons, except for emergence percentage in 2014; number of main branches and number of leaves per plant in 2015.

Correlations analyses of 25 accessions of cowpea for 2014 and 2015 cropping seasons

The correlations amongst 12 quantitative traits of 25 accessions of cowpea for 2014 and 2015 cropping seasons are shown in Tables 7 and 8 respectively. In 2014, high positive relationships were observed among peduncle length and seed yield (r = 0.85** and 0.84**), number of pods per plant and seed yield (r = 0.98** and 0.98**), seeds per pod and seed yield (r = 0.57** and 0.57**) and seeds per plant and seed yield (r = 0.97** and 0.97**); but high negative relationship was observed between number of leaves per plant and seed yield at genotypic level (r = -0.51**). In 2015, high positive relationships were observed among peduncle length and seed yield at genotypic level (r = 0.55**), number of pods per plant and seed yield (r = 0.61** and 0.71**), seeds per pod and seed yield (r = 0.78** and 0.68**), pod length and seed yield (r = 0.76** and 0.78**), seeds per plant and seed yield (r = 0.67** and 0.75**) and seed weight and seed yield (r = 0.90** and 0.73**). However, high negative relationships were observed among number of main branches and seed yield (r = -0.92**) and number of leaves and seed yield (r = 0.60**) only at the genotypic levels.

Correlations analyses of 25 accessions of cowpea for 2014 and 2015 cropping seasons

The correlations amongst 12 quantitative traits of 25 accessions of cowpea for 2014 and 2015 cropping seasons are shown in Tables 11 and 12, respectively. In 2014, high positive relationships were observed among peduncle length and seed yield (r = 0.85** and 0.84**), number of pods per plant and seed yield (r = 0.98** and 0.98**), seeds per pod and seed yield (r = 0.57** and 0.57**) and seeds per plant and seed yield (r = 0.97** and 0.97**); but high negative relationship was observed between number of leaves per plant and seed yield at genotypic level (r = -0.51**). In 2015, high positive relationships were observed among peduncle length and seed yield at genotypic level (r = 0.55**), number of pods per plant and seed yield (r = 0.61** and 0.71**), seeds per pod and seed yield (r = 0.78** and 0.68**), pod length and seed yield (r =

0.92** and 0.76**), seeds per plant and seed yield (r = 0.67** and 0.75**) and seed weight and seed yield (r = 0.90** and 0.73**). However, high negative relationships were observed among number of main branches and seed yield (r = -0.92**) and number of leaves and seed yield (r = 0.60**) only at the genotypic levels.

Table 2 continued

Source of variation	DF	PDP	PDL (cm)	SPP	SDPL	100SW (g)	SDYPL
2014 cropping season							
Replication	2	28.54**	0.13**	0.42^{ns}	3926.68**	0.63**	84.66**
Accession	24	1392.34**	35.71**	40.49**	394287.09**	44.91**	4833.39**
Error	48	26.4	0.23	1.31	5899.46	0.32	87.92
CV (%)		17.93	3.30	8.9	18.59	4.47	18.59
2015 cropping season							
Replication	2	133.33**	0.01^{ns}	2.71**	17330.41**	1.36**	198.04**
Accession	24	156.81**	75.66**	74.02**	42798.38**	57.76**	596.46**
Error	48	51.15	1.49	2.55	14864.79	1.36	195.57
CV (%)		45.19	8.41	11.93	51.35	11.09	53.01
Combined seasons							
Replication	2	108.66**	0.11**	0.66^{ns}	14606.87**	0.82**	192.11**
Accession (Acc)	24	846.70**	92.50**	97.22**	242961.68**	82.47**	2943.06**
Season (S)	1	6367.31**	0.004^{ns}	10.55**	1155922.63**	164.81**	21720.71**
Acc × S	24	702.45**	18.87**	17.28**	194123.79**	20.21**	2486.79**
Error	98	39.46	0.84	1.94	10305.96	0.84	140.70
CV (%)		26.68	6.31	10.83	24.58	7.27	23.51

**: Significant at P ≤ 0.01; ns: not significant. CV: Coefficient of Variation; DF: Degree of freedom; EM: Emergence percentage; PH: Plant height; NMB: Number of main branches; NL: Number of leaves; PEDL: Peduncle length; DFF: Number of days to first flowering; PDP: Number of pods per plant; PDL: Pod length; SPP: Number of seeds per pod; SDPL: Number of seeds per plant; 100-SW: 100 seed weight; SDYPL: Seed yield per plant

Table 3 Mean values of quantitative traits (agronomic traits) of 25 accessions in 2014 cropping season

