Journal of Applied Biological Sciences
E-ISSN: 2146-0108 18(2): 209-222, 2024
DOI: https://doi.org/10.71336/jabs.1309
Research Article

AGRO-MORPHOLOGICAL CHARACTERIZATION OF COMMON BEAN ACCESSIONS IN NORTHERN REGION OF NIGERIA

Victor Onuche Ikani[1,2*], Olamide Ahmed Falusi[2],
Oladipupo Abdulazeez Yusuf Daudu[2], Abdulhakeem Abubakar[2]

[1]Modibbo Adama University, Faculty of Life Sciences, Department of Plant Science, Yola, Nigeria
[2]Federal University of Technology, School of Life Sciences, Department of Plant Biology, Minna, Nigeria

*Corresponding Author:
E-mail: vonuche@gmail.com

(Received 02nd March 2024; accepted 06th June 2024; published: 12th June 2024)

ABSTRACT. Despite the potentials of common bean and its production in other countries of the world, it is still poorly researched on for plant improvement when compared to cowpea and soybean, this is a huge setback as far as this research is concerned. Up till now, landraces are still being cultivated by the farmers with no definite existing seed system in Nigeria. Thirty-three common bean accessions obtained from farmers in growing regions of Northern Nigeria was used for this study. Seeds of common bean was sown In 297 bags laid out using a Complete Randomized Design to study agro-morphological traits. Qualitative (11) and quantitative (9) traits were recorded following International Board of Plant Genetic Resource common bean Descriptor list. Days to flowering (23.83 days) and days to maturity (53.83 days) was lowest in PL-01. KD-14 was the best performing accession in number of pods per plant (13.83) and KG-01 had the highest pod length (20.23 cm) and number of seeds per pod (12.50 cm). Weight of one hundred seeds (104.0 g) was highest in KD-11. Positive correlations were observed among the descriptors such as days to flowering with days to maturity (r = 0.73), pod beak length with pod length (r = 0.64) and pod length with number of seeds per pod (r = 0.79). The divergence between accessions was observed using hierarchical clustering dendrogram, at a genetic distance of 48; the accessions were grouped into 11 clusters depending on the similarity of traits considered. There is need for further studies to evaluate the characterized accessions over a period of two or more years in different locations across Nigeria to see if similar observations will be made.

Keywords: *Diversity, genetic, quantitative, qualitative, traits.*

INTRODUCTION

One of the most significant grain legume for direct use by humans worldwide is the common bean (*Phaseolus vulgaris L.*). It provides a significant amount of extremely essential micronutrients and plant protein. [1, 2], offers medicinal benefits that are derived from their regular consumption [3, 4] and plays an important role in the sustainable improvements of the environment when they are cultivated using crop rotation or intercropping, due to their ability to fix nitrogen in soil and control weeds [4, 5].

Globally, it is known as a good nutritional source and an alternative component of healthy meals among poor households [6]. This is particularly true for homes in Africa, where it makes up majority of the meals, with average weekly consumptions of four times in some nations, like Uganda. [7]

Phaseolus vulgaris is a widely cultivated crop with a great deal of variability. Although many cultivars are referred to as climbers, with a lot of lateral and adventitious roots and a stem that can grow up to 3 meters in length and are angular or almost cylindrical. All wild members of the genus have a climbing habit, trifoliate, alternately oriented leaves, inflorescence and an axillary or terminal false raceme up to 15–35 cm long, bearing solitary or paired flowers placed along the rachis which are bisexual [1]. They are annual, self-pollinating legumes, cultivated for food in many parts of the world. *P. vulgaris* originated in Mesoamerica and separated about a century ago, into Mesoamerican and Andean gene pools that are now isolated in terms of reproduction [8].

Common bean was harvested over an area of 33.1 million ha and production was 28.9 million tonnes in 2019 [9]. The second most important grain legume is the bean, which is produced at a rate nearly twice that of the chickpea. Sub-Saharan Africa and Latin America are the two regions that produce the most common beans. Additionally, it is produced in regions with low temperature, and also in many tropical and subtropical regions, accounting for around three-quarter of global production [10].

Despite the potential of this crop and its production in other nations, it has not benefited from the rigorous research programme dedicated to the enhancement of soybean and cowpea, which is a fundamental setback. Since landraces are still being cultivated by farmers in Nigeria, they are severely underutilized [11]. It is not fully exploited to help in ensuring food security and reduction of poverty. Inadequate documentation and study demonstrates the extent of underutilization. Sadly, the crop is only suited for a few number of agro-ecological niches, with no recognized seed supply system, and mostly produced without the use of outside inputs, which drives up the cost of the crop [12]. Conservation of *Phaseolus* germplasm in gene banks in Nigeria is very insignificant and thereby hampering effort that could have led to the improvement of the crop in Nigeria. Genetic diversity among germplasm and interaction between major yield contributing traits is pivotal to breeding programmes that aim at the development of important cultivars [13]. To effectively conserve and utilize a crop's genetic resources, it is essential to comprehend how its genetic diversity is organized [14]. Characterizing accessions enables the measurement and organization of existing differences in the germplasm, which is crucial for genetic diversity conservation and enhancement initiatives as well as improvement programmes [15]. Hence, this research sought to collect and characterize common bean landraces using agro-morphological descriptors from areas where they are cultivated in Northern Nigeria which will facilitate further breeding and conservation of the crop in Nigeria.

MATERIALS AND METHODS

Research location and source of germplasm

Agro-morphological studies on common bean accessions was conducted at the Botanicalgarden (9˚20'58''N, 12˚29'07''E) of Modibbo Adama University Yola, Adamawa State, Nigeria. The region receives an average annual precipitation of 872.4 mm (34.35 in). A total of thirty-three (33) common bean landraces were obtained from local farmers in the four states (Kaduna, Plateau, Taraba and Kogi) where they are cultivated in Northern Nigeria. Accession numbers were assigned to the collected landraces.

