Journal of Genetics, Genomics & Plant Breeding 10(2)61-69
ISSN (Online): 2581-3293 10.63551/jggpb.vol.10.issue02.001

RESEARCH ARTICLE

Morphological assessment and genetic analysis of robusta coffee accessions

R.T.1. Feyisola[1], A.F. Adepoju[2], M. Baba Nitsa[3], I.A. Adenikan[1], Y.P. Ayoade[1], S.C. Dimonyejiaku[1], S.T. Balogun[2]

1. **Department of Plant Science, Olabisi Onabanjo University, P.M.B.2002 Ago-Iwoye, Ogun State, Nigeria**
2. **Crop Improvement Division Cocoa Research Institute of Nigeria, P.M.B.5244, Ibadan, Oyo State, Nigeria**
3. **Department of Agronomy, University of Abuja P.M.B. 117 Giri, Airport Road Abuja, Nigeria**

Manuscript received: October 1, 2025
Decision on manuscript: October 12, 2025
Manuscript accepted: October 15, 2025

✉ **bmohammed241@yahoo.com**

Abstract

This study was carried out at the Cocoa Research Institute of Nigeria, Ibadan, during the 2024 rainy season to evaluate variability among coffee accessions using important morphological traits. The experiment was laid out in a randomized complete block design with three replications. Data were collected on seven morphological characters associated with plant growth and berry attributes. Significant variation was observed in fruit shape, with 50% of the accessions producing roundish fruits, while the remaining accessions showed fruit shapes ranging from obovate to elliptic. Likewise, about 70% of the accessions produced mature berries with orange-red coloration. Principal component analysis revealed that PC1 to PC4 recorded cumulative factor loadings of 0.614%, contributing significantly to the variability detected among the ten accessions. High phenotypic coefficient of variation values were recorded for plant height at first branch (88.17%), berry weight (49.76%), seed weight (27.33%), and number of plagiotropic branches (41.60%). Similarly, high genotypic coefficient of variation values were observed for plant height at first branch (69.02%) and number of plagiotropic branches (30.94%). The findings demonstrated substantial genetic variability useful for future coffee breeding and selection programmes. The observed diversity among the evaluated accessions suggests the presence of valuable genetic resources that can enhance breeding efficiency, productivity, adaptability, and long-term improvement of coffee germplasm programs.

Keywords: Coffee, variability, berries, breeding, germplasm

Introduction

Coffee (*Coffea spp*.) is one of the most economically important cash crops consumed globally (Alli *et al.,* 2021). Robusta coffee (*Coffee canephora*) is the most cultivated species of Coffee in most African countries due to its adaptability to different environmental conditions and resistance to major pests and disease (Davis *et al.,* 2006). *Coffea canephora*, commonly known as Robusta coffee, contributes to more than 40% of the world's coffee production. It serves as a means of livelihood for millions of coffee farmers and contributes to the economies of developing nations (Ma'ruf *et al.,* 2025). In Nigeria, coffee production has been experiencing a continuous decline dated many years ago due to poor growth and yield of the coffee trees, inadequate farmer training in modern agricultural practices, limited government intervention and support, restricted access to quality agricultural inputs such as improved coffee seedlings and insufficient capital in addition to planting of poor yielding varieties (Mustopha *et al.,* 2022). In 2017, about 159.66 million bags (60 kg capacity) of coffee were produced globally of which Arabica accounts for 97.43 million bags (61%) and Robusta 62.23 million bags (39%), respectively (International Coffee Organization, 2023). Coffea depends on cross-pollination for fertilization and fruit production and as such, Robusta coffee is of high genetic diverse species than Arabica species that are of narrow genetic base (Baba Nitsa *et al.,* 2023). Genetic diversity of coffee can be assessed using different techniques ranging from the traditional morphological techniques to the modern DNA-based molecular markers. Morphological assessment of accessions with desirable morphological traits can complement genetic variability of available accessions for breeding programs (Paredes-Espinosa *et al.,* 2023). In this context, breeding a new generation of climate-smart cultivars could capitalize on the extensive genetic diversity of *C. canephora* (Andini *et al.,* 2025). The past efforts were also constrained due to a lack of adequate genetic resources in countries located outside the zone of origin of *C. canephora* in combination with political instability in some of the countries within its zone of origin (Tounekti *et al.,* 2017). Despite Nigeria's long-standing cultivation of *Coffea canephora*, national productivity remains low which is primarily due to the inadequate characterization and utilization of the crop's genetic diversity at juvenile stages thereby making farmers to identify the accession using traditional methods (Baba Nitsa *et al.,* 2020). Therefore, the objective of the study is to evaluate the morphological traits of ten selected C. canephora accessions at the juvenile growth stage.