ACC	EM (%)	PH (cm)	NMB	NL	PEDL (cm)	DFF
AC01	100.00±0.00^{e}	8.23±0.66^{a}	4.13±0.41^{b}	48.57±1.04^{h}	24.07±0.48^{ef}	47.33±0.33^{fgh}
AC02	90.00±10.00^{cde}	11.50±0.78^{abc}	4.67±0.07^{b-e}	36.20±1.00^{g}	19.06±1.39^{bcd}	40.00±0.00^{a}
AC03	73.33±6.67^{bc}	10.47±0.93^{ab}	5.47±0.29^{ef}	27.37±0.55^{f}	12.93±0.69^{a}	41.43±0.35^{abc}
AC04	76.67±8.82^{bcd}	12.10±0.95^{abc}	5.13±0.24^{c-f}	35.53±0.58^{g}	17.47±0.74^{a-d}	40.77±0.33^{ab}
AC05	96.67±3.33^{de}	12.30±1.08^{abc}	5.60±0.31^{f}	41.93±0.57^{g}	12.93±0.70^{a}	40.10±0.00^{a}
AC06	76.67±8.82^{bcd}	11.67±0.52^{abc}	5.23±0.23^{def}	23.23±0.23^{def}	19.60±1.44^{cde}	43.43±0.33^{a-e}
AC07	80.00±5.77^{b-e}	13.05±0.65^{abc}	4.93±0.67^{b-f}	35.97±0.26^{g}	16.27±1.22^{abc}	42.43±0.33^{a-d}
AC08	73.53±3.33^{bc}	12.40±0.44^{abc}	5.26±0.27^{def}	24.90±0.71^{def}	14.33±0.96^{ab}	41.43±0.33^{abc}
AC09	86.67±13.33^{b-e}	14.20±0.50^{a-d}	5.13±0.07^{c-f}	20.20±0.23^{b-f}	21.47±0.13^{de}	49.43±0.88^{hi}
AC10	100.00±0.00^{e}	11.40±1.99^{abc}	5.13±0.13^{c-f}	34.80±0.31^{g}	19.33±0.13^{b-e}	42.43±0.33^{a-d}
AC11	43.00±3.30^{a}	11.67±0.79^{abc}	3.33±0.20^{a}	13.33±1.26^{ab}	39.22±1.12^{k}	44.44±0.98^{b-g}
AC12	66.67±8.82^{b}	16.60±1.01^{b-f}	4.97±0.33^{b-f}	19.44±1.23^{a-e}	37.91±1.07^{ijk}	47.89±0.94^{gh}
AC13	90.00±0.00^{cde}	17.10±0.98^{b-f}	5.23±0.29^{def}	36.11±1.25^{g}	29.81±0.21^{gh}	45.78±0.99^{d-g}
AC14	93.33±3.33^{cde}	23.10±0.91^{fg}	5.10±0.10^{c-f}	14.22±1.36^{g}	30.56±1.21^{gh}	47.22±0.48^{e-h}
AC15	76.67±3.33^{bcd}	17.10±0.98^{b-f}	4.53±0.23^{bcd}	14.22±1.22^{abc}	33.70±0.65^{hi}	62.44±2.35^{l}
AC16	96.67±3.33^{de}	18.20±1.00^{c-f}	4.77±0.23^{b-f}	25.33±2.54^{ef}	38.57±2.38^{jk}	45.67±0.96^{d-g}
AC17	100.00±0.00^{e}	22.03±1.99^{efg}	4.33±0.33^{bc}	12.00±0.66^{a}	39.52±0.67^{k}	45.56±1.28^{d-g}
AC18	83.33±8.82^{b-e}	20.87±2.22^{defg}	4.67±0.20^{b-e}	27.11±1.92^{f}	36.72±2.38^{ijk}	42.22±0.48^{a-d}
AC19	86.67±8.82^{b-e}	26.33±3.89^{g}	5.33±0.38^{def}	37.44±9.43^{g}	13.58±0.17^{a}	87.11±1.13^{n}
AC20	96.67±3.33^{de}	39.96±8.87^{h}	4.90±0.42^{b-f}	21.67±3.15^{c-f}	33.84±0.92^{hij}	45.44±1.96^{d-g}
AC21	96.67±3.33^{de}	15.17±0.96^{a-e}	9.00±0.01^{hi}	19.53±1.23^{a-e}	27.83±4.39^{fg}	44.97±1.16^{c-g}
AC22	93.33±3.33^{cde}	16.43±0.29^{b-f}	9.67±0.33^{i}	17.83±2.18^{a-e}	16.13±0.37^{abc}	76.17±3.47^{m}
AC23	90.00±10.00^{cde}	14.80±0.31^{a-e}	8.67±0.33^{gh}	17.50±1.53^{a-d}	16.57±1.09^{a-d}	43.57±0.52^{a-f}
AC24	76.67±3.33^{bcd}	18.00±0.85^{b-f}	8.00±0.11^{g}	17.66±1.38^{a-e}	16.40±2.73^{a-d}	52.16±1.11^{ij}
AC25	100.00±0.00^{e}	17.63±1.33^{b-f}	9.67±0.33^{i}	22.60±0.68^{def}	18.73±2.47^{bcd}	53.63±1.29^{k}
GM	85.73	16.53	5.71	26.71	24.26	48.52

Means with the same superscript within a column are not significantly different from one another at P ≤ 0.01 using Duncan Multiple Range Test (DMRT). EM: Emergence percentage; PH: Plant height; NMB: Number of main branches; NL: Number of leaves; PEDL: Peduncle length; DFF: Number of days to first flowering; GM: Grand mean

Table 4 Mean values of quantitative traits (yield traits) of 25 accessions in 2014 cropping season

ACC	PDP	PDL (cm)	SPP	SDPL	100SW (g)	SDYPL (g)
AC01	10.00±1.80^{bc}	15.63±0.54^{efg}	10.80±1.44^{b}	106.24±17.96^{a-d}	11.80±0.20^{fg}	12.59±2.25^{ab}
AC02	17.20±1.55^{cd}	15.27±0.14^{ef}	14.67±0.06^{de}	252.32±23.01^{e-h}	9.23±0.13^{c}	23.32±2.22^{bc}
AC03	5.60±0.95^{ab}	15.24±0.01^{e}	10.63±0.20^{b}	59.69±10.65^{ab}	20.00±0.92^{n}	12.04±2.35^{ab}
AC04	9.00±0.69^{abc}	14.00±0.06^{d}	11.07±0.17^{b}	99.52±7.19^{abc}	15.77±0.72^{lm}	15.75±1.61^{ab}
AC05	34.67±5.66^{g}	15.98±0.27^{e-h}	15.33±0.17^{de}	531.00±85.32^{j}	9.63±0.06^{cd}	51.09±0.08^{def}
AC06	16.76±1.54^{cd}	11.21±0.16^{b}	14.43±0.12^{de}	242.05±23.28^{efg}	6.73±0.39^{b}	16.12±0.76^{ab}
AC07	7.25±2.09^{ab}	13.67±0.22^{d}	13.43±0.12^{cd}	97.89±28.86^{abc}	14.93±0.20^{jkl}	14.50±4.12^{ab}
AC08	10.97±3.53^{bc}	16.21±0.15^{gh}	14.80±0.64^{de}	165.65±55.48^{b-e}	13.60±0.25^{i}	22.71±7.86^{bc}
AC09	5.53±0.14^{ab}	14.17±0.12^{d}	12.20±0.00^{bc}	67.51±1.77^{ab}	12.43±0.56^{gh}	8.39±0.48^{ab}
AC10	4.87±0.69^{ab}	16.25±0.25^{gh}	14.46±0.52^{de}	70.15±9.24^{ab}	14.77±0.67^{jkl}	10.24±0.98^{ab}
AC11	46.78±5.95^{h}	15.65±0.43^{efg}	16.11±1.60^{ef}	735.29±24.88^{k}	13.40±0.21^{hi}	98.43±1.92^{h}
AC12	58.67±4.07^{i}	15.28±0.07^{ef}	11.33±0.84^{b}	666.35±74.13^{k}	14.77±0.18^{jkl}	98.45±11.38^{h}
AC13	35.11±1.94^{g}	13.56±0.15^{d}	11.00±0.39^{b}	384.87±10.46^{ghi}	13.20±0.11^{hi}	50.81±1.65^{def}
AC14	31.56±3.38^{g}	12.54±0.19^{c}	10.33±0.33^{b}	325.90±34.52^{fgh}	11.50±0.26^{fg}	37.39±3.62^{cd}
AC15	35.33±3.33^{g}	16.57±0.13^{h}	13.66±0.33^{cd}	481.66±40.17^{ij}	16.53±0.17^{m}	79.49±5.74^{g}
AC16	73.99±3.17^{j}	16.17±0.08^{fgh}	16.00±0.38^{ef}	1186.40±78.37^{m}	10.47±0.12^{de}	123.99±6.96^{i}
AC17	56.22±1.18^{i}	17.64±0.08^{i}	17.78±0.11^{f}	999.70±22.80^{l}	10.33±0.08^{de}	103.26±1.59^{h}
AC18	74.11±5.87^{j}	15.81±0.18^{e-h}	16.22±0.22^{ef}	1200.03±81.62^{m}	11.27±0.14^{ef}	134.96±7.44^{i}
AC19	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
AC20	53.11±2.13^{hi}	19.34±0.12^{j}	19.67±0.19^{g}	1045.04±48.94^{l}	10.30±0.17^{de}	107.68±5.69^{h}
AC21	31.70±0.82^{g}	14.23±0.12^{d}	12.23±0.44^{bc}	387.81±17.74^{hi}	15.20±0.12^{kl}	58.95±2.69^{f}
AC22	20.93±2.05^{de}	13.50±0.15^{d}	10.87±0.21^{b}	228.29±26.68^{c-f}	15.60±0.12^{lm}	35.61±4.16^{cd}
AC23	27.80±2.11^{ef}	14.03±0.61^{d}	10.30±1.73^{b}	289.44±57.61^{fgh}	14.20±0.10^{ijk}	41.10±8.18^{de}
AC24	28.70±4.45^{ef}	15.63±0.48^{efg}	12.10±0.72^{bc}	352.13±74.05^{f-i}	15.80±0.14^{lm}	55.63±11.69^{ef}
AC25	28.73±1.97^{ef}	15.77±0.55^{e-h}	12.13±0.45^{bc}	349.53±30.41^{f-i}	13.90±0.17^{ij}	48.58±4.22^{def}
GM	28.98	14.53	12.86	412.97	12.61	50.45