Experimental design and sowing of seeds

The dimension of the experimental field used was 1845 cm by 1845 cm, with a total of nine plots, each measuring 615 cm by 615 cm. A Complete Randomized Design (CRD) with three replications in nine plots were used. A total of 297 sack bags were used across the nine plots, each plot consisted of 33 thoroughly washed sack bags filled with about 25 kg of sandy loam soil and measured about 63.8 cm × 50.5 cm, spaced at 60 cm apart. The plots were demarcated with twines to minimize associated effect of neighboring plots. Two seeds were sown per bag for each accession in each replication during the 2022 common bean growing season.

Agro-morphological characterization of accessions

Genetic diversity of common bean accessions were evaluated according to the descriptor list of International Board for Plant Genetic Resources [16].

A total of 9 quantitative and 11 qualitative traits were studied. The quantitative traits studied includes: Days to flowering, Days to maturity, Plant height at maturity, Pod beak length, Pod length, Pod width, Number of pods per plant, Number of seeds per pod and 100 seed weight.

The qualitative traits studied includes: hypocotyl colour, leaf shape, growth habit, hairiness of leaves, hairiness of stem, stem pigmentation, standard flower colour, colour of wings, pod curvature, immature pod colour and mature pod colour. Qualitative data were scored based on visual evaluation while quantitative data were counted, measured using metric rulers, vernier callipers and weighing balance.

Data analyses

Mean values of the parameters were subjected to one-way Analysis of Variance (ANOVA) using R software (version 4.05). Pearson Correlation was used to analyze the relationship between traits of the bean genotypes and a paired group dendrogram based on data obtained from 9 quantitative traits were drawn using PAST 3 software. Statistical testing was carried out using Tukey's Honest Significant Difference (HSD) at $p \leq 0.05$ level of significance.

RESULTS AND DISCUSSION

Performance of agro-morphological traits of common bean accessions

The mean performance of the agro-morphological traits of accession of common bean is presented in Table 1. The different accessions varied in performance for the various quantitative traits studied. The lowest number of days to flowering (23.83 days) and maturity (53.83 days) was observed in PL-01 while the highest days to flowering and maturity was recorded in KD-07 (110.83 days) and KD-08 (195 days) respectively. Plant height at maturity varied significantly ($p<0.05$) among the accessions studied. The reduced number of days to flowering and maturity as observed in some accessions is an indication that they are early maturing and their genome could be explored in future crosses to produce early maturing varieties. Bode *et al*. [15] reported a similar trend in twenty (20) accessions of *P. vulgaris* where number of days to flowering ranged between 24-32 days but a slightly higher number of days to maturity when compared with this study. The difference in number of days to maturity could be attributed to photoperiod effect or differences that exist in the locations where both studies were carried out. The higher number of days to flowering and maturity as seen in KG-01 and KD-08 could be an indication that the accessions are late maturing, this confirms the findings of Loko *et al*. [17] that reported higher number of days to flowering (74.44 days) and maturity (108.81 days).

The highest plant height at maturity was observed in KD-15, which had an average height of 313.47 cm and the lowest was in PL-01 with a mean height of 66.40 cm at maturity. The highest average pod length of 20.23 cm was recorded in KG-01 accession while the lowest was 4.87cm in PL-14. Pod width was observed to be significantly different ($p<0.05$) in all the accessions studied with KD-15 having the highest pod width of 5.77cm while the lowest pod width of 3.17 cm was obtained in KD-12. However, KD-07 showed the lowest average pod beak length of 0.17 cm while KG-01 had the highest average pod beak length of 1.15 cm. The difference in plant height at maturity among the beans accessions studied indicate a high level of genetic diversity in their growth habit. Accessions with higher plant height at maturity can be suitable for forage purpose as their dried vines can be used to feed animals, this conforms to the findings of Sofi *et al*. [18]. High level of morphological variation was observed in the pods, the higher pod length could be as a result of more number of seeds in the pod. The highest pod length as seen in KG-01 which also had the highest number of seeds per pod, aligns with the report of Kalaimi *et al*. [19]. They showed one of the *Phaseolus vulgaris* genotype which they called “Trishuli,” had a mean pod length of 19.3 cm. However, average and smaller pod length as seen in this study have also been reported by Bode *et al*. [15] and Loko *et al*. [16]. Pod width which is an indication of how broad the seeds are varied across all the accessions although the values obtained in this study are higher than those that have been reported in similar studies. Pod widths of 1.2, 1.6 and 0.95 cm have been reported by Bode *et al*. [15], Loko *et al*. [17] and Kalaimi *et al*. [19] respectively in *Phaseolus vulgaris*. The difference in pod width may be attributed to the variation in genome of the accessions, the particular stage of development when the pods were measured as well as the environment where the plants were raised. On the other hand, variation in pod beak length is in line with the reports of Bode *et al*. [15] where they stated that the mean pod beak length of 20 accessions of *P. vulgaris* ranged between 0.2 and 1.3 cm.

The highest number of pod per plant (13.83) was observed in KD-14 while the lowest (5.08) was recorded in PL-06. The number of seeds per pod also varied significantly ($p<0.05$) across the accessions. PL-10 recorded the lowest (2.0) average number of seeds per pod while KG-01 recorded the highest (12.5) average number of seeds per pod. KD-11 showed the highest (104.70 g) one hundred seeds weight while the lowest (23.80 g) weight was recorded in PL-13. The high number of pods per plant in some accessions maybe an indication that such accessions are high yielding and could be a useful gene pool when selection are being made for crosses to produce better varieties in the future. This findings are in tandem with the report of Sofi *et al*. [18]. In their assessment of forty-two (42) bean lines, they reported an average range of number of pods per plant to be between 4.66 and 13.66. Variation in the number of seeds per pod was also observed, and this could be as a result of the genetic differences that exist between different accessions studied. This corroborates the findings of Sofi *et al*. [18] and Kalaimi *et al*. [19].