Means with the same superscript within a column are not significantly different from one another at P ≤ 0.01 using Duncan Multiple Range Test (DMRT). PDP: Number of pods per plant; PDL: Pod length; SPP: Number of seeds per pod; SDPL: Number of seeds per plant; 100-SW: 100 seed weight; SDYPL: Seed yield per plant; GM: Grand mean

Table 5 Mean values of quantitative traits (agronomic traits) of 25 accessions in 2015 cropping season

ACC	EM (%)	PH (cm)	NMB	NL	PEDL (cm)	DFF
AC01	93.33±6.66^{ghi}	28.65±2.84^{def}	4.92±0.22^{ab}	28.00±4.75^{abc}	28.14±1.92^{de}	38.92±2.20^{a}
AC02	83.33±3.33^{e-i}	34.07±1.14^{ef}	5.25±0.62^{ab}	29.75±4.93^{abc}	27.62±4.19^{de}	40.50±0.25^{ab}
AC03	36.67±3.33^{a}	19.02±0.72^{ab}	5.11±0.89^{ab}	29.75±1.84^{abc}	27.33±2.45^{d}	46.78±0.61^{b-f}
AC04	70.00±0.00^{c-f}	25.29±0.60^{bcd}	5.83±0.08^{ab}	22.33±2.86^{abc}	24.29±0.46^{bcd}	41.42±1.87^{abc}
AC05	70.00±5.77^{c-f}	28.36±2.84^{def}	5.25±0.28^{ab}	18.17±0.96^{ab}	29.13±3.91^{de}	41.67±1.82^{a-d}
AC06	93.33±3.33^{ghi}	26.62±1.73^{b-e}	4.41±1.26^{ab}	16.33±2.74^{a}	25.91±5.22^{cd}	45.92±0.33^{b-f}
AC07	70.00±15.27^{c-f}	24.51±5.96^{bcd}	4.91±1.40^{ab}	21.17±5.96^{abc}	23.82±2.42^{bcd}	43.75±2.43^{a-e}
AC08	66.67±3.33^{c-f}	27.60±0.95^{cde}	4.75±0.38^{ab}	23.58±4.20^{abc}	24.76±1.27^{bcd}	51.06±1.86^{f}
AC09	96.67±3.33^{hi}	29.88±2.81^{def}	3.83±0.08^{a}	16.08±0.36^{a}	25.90±0.90^{cd}	48.25±0.90^{def}
AC10	73.33±8.81^{c-g}	30.00±2.32^{def}	5.17±0.65^{ab}	33.42±4.18^{bc}	29.39±2.72^{de}	45.75±1.87^{b-f}
AC11	60.00±10.00^{bcd}	18.90±2.19^{ab}	5.56±0.15^{ab}	27.72±7.56^{abc}	30.88±0.77^{de}	43.58±0.71^{a-d}
AC12	96.67±3.33^{hi}	25.35±2.24^{bcd}	5.17±0.79^{ab}	18.75±2.40^{ab}	22.84±1.79^{bcd}	42.17±0.44^{a-d}
AC13	100.00±0.00^{i}	22.63±1.05^{a-d}	6.25±0.14^{b}	29.92±5.29^{abc}	25.93±1.44^{cd}	45.33±0.65^{b-f}
AC14	93.33±6.66^{ghi}	22.24±2.46^{a-d}	5.33±0.30^{ab}	24.00±2.43^{abc}	24.01±1.42^{bcd}	47.50±0.38^{c-f}
AC15	63.33±8.81^{cde}	16.91±3.53^{a}	5.00±0.80^{ab}	25.17±4.22^{abc}	17.14±1.48^{b}	38.50±2.32^{a}
AC16	80.00±10.00^{d}-i	22.46±2.51^{a-d}	5.55±0.25^{ab}	30.42±6.82^{abc}	26.61±1.20^{cd}	44.33±1.67^{a-e}
AC17	100.00±0.00^{i}	35.21±0.87^{f}	3.92±0.22^{a}	27.00±6.17^{abc}	25.21±2.00^{bcd}	47.42±1.34^{c-f}
AC18	76.67±6.67^{c-h}	25.89±2.64^{bcd}	5.17±0.46^{ab}	22.42±1.22^{abc}	25.08±1.82^{bcd}	42.58±0.60^{a-d}
AC19	100.00±0.00^{i}	28.79±1.64^{def}	5.83±0.83^{ab}	34.58±1.81^{c}	0.00±0.00^{a}	59.28±1.44^{g}
AC20	93.33±6.66^{ghi}	29.91±2.84^{def}	4.83±0.46^{ab}	26.83±6.92^{abc}	29.41±2.20^{de}	47.58±2.02^{c-f}
AC21	86.67±3.33^{f-i}	22.43±1.83^{a-d}	4.83±0.16^{ab}	32.16±4.84^{bc}	25.74±1.46^{cd}	47.42±2.38^{c-f}
AC22	63.33±6.66^{cde}	24.91±3.04^{bcd}	6.06±0.70^{b}	32.97±7.37^{bc}	18.72±1.77^{bc}	60.11±4.96^{g}
AC23	86.67±3.33^{f-i}	25.09±2.54^{bcd}	6.25±0.52^{b}	23.67±2.33^{abc}	35.70±5.26^{e}	46.00±1.51^{b-f}
AC24	43.33±3.33^{ab}	22.87±2.44^{a-d}	4.78±0.67^{ab}	24.67±4.94^{abc}	24.01±2.93^{bcd}	51.45±2.22^{f}
AC25	56.67±3.33^{bc}	20.23±1.40^{abc}	5.00±0.38^{ab}	23.33±2.45^{abc}	29.01±2.34^{de}	50.25±3.25^{ef}
GM	78.13	25.51	5.16	25.73	25.06	46.3

Means with the same superscript within a column are not significantly different from one another at P ≤ 0.01 using Duncan Multiple Range Test (DMRT). EM: Emergence percentage; PH: Plant height; NMB: Number of main branches; NL: Number of leaves; PEDL: Peduncle length; DFF: Number of days to first flowering; GM: Grand mean

Table 6 Mean values of quantitative traits (yield traits) of 25 accessions in 2015 cropping season

ACC	PDP	PDL (cm)	SPP	SDPL	100SW (g)	SDYPL (g)
AC01	23.42±3.09^{b-e}	18.13±0.36^{i-l}	14.50±0.38^{e-i}	337.83±39.69^{c-g}	7.99±0.09^{bc}	27.07±3.46^{a-d}
AC02	25.17±7.46^{cde}	16.68±0.56^{g-l}	16.00±1.01^{g-l}	412.56±34.52^{fg}	6.23±0.11^{b}	25.83±8.44^{abc}
AC03	19.00±2.02^{b-e}	20.33±0.53^{m}	15.50±0.72^{g-k}	291.71±18.03^{b-g}	17.42±0.03^{k}	50.83±3.11^{cd}
AC04	15.17±5.10^{b-e}	15.34±0.49^{efg}	14.75±0.90^{f-j}	226.73±51.02^{a-g}	15.27±0.25^{j}	34.38±7.30^{bcd}
AC05	26.33±7.13^{e}	17.08±0.26^{g-l}	17.42±0.22^{i-l}	461.25±30.02^{g}	6.22±0.04^{b}	28.67±8.00^{bcd}
AC06	23.25±4.76^{b-e}	13.08±0.36^{cd}	17.00±0.66^{h-l}	390.88±73.59^{efg}	7.09±0.02^{bc}	27.71±5.17^{bcd}
AC07	15.25±2.50^{b-e}	15.84±0.32^{f-i}	13.83±0.92^{d-g}	213.88±45.86^{a-f}	12.81±0.03^{ghi}	27.40±5.87^{bcd}
AC08	17.50±1.39^{b-e}	18.64±0.24^{lm}	15.58±0.68^{g-l}	274.48±32.16^{b-g}	10.36±0.04^{def}	28.43±3.33^{bcd}
AC09	12.75±3.90^{a-e}	15.97±1.49^{f-j}	17.26±0.68^{h-l}	225.25±77.95^{a-g}	12.50±0.06^{e-i}	28.19±9.74^{bcd}
AC10	13.58±4.01^{a-e}	18.32±0.51^{klm}	18.58±0.46^{kl}	251.67±72.23^{b-g}	13.07±0.08^{hi}	32.78±9.19^{bcd}
AC11	11.25±3.21^{a-d}	14.01±0.42^{def}	11.75±0.76^{cde}	132.02±36.65^{a-d}	11.74±0.07^{e-h}	15.49±4.30^{ab}
AC12	25.42±5.04^{de}	17.98±0.31^{g-l}	14.25±0.90^{d-h}	369.60±90.55^{c-g}	14.37±0.11^{ij}	52.91±12.64^{cd}
AC13	26.25±8.40^{e}	12.99±0.32^{cd}	10.50±0.38^{c}	276.54±88.41^{b-g}	12.53±0.08^{f-i}	34.68±11.09^{bcd}
AC14	8.83±2.41^{ab}	9.03±2.10^{b}	7.17±1.82^{b}	71.56±9.20^{ab}	11.56±0.08^{e-h}	8.32±3.40^{ab}
AC15	10.50±1.28^{abc}	11.49±0.48^{c}	12.08±0.30^{c-f}	127.52±18.31^{abc}	7.93±0.06^{bc}	10.13±1.53^{ab}
AC16	10.83±2.76^{a-d}	15.79±0.45^{fgh}	17.75±0.28^{jkl}	192.92±50.95^{a-f}	8.42±0.02^{cd}	16.22±4.25^{ab}
AC17	14.67±5.48^{b-e}	16.59±0.25^{g-l}	17.50±0.63^{i-l}	263.08±10.30^{b-g}	10.29±0.07^{de}	26.98±10.52^{a-d}
AC18	19.75±7.05^{b-e}	16.96±0.39^{g-l}	15.75±1.08^{g-l}	296.13±21.12^{b-g}	10.69±0.07^{efg}	31.61±9.84^{bcd}
AC19	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
AC20	20.00±3.16^{b-e}	18.20±0.47^{jkl}	18.67±0.65^{l}	375.85±69.89^{d-g}	14.42±0.11^{ij}	54.09±9.82^{d}
AC21	14.42±0.33^{a-e}	16.03±0.10^{f-k}	11.42±0.44^{cd}	164.65±8.09^{a-e}	11.08±3.32^{e-h}	17.70±4.86^{ab}
AC22	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
AC23	21.17±4.05^{b-e}	14.24±0.65^{def}	10.42±0.82^{c}	227.04±61.01^{a-g}	12.81±0.13^{ghi}	28.92±7.47^{bcd}
AC24	11.83±6.09^{a-e}	17.79±0.92^{h-l}	15.67±2.84^{g-l}	207.67±25.67^{a-f}	17.34±0.26^{k}	35.49±11.03^{bcd}
AC25	12.50±1.89^{a-e}	13.56±1.04^{cde}	11.50±0.43^{cd}	144.37±25.04^{abcd}	10.79±0.10^{efg}	15.61±2.82^{ab}
GM	15.95	14.52	13.39	237.41	10.52	26.38

Means with the same superscript within a column are not significantly different from one another at $P \leq 0.01$ using Duncan Multiple Range Test (DMRT). PDP: Number of pods per plant; PDL: Pod length; SPP: Number of seeds per pod; SDPL: Number of seeds per plant; 100-SW: 100 seed weight; SDYPL: Seed yield per plant; GM: Grand mean

Table 7 Combined mean values of quantitative traits (agronomic traits) of 25 accessions for 2014 and 2015 cropping seasons