The weight of one hundred seeds for each accession also differed greatly, thus showing high level of genetic variation existing between the accessions. The highest weight of one hundred seeds in this study is slightly higher than those reported by Bode *et al*. [15], and Xhulaj [24]. However the weight of other accession fall within the same range as those reported by Loko *et al*. [17] and Kalaimi *et al*. [19]. The difference in the weight of hundred seeds can be attributed to variations that exist in the length, width, height and size of the landraces used in the various studies.

Genotypic correlation coefficient (pearson) among 9 quantitative traits of common accessions

The analysis on correlation coefficient (Table 2) showed that several descriptors were positively correlated with each other. Based on the results, days to maturity correlated strongly with number to days of flowering (r= 0.73). Pod beak length also correlated positively with pod length (r= 0.64).

A strong correlation was recorded between number of seeds per pod with pod length (r= 0.79). One hundred seed weight showed a positive correlation to pod width (r= 0.59) and number of pods per plant (r= 0.58). Negative correlation was observed among several traits such as pod length with days to flowering (r=-0.24), pod length with days to maturity (r= -0.03), pod width with pod length (r= -0.03), number of pods per plant with number of days to flowering (r= -0.02) and maturity (r=-0.03). The weight of hundred seeds of *Phaseolus vulgaris* accessions also showed a negative correlation with days to flowering (r= -0.15), days to maturity (r= -0.13) and number of seeds per pod (r= -0.23).

Different correlation present among measurable traits showed that it is possible to improve several performances from breeding one of them. Strongly correlated traits were possibly under the influence of the same genes which during selection could be selected simultaneously based on one of the traits [20]. The significantly strong positive correlation of pod length, pod width, days to flowering, days to maturity, number of seeds per pod and one hundred seeds weight indicates that these traits were efficient in yield determination. Similar findings have been reported by Rana *et al*. [21] and Loko *et al*. [17]. However, some traits such as pod length, number of pods per plant with days to flowering which showed negative correlation might be an indication that such traits were not under the control of the same gene. This is in conformity with the findings of Sofi *et al*. [18] and Loko *et al*. [17].

Table 1. *Agro-morphological Performance of Common Bean Accessions from Northern Nigeria*

ACC. I.D	DTF	DTM	PHM (cm)	PDL (cm)	PDW (cm)	PBL (cm)	NPPP	NSPP	HSWT (g)
KD- 01	53.83 ± 0.58^{n}	9.67 ± 1.53^{cde}	165.58 ± 1.23^{cdf}	8.00 ± 0.17^{defg}	4.17 ± 0.45^{efghij}	0.60 ± 0.10^{cd}	6.00 ± 0.50^{hijk}	6.00 ± 0.00^{b}	34.97 ± 4.51^{efgh}
KD- 02	74.67 ± 0.29^{ij}	7.50 ± 0.50^{bcde}	191.38 ± 2.70^{cde}	7.63 ± 0.70^{efghi}	4.97 ± 0.35^{abcdef}	0.42 ± 0.06^{defghi}	10.00 ± 0.86^{abcdefgh}	3.00 ± 0.00^{f}	83.50 ± 2.00^{b}
KD- 03	80.67 ± 0.29^{gh}	3.67 ± 0.29^{bcde}	275.08 ± 1.67^{ab}	9.27 ± 0.51^{c}	5.57 ± 0.05^{ab}	0.42 ± 0.03^{defghi}	13.67 ± 1.04^{ab}	4.00 ± 0.00^{d}	84.43 ± 4.73^{b}
KD- 04	74.33 ± 2.25^{ij}	3.67 ± 0.58^{bcde}	174.63 ± 8.40^{cdef}	5.93 ± 0.21^{mno}	4.60 ± 0.36^{cdefghi}	0.35 ± 0.00^{fghijk}	9.00 ± 0.50^{cdefghijk}	4.00 ± 0.00^{d}	46.13 ± 3.06^{cdef}
KD- 05	88.50 ± 0.87^{cd}	23.50 ± 0.87^{bcd}	121.52 ± 1.35^{fghi}	7.90 ± 0.10^{defgh}	5.20 ± 0.17^{abcd}	0.40 ± 0.00^{defghij}	7.67 ± 0.76^{efghijk}	3.00 ± 0.00^{f}	33.40 ± 4.36^{fgh}
KD- 06	84.83 ± 0.29^{de}	23.67 ± 0.58^{bcd}	214.78 ± 3.64^{bcd}	6.10 ± 0.50^{klmno}	4.10 ± 0.17^{fghij}	0.22 ± 0.03^{ijk}	5.67 ± 0.29^{ijk}	4.00 ± 0.00^{d}	33.33 ± 2.52^{fgh}
KD- 07	110.83 ± 0.29^{a}	35.17 ± 1.89^{abc}	157.72 ± 5.50^{def}	6.17 ± 0.23^{jklmn}	4.20 ± 0.17^{efghij}	0.17 ± 0.03^{k}	5.33 ± 0.58^{jk}	4.00 ± 0.00^{d}	35.70 ± 4.58^{defgh}
KD- 08	109.83 ± 0.29^{a}	95.00 ± 0.42^{a}	178.50 ± 1.93^{cdef}	5.27 ± 0.21^{no}	4.27 ± 0.15^{efghij}	0.22 ± 0.08^{ijk}	7.83 ± 1.04^{efghijk}	4.00 ± 0.00^{d}	34.96 ± 3.51^{efgh}
KD- 09	82.67 ± 0.76^{ef}	2.33 ± 0.58^{bcde}	196.12 ± 2.48^{cde}	6.80 ± 0.26^{ghijklm}	4.43 ± 0.15^{cdefghij}	0.33 ± 0.03^{fghijk}	9.17 ± 0.29^{cdefghijk}	3.00 ± 0.00^{f}	43.10 ± 5.20^{cdefg}
KD- 10	64.83 ± 0.29^{lm}	3.00 ± 0.87^{bcde}	210.00 ± 5.41^{bcd}	8.70 ± 0.92^{cde}	5.27 ± 0.29^{abc}	0.50 ± 0.05^{cdefg}	11.50 ± 3.61^{abcde}	3.50 ± 0.00^{e}	84.43 ± 4.16^{b}
KD- 11	67.83 ± 0.29^{kl}	0.67 ± 0.29^{bcde}	194.92 ± 8.86^{cde}	9.13 ± 0.55^{cd}	$5.23a\pm0.23^{bc}$	0.53 ± 0.06^{cdef}	8.33 ± 0.76^{defghijk}	3.00 ± 0.00^{f}	104.70 ± 7.21^{a}
KD- 12	40.16 ± 0.29^{o}	3.33 ± 0.29^{cde}	87.72 ± 9.81^{ghij}	7.90 ± 0.10^{defgh}	3.17 ± 0.06^{k}	0.88 ± 0.03^{b}	7.00 ± 0.50^{fghijk}	3.50 ± 0.00^{e}	44.17 ± 4.73^{cdefg}
KD- 13	63.33 ± 0.29^{m}	5.33 ± 0.29^{bcde}	172.08 ± 4.20^{cdef}	7.67 ± 0.35^{efghi}	4.43 ± 0.12^{cdefghij}	0.40 ± 0.00^{defghij}	7.00 ± 2.02^{fghijk}	3.00 ± 0.00^{f}	79.93 ± 5.03^{b}
KD- 14	75.16 ± 0.29^{hi}	5.50 ± 0.50^{bcde}	175.50 ± 1.27^{cdef}	7.70 ± 0.36^{efghi}	4.83 ± 0.40^{bcdefg}	0.42 ± 0.03^{defghi}	13.83 ± 1.15^{a}	3.00 ± 0.00^{f}	84.47 ± 4.04^{b}
KD- 15	76.50 ± 0.50^{hi}	3.83 ± 0.76^{bcde}	313.47 ± 4.35^{a}	7.60 ± 0.26^{efghi}	5.77 ± 0.55^{a}	0.35 ± 0.05^{fghijk}	10.50 ± 0.87^{abcdef}	3.50 ± 0.00^{e}	84.63 ± 4.51^{b}
PL- 01	23.83 ± 0.29^{q}	53.83 ± 0.29^{e}	66.40 ± 2.08^{hij}	9.13 ± 0.21^{cd}	3.77 ± 0.06^{ijk}	1.08 ± 0.06^{ab}	9.67 ± 2.25^{abcdefghi}	3.00 ± 0.00^{f}	54.70 ± 4.36^{c}
PL- 02	77.00 ± 1.80^{hi}	2.33 ± 1.04^{bcde}	79.88 ± 5.47^{hij}	5.87 ± 0.29^{mno}	4.37 ± 0.12^{cdefghi}	0.35 ± 0.00^{fghijk}	10.00 ± 3.46^{abdefgh}	3.50 ± 0.00^{e}	42.17 ± 8.08^{cdefg}
PL- 03	78.50 ± 0.00^{gh}	3.33 ± 0.58^{bcde}	133.80 ± 0.05^{efgh}	6.07 ± 0.35^{lmno}	4.80 ± 0.20^{bcdefgh}	0.28 ± 0.03^{hijk}	10.33 ± 0.76^{abcdefg}	3.00 ± 0.00^{f}	43.87 ± 4.04^{cdefg}
PL- 04	76.00 ± 0.00^{hi}	7.83 ± 0.29^{bcde}	217.98 ± 8.33^{bcd}	7.37 ± 0.29^{fghij}	5.07 ± 0.40^{abcde}	0.30 ± 0.05^{ghijk}	9.17 ± 0.29^{cdefghijk}	3.00 ± 0.00^{f}	47.00 ± 10.00^{cdef}
PL- 05	71.17 ± 0.48^{jk}	5.83 ± 0.29^{bcde}	204.70 ± 1.47^{cd}	7.30 ± 0.70^{fghijkl}	4.87 ± 0.25^{abcdefg}	0.27 ± 0.08^{hijk}	8.50 ± 1.00^{defghijk}	4.00 ± 0.00^{d}	49.60 ± 8.54^{cde}
PL- 06	42.67 ± 0.29^{o}	3.67 ± 0.29^{bcde}	54.43 ± 5.49^{ij}	6.90 ± 0.36^{ghijklm}	4.20 ± 0.26^{efghij}	0.33 ± 0.08^{fghijk}	5.00 ± 0.50^{k}	3.50 ± 0.00^{e}	51.70 ± 5.29^{cd}
PL- 07	67.67 ± 0.29^{kl}	2.57 ± 0.81^{bcde}	212.62 ± 6.75^{bcd}	6.30 ± 0.10^{jklmn}	3.67 ± 0.21^{jk}	0.65 ± 0.05^{c}	6.00 ± 0.50^{hijk}	3.50 ± 0.00^{e}	33.03 ± 2.31^{fgh}
PL- 08	82.83 ± 0.29^{ef}	2.00 ± 0.87^{bcde}	156.58 ± 9.45^{defg}	6.97 ± 0.11^{ghijklm}	4.30 ± 0.10^{defghij}	0.98 ± 0.03^{ab}	8.50 ± 0.87^{defghijk}	3.00 ± 0.00^{f}	35.23 ± 4.16^{efgh}
PL- 09	53.17 ± 0.29^{n}	8.00 ± 0.50^{cde}	164.95 ± 0.31^{cdef}	8.27 ± 0.15^{cdef}	4.03 ± 0.58^{ghijk}	1.03 ± 0.13^{ab}	6.00 ± 0.50^{hijk}	5.00 ± 0.00^{c}	28.33 ± 7.64^{gh}
PL- 10	39.50 ± 0.50^{o}	3.83 ± 0.76^{bcde}	208.37 ± 7.96^{bcd}	7.20 ± 0.53^{fghijkl}	4.87 ± 0.45^{abcdefg}	0.37 ± 0.08^{efghijk}	9.50 ± 0.00^{bcdefghij}	2.00 ± 0.00^{g}	44.10 ± 5.00^{cdefg}
PL- 11	31.17 ± 0.29^{p}	2.67 ± 0.76^{de}	66.40 ± 4.93^{hij}	10.733 ± 0.47^{b}	3.90 ± 0.26^{hijk}	1.03 ± 0.13^{ab}	9.67 ± 2.02^{abcdefghi}	4.00 ± 0.00^{d}	55.53 ± 3.51^{c}
PL- 12	88.00 ± 0.00^{cd}	16.83 ± 0.76^{bcd}	171.48 ± 5.98^{cdef}	6.47 ± 0.15^{ijklmn}	4.37 ± 0.23^{cdefghij}	0.37 ± 0.03^{efghijk}	9.17 ± 0.29^{cdefghijk}	3.50 ± 0.00^{e}	33.40 ± 4.36^{fgh}
PL- 13	89.83 ± 0.29^{c}	17.00 ± 0.00^{bcd}	228.17 ± 9.54^{bc}	5.23 ± 0.37^{no}	3.90 ± 0.20^{hijk}	0.33 ± 0.03^{fghijk}	8.83 ± 0.58^{defghijk}	4.00 ± 0.00^{d}	23.80 ± 3.00^{h}
PL- 14	97.50 ± 0.50^{b}	22.50 ± 3.04^{bcd}	174.38 ± 5.12^{cdef}	4.87 ± 0.06^{o}	4.47 ± 0.05^{cdefghij}	0.47 ± 0.03^{cdefgh}	9.00 ± 0.50^{cdefghijk}	3.00 ± 0.00^{f}	33.60 ± 2.00^{efgh}
TA- 01	56.33 ± 0.29^{n}	8.17 ± 3.18^{cde}	179.67 ± 3.38^{cdef}	8.03 ± 0.12^{cdefg}	3.77 ± 0.35^{ijk}	0.58 ± 0.12^{cd}	6.17 ± 0.57^{ghijk}	5.00 ± 0.00^{c}	33.37 ± 4.98^{fgh}
TA- 02	84.17 ± 1.15^{ef}	2.17 ± 1.44^{bcde}	165.68 ± 1.86^{cdef}	6.70 ± 0.26^{hijklm}	4.40 ± 0.20^{cdefghij}	0.57 ± 0.12^{cde}	9.33 ± 1.26^{cdefghij}	3.00 ± 0.00^{f}	35.27 ± 4.04^{efgh}
TA- 03	66.00 ± 0.00^{lm}	5.50 ± 3.12^{bcde}	180.05 ± 9.16^{cdef}	7.33 ± 0.51^{fghijk}	5.03 ± 0.05^{abcde}	0.25 ± 0.05^{ijk}	12.17 ± 2.31^{abcd}	3.00 ± 0.00^{f}	46.90 ± 4.36^{cdef}
KG-01	109.33 ± 0.58^{a}	52.17 ± 1.52^{ab}	216.33 ± 9.17^{bcd}	20.23 ± 0.35^{a}	4.03 ± 0.25^{ghijk}	1.15 ± 0.10^{a}	7.00 ± 0.00^{fghijk}	12.50 ± 0.00^{a}	36.13 ± 4.04^{defgh}