ACC	EM (%)	PH (cm)	NMB	NL	PEDL (cm)	DFF
AC01	96.67±3.33^{gh}	18.44±1.67^{abc}	4.53±0.29^{ab}	38.28±2.78^{h}	26.10±1.08^{d-h}	43.13±1.26^{a-d}
AC02	86.67±3.33^{d-h}	22.79±0.84^{cde}	4.96±0.29^{abc}	32.97±2.73^{e-h}	23.34±1.62^{b-f}	40.25±0.12^{a}
AC03	55.00±2.88^{ab}	14.75±0.41^{a}	5.29±0.56^{abc}	28.56±1.11^{a-h}	20.13±1.04^{bcd}	44.11±0.29^{a-e}
AC04	73.33±4.41^{b-e}	18.69±0.71^{abc}	5.48±0.11^{abc}	28.93±1.47^{b-h}	20.88±0.42^{b-e}	41.09±0.96^{abc}
AC05	83.33±1.66^{d-h}	20.33±0.96^{abc}	5.43±0.22^{abc}	30.05±0.73^{c-h}	21.03±1.88^{b-e}	40.88±0.91^{ab}
AC06	85.00±5.77^{d-h}	19.14±0.75^{abc}	4.83±0.74^{ab}	19.78±1.43^{abc}	22.76±2.14^{b-f}	44.68±0.28^{a-e}
AC07	75.00±5.77^{c-f}	18.78±1.66^{abc}	4.93±0.69^{abc}	28.57±2.87^{a-h}	20.04±1.67^{bcd}	43.09±1.33^{a-d}
AC08	70.00±0.00^{a-d}	20.00±0.65^{abc}	5.01±0.26^{abc}	24.24±1.92^{a-f}	19.54±0.46^{bc}	46.25±1.09^{def}
AC09	91.67±8.33^{e-h}	22.04±1.65^{b-e}	4.48±0.06^{ab}	18.14±0.17^{a}	23.69±0.41^{c-f}	48.84±0.48^{efg}
AC10	86.67±4.41^{d-h}	20.70±0.92^{abc}	5.15±0.33^{abc}	34.11±2.23^{fgh}	24.36±1.29^{c-f}	44.09±1.10^{a-e}
AC11	51.67±10.13^{a}	15.29±1.20^{ab}	4.45±0.03^{ab}	20.53±3.82^{a-d}	35.04±0.17^{j}	44.01±0.30^{a-e}
AC12	81.67±4.41^{d-h}	20.97±1.47^{a-d}	5.07±0.23^{abc}	19.09±1.22^{ab}	30.38±1.41^{g-j}	45.03±0.66^{a-e}
AC13	95.00±0.00^{fgh}	19.86±0.85^{abc}	5.74±0.19^{bcd}	33.01±2.13^{e-h}	27.87±0.72^{f-i}	45.56±0.48^{b-f}
AC14	93.33±4.41^{fgh}	22.67±1.66^{cde}	5.23±0.18^{abc}	30.61±1.59^{d-h}	27.29±1.06^{f-i}	47.36±0.18^{d-g}
AC15	70.00±5.00^{a-d}	17.42±1.59^{abc}	4.77±0.49^{ab}	19.69±2.71^{abc}	25.42±1.02^{c-g}	50.47±0.09^{fg}
AC16	83.33±4.41^{d-h}	20.33±1.67^{abc}	5.13±0.24^{abc}	27.88±4.49^{a-g}	32.59±1.71^{ij}	45.00±0.79^{a-e}
AC17	100.00±0.00^{h}	28.62±1.29^{e}	4.13±0.07^{a}	19.50±2.75^{abc}	32.37±0.76^{ij}	46.49±1.25^{def}
AC18	80.00±2.88^{d-g}	23.33±1.62^{cde}	4.92±0.25^{abc}	24.76±0.44^{a-f}	30.90±2.09^{g-j}	42.40±0.07^{a-d}
AC19	93.33±4.41^{fgh}	27.56±2.77^{de}	5.59±0.19^{a-d}	36.01±4.08^{gh}	6.79±0.08^{a}	73.19±0.31^{i}
AC20	95.00±2.88^{fgh}	34.93±4.41^{f}	4.87±0.19^{ab}	24.25±1.96^{a-f}	31.63±1.28^{hij}	46.51±0.45^{def}
AC21	91.67±3.33^{e-h}	18.80±0.75^{abc}	6.92±0.08^{def}	26.35±1.85^{a-g}	26.79±1.52^{e-i}	46.19±0.73^{c-f}
AC22	78.33±1.67^{c-g}	20.67±1.61^{abc}	7.86±0.27^{f}	25.40±2.76^{a-f}	17.43±0.81^{b}	68.14±4.21^{h}
AC23	88.33±6.67^{d-h}	19.95±1.12^{abc}	7.45±0.27^{ef}	20.58±1.76^{a-d}	26.14±2.56^{d-h}	44.78±0.68^{a-e}
AC24	60.00±0.00^{abc}	20.44±0.88^{abc}	6.39±0.33^{cde}	21.17±2.37^{a-d}	20.20±1.28^{bcd}	51.81±0.59^{g}
AC25	78.33±1.67^{cdefg}	18.94±1.28^{abc}	7.33±0.35^{ef}	22.97±1.19^{a-e}	23.87±1.98^{c-f}	51.94±1.65^{g}
GM	81.93	21.02	5.44	26.22	24.66	47.41

Means with the same superscript within a column are not significantly different from one another at $P \leq 0.01$ using Duncan Multiple Range Test (DMRT). EM: Emergence percentage; PH: Plant height; NMB: Number of main branches; NL: Number of leaves; PEDL: Peduncle length; DFF: Number of days to first flowering; GM: Grand mean

Table 8 Combined mean values of quantitative traits (yield traits) of 25 accessions for 2014 and 2015 cropping seasons