DTF: Days to Flowering, DTM: Days to Maturity, PHM: Plant Height at Maturity, PDL: Pod Length, PDW: Pod Width, PBL: Pod Beak Length, NPPP: Number of Pods per Plant, NSPP: Number of Seeds per Pod, HSWT: Hundred Seed Weight

Table 2. *Genotypic Correlation Coefficient (Pearson) among 9 Quantitative Traits of Phaseolus species Accessions*

Traits	DTF	DTM	PHM	PDL	PDW	PBL	NPPP	NSPP	HSWT
DTF	1								
DTM	0.73499	1							
PHM	0.444665	0.293943	1						
PDL	-0.03601	-0.00448	0.041464	1					
PDW	0.210939	0.118201	0.437826	-0.03186	1				
PBL	-0.53686	-0.30164	-0.34952	0.644312	-0.29296	1			
NPPP	-0.02359	-0.03419	0.201044	-0.00416	0.459632	-0.07122	1		
NSPP	0.262621	0.215485	0.133002	0.798557	-0.25082	0.385397	-0.29497	1	
HSWT	-0.15491	-0.12751	0.248735	0.17427	0.595315	0.019793	0.58277	-0.22978	1

**DTF: Days to Flowering, DTM: Days to Maturity, PHM: Plant Height at Maturity, PDL: Pod Length, PDW: Pod Width, PBL: Pod Beak Length, NPPP: Number of Pods per Plant, NSPP: Number of Seeds per Pod, HSWT: Hundred Seed Weight*

Qualitative traits of thirty-three common bean accessions from northern Nigeria

Table 3 shows the result of eleven qualitative traits studied in the various accessions of common bean. Hypocotyl colour for all accessions was green except in KD-14 and KD-15 which had a purple colour. Similaar to this study, Chandrashekhar [22] reported purple, light green, light purple and pale green colour of hypocotyl in French bean. However, contradicts the result of Kanwar and Mehta [23] that reported a creamish white hypocotyl colour pigmentation in sixty two landraces of French bean.

Leaflet shape differed only in KG-01, which had a lanceolate leaflet shape while every other accession studied had a triangular leaflet shape. Growth habit was determinate (non-climbing) in PL-01 while all other accession had an indeterminate (climbing) growth habit. Both hairiness of leaves and stem was observed in KD-01, PL-01, PL-06, PL-09, PL-11 and TA-01. Hairiness of leaves only was observed in KD-12, PL-07 and PL-10. There was variation in stem pigmentation of the different accessions which includes pink (KD-01, PL-09, TA-01), green (KD-02, KD-04, KD-05, KD-07, KD-11, KD-13, PL-01, PL-03, PL-04, PL-05, PL-06, PL-11, PL-13, PL-14 and TA-03) green with purple (KD-03), green with brown (KD-08 and PL-12), Green with pink (KD-06), Purple (KD-09, KD-10, KD-14, KD-15, PL-07, PL-08, PL-10 and TA-02), maroon (KD-12) and green/pink (KG-01). Leaflet shape is a certifying descriptor for distinguishing genotypes. The leaflet shape of thirty two of the accessions used in this study were triangular, and this is in agreement with the report of Loko *et al*. [17]. Plant growth habit which could be determinate or bush (non-climbing) and indeterminate (climbing) was also studied, and only one accession (PL-01) was a non-climber while all other accessions showed an indeterminate pattern of growth. This study showed that the non-climber flowered and matured early while the climber took a longer time to flower and mature. This might be a result of the extended time they have to undergo vegetative growth. Accessions with indeterminate growth will be suitable for mixed cropping system of farming with maize, sorghum and millet as the stalk of this crops can serve as stakes for the bean accessions to climb on. Sofi *et al*. [18] have reported twenty nine genotypes that are non-climbers and twelve climbing genotypes, and also in a similar study [17] by fifty seven genotypes have been reported to be climbers. Presence of hairs on the leaves, stem or leaves and stem is a distinguishing feature that depicts morphological variability in the accessions. Hairs were absent on some genotypes as well. The presence of hairs on stem and leaves of French bean have been reported by Kalaimi *et al*. [19]. Stem pigmentation is an important trait that has been used to describe *Phaseolus vulgaris* over time. The variation in stem colour maybe an indication of the dominant plastid in the stems. Stems with only green colours might have a dominant chloroplast plastid responsible for the production of chlorophyll which is the most abundant in such stem. Green, purple and green with pink stem pigmentation have been reported by Loko *et al*. [17] and Kalaimi *et al.* [19].

Standard flower colour was yellow (KD-01, KD-02, KD-04, KD—08, KD-09, PL-05, PL-08, PL-09, TA-01, TA-02 and TA-03), cream (KD-03, KD-05, KD-13, KD-14, KD-15 and PL-12), white (KD-06, KD-07, KD-11, PL-02, PL-03, PL-04, PL-06, PL-13, PL-14 and KG-01), lilac (KD-10, KD-12 and PL-01) and purple (PL-07, PL=10 and PL-11). Colour of wings of the accession was white (KD-12, PL-01, PL-07 and PL-11), cream (KD-13, PL-06 and PL-10) and green in every other accession. Pod curvature varied from straight, slightly curved to curved. Majority of the pods were slightly curved with only two accessions (PL-11 and KG-01) having a straight pod while KD-01, KD-04, KD-07, KD-10, KD-11, PL-09, and TA-01 had curved pods. Immature pod colour was green with purple stripes in PL-11 and plain green for all other accessions while at maturity, the pod colour differed in some accessions. Three accessions (KD-01, PL-09 and TA-01) showed pink colour, persistent green was seen in KD-02 and KD-03, maroon in KD-12, dark purple in PL-10, pale yellow with purple stripes in PL-11, green with brown in KG-01 and yellow in every other accession. The variation in the standard flower and wing colour across the accessions is due to the genetic difference that exist between them, and the coloured flowers might play a significant role in attracting agents of pollination (insects). Kalaimi *et al*. [19] have reported the presence of white and purple coloured flowers in French bean genotypes. White with lilac, purple, white with green coloured flowers and wings have also been reported by Sofi *et al*. [18]. In the assessment of forty two common bean landraces.

Data collected on pod curvature showed that only two accessions were straight, seven had curved pods and twenty four had slightly curved pods, this is in line with the report of Loko *et al*. [17] in their assessment of fifty seven common bean accessions at republic of Benin. They reported that fifty one of the accessions studied had slightly curved pods, had three straight and another three had curved pods.

Green immature pod colour have been reported by Kalaimi *et al*. [19]. Other immature pod colour such as green with purple stripes is as described by the common bean descriptor list [16]. Pod colour at physiological maturity also showed great variation in accessions studied. Green with yellow and solely yellow pod colour have also been reported [17]. Sofi *et al*. [18] have reported other colours such as pink, maroon and purple.