ACC	PDP	PDL (cm)	SPP	SDPL	100SW (g)	SDYPL (g)
AC01	16.70±2.22^{b-e}	16.88±0.44^{kl}	12.65±0.82^{d-g}	222.04±20.43^{bc}	9.89±0.06^{cd}	19.83±1.83^{ab}
AC02	21.18±4.47^{b-f}	15.97±0.29^{g-k}	15.33±0.53^{i-m}	332.44±77.77^{cde}	7.73±0.07^{b}	24.58±5.31^{bcd}
AC03	12.30±1.25^{a-d}	17.97±0.26^{lm}	13.07±0.41^{e-i}	175.74±10.55^{abc}	18.71±0.45^{m}	31.43±2.12^{bcd}
AC04	12.08±1.13^{a-d}	14.67±0.23^{efg}	12.91±0.53^{e-i}	163.12±21.99^{abc}	15.52±0.39^{kl}	25.07±2.99^{bcd}
AC05	30.50±5.85^{fgh}	16.53±0.09^{i-l}	16.38±0.10^{klm}	496.13±97.46^{efg}	7.39±0.01^{b}	39.89±7.34^{b-e}
AC06	20.00±2.43^{b-f}	12.14±0.24^{cd}	15.72±0.33^{j-m}	316.48±39.43^{b-e}	6.91±0.19^{b}	21.91±2.53^{bc}
AC07	11.25±0.50^{abc}	14.76±0.23^{e-h}	13.63±0.41^{f-j}	155.88±9.28^{abc}	13.87±0.09^{ij}	20.95±1.00^{bc}
AC08	14.23±1.69^{bcd}	17.43±0.13^{klm}	15.19±0.28^{h-m}	220.07±28.53^{bc}	11.98±0.11^{fgh}	25.57±3.92^{bcd}
AC09	9.14±1.88^{ab}	15.07±0.69^{f-i}	14.73±0.37^{g-l}	146.37±38.12^{abc}	12.47±0.25^{f-i}	18.29±8.27^{ab}
AC10	9.22±2.01^{ab}	17.29±0.15^{klm}	16.53±0.36^{lm}	160.91±37.09^{abc}	13.92±0.35^{ij}	21.51±4.62^{bc}
AC11	29.01±4.37^{efg}	14.83±0.17^{e-h}	13.93±1.13^{f-k}	433.66±30.76^{def}	12.57±0.11^{f-i}	56.96±3.09^{ef}
AC12	42.04±55^{hi}	16.15±0.07^{g-l}	12.79±0.48^{e-h}	517.98±15.41^{fgh}	14.57±0.13^{jk}	75.68±10.42^{fg}
AC13	30.68±4.65^{fgh}	13.28±0.08^{de}	10.75±0.13^{cde}	330.71±44.19^{cde}	13.87±0.09^{ghi}	42.75±5.77^{cde}
AC14	20.19±0.78^{b-f}	10.78±1.13^{c}	8.75±1.04^{c}	198.73±15.41^{bc}	11.53±0.16^{efg}	22.85±2.02^{bc}
AC15	22.92±1.13^{c-f}	14.03±0.17^{ef}	12.87±0.29^{e-i}	304.59±16.79^{bcd}	12.23±0.10^{fgh}	44.82±2.53^{de}
AC16	42.42±2.43^{hi}	15.98±0.20^{g-k}	16.88±0.33^{lm}	689.66±55.74^{hi}	9.45±0.05^{c}	70.11±4.87^{fg}
AC17	35.45±2.41^{ghi}	17.12±0.12^{kl}	17.64±0.26^{mn}	631.39±42.74^{ghi}	10.32±0.03^{cde}	65.12±4.75^{fg}
AC18	46.93±5.86^{i}	16.39±0.26^{h-l}	15.99±0.63^{j-m}	748.08±79.75^{i}	10.98±0.11^{def}	83.29±7.96^{g}
AC19	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00 ^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
AC20	36.56±2.47^{ghi}	18.77±0.18^{m}	19.17±0.37^{n}	710.45±58.15^{i}	12.36±0.13^{f-i}	80.88±7.33^{g}
AC21	23.05±0.57^{c-f}	15.13±0.11^{f-j}	11.83±0.43^{def}	276.23±12.84^{bcd}	13.14±1.66^{g-j}	38.33±1.09^{b-e}
AC22	10.47±1.02^{abc}	6.75±0.07^{b}	5.43±0.11^{b}	114.15±13.34^{ab}	7.80±0.00^{b}	17.81±2.08^{ab}
AC23	24.48±3.06^{d-g}	14.14±0.59^{efg}	10.63±1.11^{cd}	258.24±56.06^{bcd}	13.51±0.06^{hij}	35.01±7.41^{bcd}
AC24	20.27±1.99^{b-f}	16.71±0.22^{jkl}	13.88±1.13^{f-j}	279.89±46.26^{bcd}	16.57±0.13^{l}	45.56±7.72^{de}
AC25	20.62±0.70^{b-f}	14.67±0.77^{efg}	11.82±0.08^{def}	246.95±9.19^{bcd}	12.35±0.05^{f-i}	32.09±1.23^{bcd}
GM	22.47	14.53	13.13	325.19	11.57	38.41

Means with the same superscript within a column are not significantly different from one another at P ≤ 0.01 using Duncan Multiple Range Test (DMRT). PDP: Number of pods per plant; PDL: Pod length; SPP: Number of seeds per pod; SDPL: Number of seeds per plant; 100-SW: 100 seed weight; SDYPL: Seed yield per plant; GM: Grand mean

Table 9 Estimates of genetic parameters of quantitative traits of 25 accessions for 2014 cropping season

Trait	Mean	GV	PV	GCV (%)	PCV (%)	H^2B (%)	GAM (%)
EM	85.73	132.67	272.13	13.44	19.24	48.75	19.32
PH	16.53	38.11	52.23	37.35	43.72	72.96	474.89
NMB	5.71	3.04	3.24	30.54	31.52	93.83	60.93
NL	26.71	92.74	107.76	347.21	403.44	86.06	68.90
PEDL	24.26	86.89	94.32	38.42	40.03	92.12	75.97
DFF	48.52	124.81	128.20	23.03	23.34	97.36	46.81
PDP	28.98	455.31	481.71	73.63	75.74	94.52	147.46
PDL	14.53	11.83	12.06	23.67	23.9	98.09	48.29
SPP	12.86	13.06	14.37	28.1	29.48	90.88	55.19
SDPL	412.97	129462.54	135362.00	87.13	89.09	95.64	175.52
100SW	12.61	14.86	15.18	30.56	30.89	97.89	62.29
SDYPL	50.45	1581.82	1669.74	78.83	80.99	94.73	158.06

EM: Emergence percentage; PH: Plant height; NMB: Number of main branches; NL: Number of leaves; PEDL: Peduncle length; DFF: Number of days to first flowering; PDP: Number of pods per plant; PDL: Pod length; SPP: Number of seeds per pod; SDPL: Number of seeds per plant; 100-SW: 100 seed weight; SDYPL: Seed yield per plant. GV: Genotypic variance; PV: Phenotypic variance; GCV: Genotypic coefficient of variation; PCV: Phenotypic coefficient of variation; H^2B: Heritability; GAM: Genetic advance as percent of mean

Table 10 Estimates of genetic parameters of quantitative traits of 25 accessions for 2015 cropping season

Trait	Mean	GV	PV	GCV (%)	PCV (%)	H^2B (%)	GAM (%)
EM	78.13	288.83	389.22	21.75	25.25	74.21	38.60
PH	25.51	15.43	30.86	15.39	21.78	50.00	22.43
NMB	5.16	0.08	0.95	5.65	18.92	8.95	3.48
NL	25.73	11.32	62.19	13.08	30.65	18.2	11.50
PEDL	25.06	36.92	49.09	24.25	27.96	75.21	43.32
DFF	46.30	24.43	35.86	10.68	12.93	68.13	108.70
PDP	15.95	34.95	86.90	37.06	58.45	40.22	48.42
PDL	14.52	24.72	26.21	34.24	35.26	94.32	68.51
SPP	13.39	23.82	26.37	36.45	38.35	90.33	71.36
SDPL	237.41	9311.19	24175.99	40.64	65.49	38.51	51.96
100SW	10.52	18.80	20.16	41.23	42.68	93.25	81.99
SDYPL	26.38	133.63	329.20	43.82	68.78	40.59	57.51

EM: Emergence percentage; PH: Plant height; NMB: Number of main branches; NL: Number of leaves; PEDL: Peduncle length; DFF: Number of days to first flowering; PDP: Number of pods per plant; PDL: Pod length; SPP: Number of seeds per pod; SDPL: Number of seeds per plant; 100-SW: 100 seed weight; SDYPL: Seed yield per plant. GV: Genotypic variance; PV: Phenotypic variance; GCV: Genotypic coefficient of variation; PCV: Phenotypic coefficient of variation; H^2B: Heritability; GAM: Genetic advance as percent of mean

Discussion

A better understanding of the magnitude and nature of the existing genetic variability for various traits, the extent of character heritability, inter character association and their effects directly and indirectly on yield among available individuals of a germplasm collection, is a prerequisite for breeding new ones with improved characters. To overcome the issue of low productivity in cowpea, it is appropriate to distinguish high yielding genotypes with shield from major biotic and abiotic restraints among germplasm collections. Distinguishing proof of these better genotypes, their addition in breeding schemes combined with establishment of reasonable choice criteria will be useful for fruitful varietal improvement programs. Analysis of variance of genotypes for different attributes and relationship of characteristics in connection to yield contributing elements of the crop would be vital for an effective selection scheme (Ajayi et al., 2014). Cowpea is an important legume of the tropical and subtropical nations for its high protein content and tremendous capacity to fix atmospheric nitrogen in soil for soil improvement. Earlier studies on cowpeas using morphological traits (quantitative and qualitative) have been carried out by many researchers, and these traits have been found to be of great importance to distinguish genetic variability, and have led to a better classification of cowpea genotypes (Doumbia et al., 2014; Ajayi, 2019).

In the present study, genetic variability among 25 accessions of cowpea from different origins was evaluated based on morphological traits for two periods in the year 2014 and 2015. The large variance amongst accessions for all characteristics during every season suggests that further improvements are feasible. This is in line with the findings of many workers on cowpea (Lesley, 2005; Ajayi & Adesoye, 2013; Ajayi et al., 2014) and on other crop species (Osekita & Ajayi, 2013; Fayeun, 2015; Osekita et al., 2015). Non-significant season effect for number of leaves, peduncle length and pod length indicated adaptability of accessions in the two years of the study. The result of the combined ANOVA indicated that accessions differ significantly for all traits.

Differences observed among accessions in some instances were more season specific as some accessions retained stability in performance as regards yield and other component traits across seasons. The significant genotype x environment effects detected in the present study point to the fact that the accessions involved in the evaluation were not consistent in their performances across seasons (Horn et al., 2018). This has been the major problem in the comparison of performance of genotypes of a species across environments in stunting the effectiveness of selection. Similar results were observed in Nigeria by Odeseye et al. (2018), among cowpea genotypes evaluated across two locations, Adeigbe et al. (2011) among cowpea genotypes evaluated across three seasons. Previous studies have affirmed that consistent genotypes in terms of performance across environments or with little variations across environments are deemed to be generally adaptable (Odeseye et al., 2018; Petit et al., 2020). These are in line with the findings of the present study; accessions AC12, AC17, AC20 and AC18 which were consistently the highest yielders across seasons could be the best candidates for selection, nevertheless, evaluations in mega environments are required to pinpoint accessions with consistent performances. Mean output was greater in 2014 than in 2015 for the number of seeds per plant, seed yield and 100-seed weight. The range obtained for the number of days to flowering in the present study in each season was within the range previously reported by some workers (Adewale et al., 2010), but higher than the range reported by Gerrano et al. (2015).

Table 11 Genotypic (above) and phenotypic (below) correlations among quantitative traits of 25 accessions for 2014 planting season

	EM	**PH**	**NMB**	**NL**	**PEDL**	**DFF**	**PDP**	**PDL**	**SPP**	**SDPL**	**100SW**	**SDYPL**
		0.32	0.38	0.37	-0.11	0.08	-0.02	0.07	0.02	0.04	-0.25	-0.09
EM		0.26	0.32	0.33	-0.11	0.07	-0.01	0.06	0.01	0.03	-0.22	-0.09
			0.01	-0.24	0.40*	0.34	0.45*	-0.06	0.08	0.53**	-0.39*	0.48*
PH			0.00	-0.22	0.38	0.33	0.43*	-0.06	0.08	0.50*	-0.37	0.46*
				-0.23	-0.42*	0.30	-0.13	-0.07	-0.27	-0.23	0.27	-0.16
NMB				-0.28	-0.42*	0.29	-0.14	-0.07	-0.26	-0.23	0.27	-0.16
					-0.39*	-0.11	-0.42*	-0.30	-0.32	-0.40*	-0.30	-0.51**
NL					-0.38	-0.11	-0.40	-0.29	-0.31	-0.39*	-0.29	-0.49*
						-0.15	0.84**	0.37	0.47*	0.81**	-0.02	0.85**
PEDL						-0.15	0.82**	0.36	0.46*	0.80**	-0.02	0.84**
							-0.19	-0.66**	-0.66**	-0.21	-0.34	-0.15
DFF							-0.19	-0.65**	-0.65**	-0.21	-0.34	-0.15
								0.44*	0.55**	0.96**	-0.03	0.98**
PDP								0.43*	0.53**	0.97**	-0.03	0.98**
									0.86**	0.46*	0.60**	0.48*
PDL									0.85**	0.46*	0.60**	0.47*
										0.64**	0.23	0.57**
SPP										0.63**	0.23	0.57**
											-0.12	0.97**
SDPL											-0.12	0.97**
												0.03
100SW												0.03
SDYPL												

*: Significant at P ≤ 0.05; **: Significant at P ≤ 0.01. EM: Emergence percentage; PH: Plant height; NMB: Number of main branches; NL: Number of leaves; PEDL: Peduncle length; DFF: Number of days to first flowering; PDP: Number of pods per plant; PDL: Pod length; SPP: Number of seeds per pod; SDPL: Number of seeds per plant; 100-SW: 100 seed weight; SDYPL: Seed yield per plant

Table 12 Genotypic (above) and phenotypic (below) correlations among quantitative traits of 25 accessions for 2015 planting season

	EM	PH	NMB	NL	PEDL	DFF	PDP	PDL	SPP	SDPL	100SW	SDYPL
		0.63**	-0.08	-0.01	-0.17	-0.03	0.22	-0.20	-0.07	0.17	-0.27	-0.07
EM		0.54**	-0.08	-0.06	-0.14	-0.06	0.20	-0.17	-0.06	0.15	-0.26	-0.03
			-1.00**	-0.20	-0.05	0.13	0.26	0.14	0.33	0.61**	-0.27	0.22
PH			-0.33	-0.03	0.00	0.06	0.23	0.12	0.27	0.43*	-0.24	0.18
				0.58**	-0.32	0.32	-0.58**	-0.99**	-1.00**	-0.54**	-0.39*	-0.92**
NMB				0.41*	-0.11	0.11	-0.11	--0.45*	-0.57**	-0.31	-0.20	-0.23
					-0.59**	0.55**	-0.73**	-0.52**	-0.66**	-0.74**	-0.43*	-0.60**
NL					-0.27	0.34	-0.41	-0.31	-0.41	-0.43	-0.28	-0.32
						-0.55**	0.70**	0.75**	0.65**	0.64**	0.59**	0.55**
PEDL						-0.50*	0.59**	0.70**	0.61**	0.53**	0.54**	0.47*
							-0.83**	-0.68**	-0.67**	-0.71**	-0.39*	-0.46*
DFF							-0.67**	-0.63**	-0.62**	-0.60**	-0.35	-0.39*
								0.84**	0.73**	0.88**	0.46*	0.61**
PDP								0.70**	0.62**	0.92**	0.37	0.71**
									0.92**	0.94**	0.74**	0.92**
PDL									0.91**	0.73**	0.72**	0.76**
										0.95**	0.58**	0.78**
SPP										0.77**	0.56**	0.68**
											0.42*	0.67**
SDPL											0.29	0.75**
												0.90**
100SW												0.73**
SDYPL												