Table 3. *Qualitative Traits of Common Bean accessions from Northern Nigeria*

ACC. I.D.	HC	LS	GH	HL	HS	SP	SFC	CW	IPC	MPC	PCU
KD- 01	Green	Triangular	Indeterminate	Present	Present	Pink	Yellow	Green	Green	Pink	Curved
KD- 02	Green	Triangular	Indeterminate	Absent	Absent	Green	Yellow	Green	Green	Persistent green	Slightly curved
KD- 03	Green	Triangular	Indeterminate	Absent	Absent	Green with purple	Cream	Green	Green	Persistent green	Slightly curved
KD- 04	Green	Triangular	Indeterminate	Absent	Absent	Green	Yellow	Green	Green	Yellow	Curved
KD- 05	Green	Triangular	Indeterminate	Absent	Absent	Green	Cream	Green	Green	Yellow	Slightly curved
KD- 06	Green	Triangular	Indeterminate	Absent	Absent	Green with pink	White	Green	Green	Yellow	Slightly curved
KD- 07	Green	Triangular	Indeterminate	Absent	Absent	Green	White	Green	Green	Yellow	Curved
KD- 08	Green	Triangular	Indeterminate	Absent	Absent	Green with brown	Yellow	Green	Green	Yellow	Slightly curved
KD- 09	Green	Triangular	Indeterminate	Absent	Absent	Purple	Yellow	Green	Green	Yellow	Slightly curved
KD- 10	Purple	Triangular	Indeterminate	Absent	Absent	Purple	Lilac	Green	Green	Yellow	Curved
KD- 11	Green	Triangular	Indeterminate	Absent	Absent	Green	White	Green	Green	Yellow	Curved
KD- 12	Purple	Triangular	Indeterminate	Present	Absent	Maroon	Lilac	White	Green	Maroon	Slightly curved
KD- 13	Green	Triangular	Indeterminate	Absent	Absent	Green	Cream	Cream	Green	Yellow	Slightly curved
KD- 14	Purple	Triangular	Indeterminate	Absent	Absent	Purple	Cream	Green	Green	Yellow	Slightly curved
KD- 15	Purple	Triangular	Indeterminate	Absent	Absent	Purple	Cream	Green	Green	Yellow	Slightly curved
PL- 01	Green	Triangular	Determinate	Present	Present	Green	Lilac	White	Green	Yellow	Slightly curved
PL- 02	Green	Triangular	Indeterminate	Absent	Absent	Green	White	Green	Green	Yellow	Slightly curved
PL- 03	Green	Triangular	Indeterminate	Absent	Absent	Green	White	Green	Green	Yellow	Slightly curved

***HC: Hypocotyl Colour, LS: leaflet Shape, GH: Growth Habit, HL: Hairiness of Leaves, HS: Hairiness of Stem, SP: Stem Pigmentation, SFC: Standard Flower Colour, CW: Colour of Wings IPC: Immature Pod Colour, MPC: Mature Pod Colour, PCU: Pod Curvature*

***Table 3.** Qualitative Traits of Common Bean accessions from Northern Nigeria*

ACC. I.D.	HC	LS	GH	HL	HS	SP	SFC	CW	IPC	MPC	PCU
PL- 04	Green	Triangular	Indeterminate	Absent	Absent	Green	White	Green	Green	Yellow	Slightly curved
PL- 05	Green	Triangular	Indeterminate	Absent	Absent	Green	Yellow	Green	Green	Yellow	Slightly curved
PL- 06	Green	Triangular	Indeterminate	Present	Present	Green	White	Crea m	Green	Yellow	Slightly curved
PL- 07	Green	Triangular	Indeterminate	Present	Absent	Purple	Purple	White	Greem	Yellow	Slightly curved
PL- 08	Green	Triangular	Indeterminate	Absent	Absent	Purple	Yellow	Green	Green	Yellow	Slightly curved
PL- 09	Green	Triangular	Indeterminate	Present	Present	Pink	Yellow	Green	Green	Pink	Curved
PL- 10	Green	Triangular	Indeterminate	Present	Absent	Purple	Purple	Crea m	Green	Dark purple	Slightly curved
PL- 11	Green	Triangular	Indeterminate	Present	Present	Green	Purple	White	Green with purple stripes	Pale yellow with purple stripes	Straight
PL- 12	Green	Triangular	Indeterminate	Absent	Absent	Green with brown	Cream	Green	Green	Yellow	Slightly curved
PL- 13	Green	Triangular	Indeterminate	Absent	Absent	Green	White	Green	Green	Yellow	Slightly curved
PL- 14	Green	Triangular	Indeterminate	Absent	Absent	Green	White	Green	Green	Yellow	Slightly curved
TA- 01	Green	Triangular	Indeterminate	Present	Present	Pink	Yellow	Green	Green	Pink	Curved
TA- 02	Green	Triangular	Indeterminate	Absent	Absent	Purple	Yellow	Green	Green	Yellow	Slightly curved
TA- 03	Green	Triangular	Indeterminate	Absent	Absent	Green	Yellow	Green	Green	Yellow	Slightly curved
KG-01	Green	Lanceolate	Indeterminate	Absent	Absent	Green/Pink	White	Green	Green	Green with brown	Straight

******HC: Hypocotyl Colour, LS: leaflet Shape, GH: Growth Habit, HL: Hairiness of* Leaves, HS: Hairiness of Stem, SP: Stem Pigmentation, SFC: Standard

Hierarchical clustering of the accession of common bean

Results in the hierarchical cluster analysis on quantitative traits is presented in Fig. 1. The clustering of *Phaseolus* accessions at a genetic distance of forty eight, produced eleven distinct clusters. Cluster 1 comprises of KD-12, PL-06, PL-01 and PL-11. KD- 12 and PL- 06 showed similarities in traits such as, days to flowering and number of seeds per pod while PL-01 and PL-11 showed similarity in the days to flowering, number of days to maturity and in most yield parameters.

Cluster 2 comprised of a single accession which was PL-07. Cluster 3 comprised of eight accessions which were KD-04, TA-03, PL-08, TA-02, PL-12, PL-09, KD-01 and TA-01. KD- 04 and TA- 03 clustered together showing similarity in one hundred seeds weight and plant height at maturity. PL- 08 and TA- 02 were clustered together showing a close neighbors and possess a higher level of similarity, compared to other accessions. At a genetic distance of forty eight, PL- 09, KD- 01 and TA- 01 clustered together and showed similarity in days to flowering, days to maturity, plant height at maturity, pod length and number of pods per plant. Cluster 4 is made up of a total of six accessions comprising of KD-06, PL-13, KD-09, PL-04, PL-05 and PL-07. Only a single accession is found in cluster 5 which is PL-10. Five accessions consisting of KD-10, KD-11, KD-13, KD-02 and KD-14 made up cluster 6. KD-05 and PL-03 were found in cluster 7. One accession, KD-07 was found in cluster 8. Cluster 9 comprised of two accessions which were KD-08 and KG-01 with both showing similarity in the number of days to maturity. PL-14 was the only accession in cluster 10 while cluster 11 had two accessions which were KD-03 and KD-15, and showed similarity in some quantitative traits which includes days to maturity, pod width and one hundred seed weight.