*: Significant at P ≤ 0.05; **: Significant at P ≤ 0.01. EM: Emergence percentage; PH: Plant height; NMB: Number of main branches; NL: Number of leaves; PEDL: Peduncle length; DFF: Number of days to first flowering; PDP: Number of pods per plant; PDL: Pod length; SPP: Number of seeds per pod; SDPL: Number of seeds per plant; 100-SW: 100 seed weight; SDYPL: Seed yield per plant

Accessions AC02, AC05, AC04, AC18, AC07 and AC01 were consistently early flowering accessions. Early flowering among these accessions may be linked to their genotypic differences combined with the prevailing environmental influences which include soil conditions, altitude and temperature as reported by Gerrano et al. (2015). Early flowering in cowpea leads to early physiological maturity and this is an important attribute for environments with prevailing drought stress; for selection for earliness facilitates drought escape (Gerrano et al. 2015). There was significant variation for days to flowering across seasons, implying that flowering of an accession depended on the differences in photoperiodicity of the seasons in contradiction to the findings of Odeseye et al. (2018).

Number of days to first flowering and pod length showed the least coefficient of variation (CV) in all seasons, indicating high level of uniformity among these traits compared to plant height, number of pods per plant, number of seeds per plant and seed yield which were less uniform as a result of their higher CV. Adewale et al. (2010), Adeigbe et al. (2011), Nwosu et al. (2013) & Ajayi et al. (2014) have noted these models of elevated variations. Phenotypic coefficient of variation (PCV) is normally higher than the matching genotypic coefficient of variation (GCV), but in rare circumstances, PCV and GCV are the same. In this study, PCV was higher than GCV for all traits and the differences between PCV and the corresponding GCV for most traits were narrow across seasons. Little differences between PCV and GCV indicated strong genetic effect on traits (Ajayi et al., 2017). High and consistent PCV and GCV of traits such as peduncle length, number of pods per plant, pod length, number of seeds per pod, number of seeds per plant, seed weight and seed yield across seasons indicated that accessions had broad genetic base for these traits and possibility of their improvement through selection. The findings are consistent with several outcomes (Selvam et al., 2000; Adewale et al., 2010; Adeigbe et al., 2011; Nwosu et al., 2013; Ajayi et al., 2014). Heritability estimates were consistently ranged from moderate to high for most traits across seasons except for number of main branches and number of leaves per plant. Heritability estimates of combined environments nullify biases which result from genotype by environment interactions (GEI); though may be of lower magnitude, they are most reliable at predicting genetic gain in traits (Mulder & Bijma, 2005; Osekita, 2017). Being regarded with genetic advance, heritability is much more efficient for adequate selection; high heritability followed by high genetic advance (GAM) suggests additive genetic effects, therefore selection is efficient. High heritability followed by low GAM suggests non-additive genetic effect; poor heritability with high GAM furthermore point toward additive gene effect and poor heritability with low GAM demonstrates that characteristics are extremely regulated by environmental factors leading to unsuccessful selection (Ajayi et al., 2017). High and consistent broad sense heritability estimates observed in most traits in this study across seasons indicated that selection could be made on them for crop improvement. This is in line with the findings of several workers in cowpea (Selvam et al., 2000; Adewale et al., 2010; Adeigbe et al., 2011; Nwosu et al., 2013; Ajayi et al., 2014) and rice (Akinwale et al., 2011). For all traits, high GAMs were observed consistently across seasons except for emergence percentage, number of main branches and number of leaves per plant, indicating additive gene effects, and implying that successful improvement progress could be made for yield by selection. These are consistent with the findings of Nehru & Manjunath (2009) and Ajayi et al. (2014) on cowpea.

It would be of importance for breeding objectives to quantify genotypic and phenotypic associations among the assessed traits obtained in this analysis. A major factor in economic and difficult trait such as yield is the degree to which the traits interact (Akinwale et al., 2011). Correlations are degrees of the strength of interaction between traits, bringing about positive change for all positively correlated characteristics and setbacks for negatively correlated attributes (Ajayi et al., 2014). According to Ajayi et al. (2017), phenotypic relationships suggest data on the nature of the associations found between two traits as affected by environmental factors. Whereas genotypic relations suggest data on the underlying relationship between genes regulating any two traits; thus, a greater importance is exerted when an effective selection scheme is implemented. Generally, most positively related attributes had higher genotypic interactions compared to phenotypic; nonetheless phenotypic correlation was greater than genotypic among negatively correlated traits in this study. In line with the above, genotypic correlation is reasoned to be more essential since it reflects the minimal environmental influence among these traits. In line with these, significant and positive correlations between two traits implies that such traits can be improved simultaneously in a breeding program (Fayeun, 2015). Therefore, for improvement of seed yield in cowpea, it is pertinent to determine the degree and path of association between seed yield and its component characters (Sadras et al., 2019). It was laid bare in this study that significant phenotypic and genotypic correlations existed in some of the measured traits.

The consistent positive relationship amongst the seed yield, peduncle length and number of pods, seeds per pod, pod length and seeds per plant of these accessions across seasons will be useful in designing an effective selection program for the crop. By implication, increase in seed yield of cowpea could result from the increase in all traits with positive correlations with seed yield. The negative significant correlations between pod length and days to first flowering; seeds per pod and days to first flowering across seasons indicated that accessions which flowered early had longer pod length and more seeds per pod that can lead to more seeds per plant and consequently resulted in higher seed yield. These agree with the work of Umar et al. (2010); Adeigbe et al. (2011) and Ajayi et al. (2014).

Conclusion

The various accessions exhibited considerable disparity for yield as well as several yield contributing traits across seasons. It was revealed from this study that performance and selection could be projected dependably if the choice of individuals is based on traits with high broad sense–heritability estimates in addition to high genetic advance. Consequently, improvements could be achieved through phenotypic selection on seed yield, plant height, number of main branches, and number of leaves, peduncle length, and days to first flowering, pods per plant, seeds per plant, pod length, seed weight and seeds per pod. The positive and significant correlations among such traits as seed yield, peduncle length, and number of pods; seeds per pod, pod length and seeds per plant of different accessions across seasons will be useful in designing an effective selection program for the crop. Genotype by environment interaction (GEI) as revealed by the combined ANOVA across seasons indicated the effect of interactions of GE on grain yield. Accessions such as AC16, AC20, AC18, AC17, AC05, AC12 and AC11 were different for such traits as moderate number of days to first flowering and high seed yield. AC19 and AC22 were very poor yielding with excessively high number of days to first flowering.

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