The hierarchical cluster analysis help to group accessions into clusters based on the similarity existing among the germplasm, irrespective of their place of collection.

The clustering of thirty three accessions of common bean into eleven clusters implies that each accession clustered together in a group, possess similarity in one quantitative trait or the other. This is in line with the findings of Xhulaj [24] that reported thirty accessions of *Phaseolus vulgaris* grouped into seven clusters based on similarity in their quantitative traits. Loko *et al*. [17] also reported a similar trend in *Phaseolus vulgaris*, where fifty accessions of beans were grouped into eight different clusters with each cluster containing accessions that are similar in quantitative and qualitative characters.

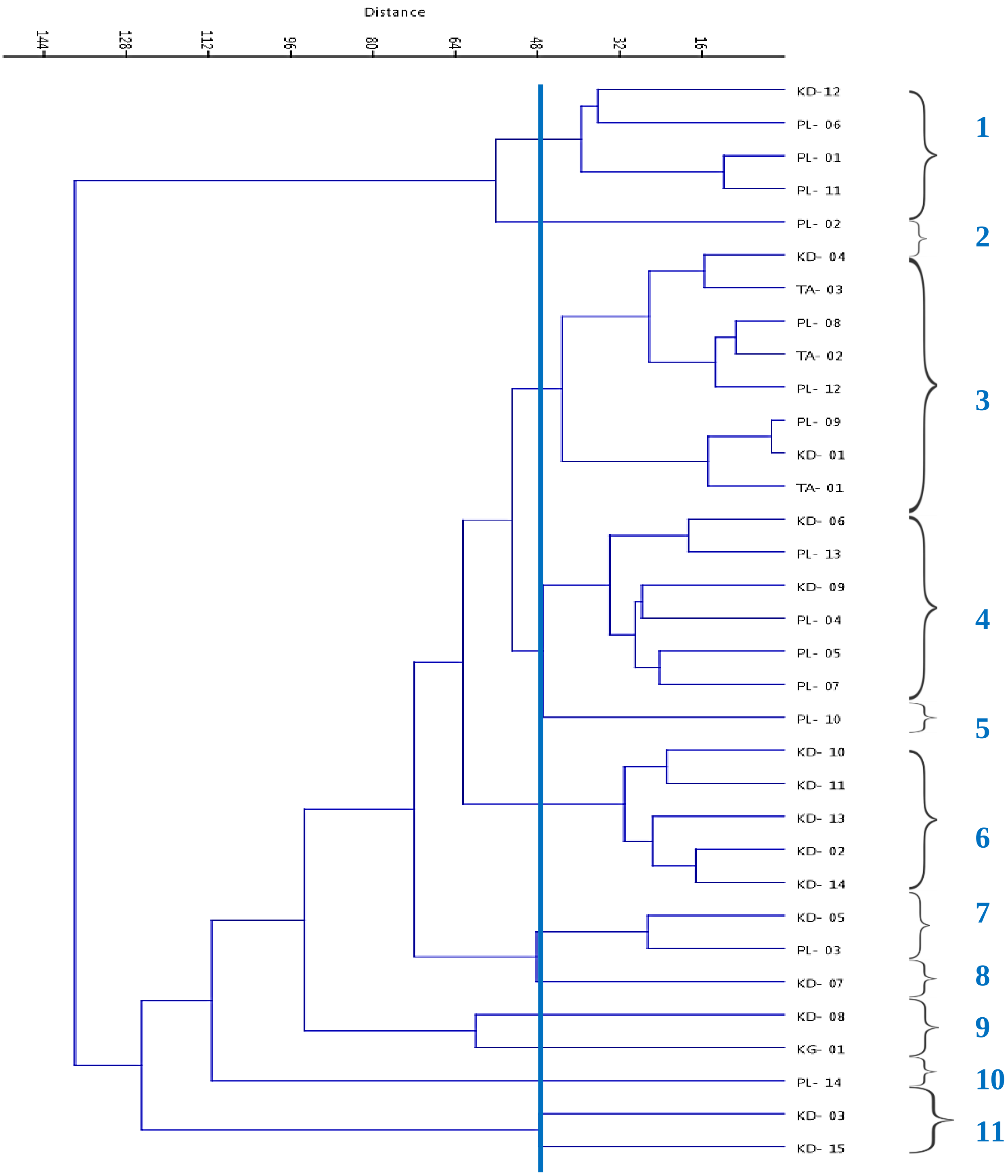

Fig. 1. *Paired group dendrogram based on 9 quantitative traits for 33 Common Bean accessions*

CONCLUSION

Among the common bean accessions of this study, differences existed in their agro morphological performance, and this suggested the diversity in their genetic makeup. The agro morphological studies showed that PL-01 and PL-11 had the lowest number of days to flowering and maturity and hence can be exploited for production of early maturing varieties. Number of pods per plant was highest in KD-14, hence it can be explored for the production of high yielding varieties. KG-01 had the highest pod length and number of seeds per pod, therefore it can be harnessed for the production of high yielding varieties. KD-11 had the highest weight of one hundred seeds. Strong positive correlations were observed among the descriptors such as days to flowering with days to maturity (r = 0.73), pod beak length with pod length (r = 0.64) and pod length with number of seeds per pod (r = 0.79). There is need for further studies to evaluate the characterized accessions over a period of two or more years in different locations across Nigeria to see if similar observations will be made.

Conflict of Interest. The authors declared that there is no conflict of interest.

Authorship Contributions. Concept: V.O.I, O.A.F., Design: V.O.I., O.A.Y.D, Data Collection or Processing: A. A., O.A.Y.D., Analysis or Interpretation: A. A., O.A.Y.D., Literature Search: V.O.I, O.A.F., Writing: V.O.I.

Financial Disclosure. This research received no grant from any funding agency/sector.

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