Materials and methods

The research was carried out at the Cocoa Research Institute of Nigeria (CRIN), Ibadan, Oyo State, during the 2024 cropping season. Cocoa Research Institute of Nigeria is located at latitude 7° 12' 55" N and 3° 51' 45" E, at an altitude of 122 m above sea level, with an average annual rainfall ranging between 1200-1500 mm. The experimental materials comprised of ten (10) genetically distinct Robusta coffee plants, planted at CRIN germplasm. The selected accessions included: OMO1, IYA2, CIII, C105, T1049, M36, DST, BKB1, ABUKI, and T45. The accessions were labeled accordingly using unique codes for ease of identification during data collection. The experiment was laid out in a randomized complete block design (RCBD) with all treatments replicated three times. Each plot measured 8 m x 8 m with 9 stands of coffee plants per plot given a total plot area of 64 m2. Field maintenance was carried through out the period.

Manual weeding and pest management were carried out to ensure healthy growth and to prevent biotic stress from affecting the seedlings. Morphological traits considered include plant height to apex (cm), stem diameter (mm), number of leaves, internode length (cm), and leaf shape. Data were also taken on leaf and fruit characteristics which include leaf shape; (1 obovate, 2 ovate, 3 elliptic, and 4 lanceolate), leaf apex shape (1 round, 2 obtuse, 3 acute, 4 acuminate, and 5 apiculate), stem colour (1 light green, 2 dark green, 3 reddish, and 4 brownish/woody), leaf colour, leaf deformities (1 curling, 2 yellowing 3 spotting, 4 crinkled, and 5 blight), leaf arrangement (1 alternate, 2 opposite). All these were taken in accordance with the International Plant Genetics Resources Institute (IPGRI) descriptor for coffee species (1996). Each measurement was taken in the early morning hours due to midday transpiration. For each accession, data were collected on the three randomly selected and tagged seedlings on each plot given a total of nine observation per accession.

All data on the morphological characters of the ten *Coffea canephora* accessions were subjected to statistical analysis using the Statistical Analysis System (SAS) software, version 9.4. (2013). Pearson correlation coefficients were computed to assess the strength of the relationship between the measured traits. Furthermore, principal component analysis (PCA) was used to identify the major traits contributing to the observed morphological variability. Eigenvalues and eigen vectors were used to identify key traits influencing variation among the accessions. Characters with eigenvalues greater than 1 were considered to have a significant impact on the variability of the accessions. These analyses provided comprehensive insights into the diversity and relationships among the evaluated *Coffea canephora* accessions based on their vegetative and yield component traits. The mean values were used for genetic analysis to determine the phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) based on the formula of Sivasubramanian and Madhava (1973). This involves dividing the square root of the genotypic and phenotypic variances by the population mean and multiplying by 100. The obtained values were categorized as follows: Less than 10% = low, 10-20% = Moderate, more than 20% = High. Broad-sense heritability was determined using the formula of Singh (2001). For this study, heritability was classified into three groups according to Johnson et al. (1955). Low =30%, moderate = 30-60% and high = > 60%. Estimation of genetic advance (GA) and percentage of mean was done following the formula described by Johnson *et al.,* (1955). Genetic advance was classified as between 0% - 10% as low, 10% - 20% as intermediate, and values greater than (>20%) as high.

Results and discussion

The results in Table 1 revealed the characteristics of fruits and leaves of the ten Robusta coffee accessions studied. The results showed that of the total ten accessions, 60% of the population had acute leaf shapes, whereas the remaining 40% of the accessions indicated leaf shapes that were acuminate. This confirm the existence of diversity among the accessions studied which could be used as criterial for selection. This finding corroborates the report by Njihia *et al.,* (2025) as they reported the existence of variations in leaf shape of cowpea in germplam. The fruit shape of the ten accessions as shown on Table 1 revealed that 50% of the coffee accessions had a fruit shape that were roundish, 10% had fruit shape that were obovate, 20% of the accession showed fruit shape that looked ovate, 10% of the accessions recorded fruit shape that were elliptic and 10% of the other

Journal of Genetics, Genomics & Plant Breeding 10(2)61-69
ISSN (Online): 2581-3293 10.63551/jggpb.vol.10.issue02.001

accessions exhibited fruit shapes that were oblong respectively. The differences in the fruit characters indicated that it could be used as a criterion in the selection of coffee for an improvement program, as choices can be made based on preference. It has been observed that fruit shape has significant effects on the processing of coffee for seed production using mechanical methods and for consumption, as it affects coffee quality (Bizimungu *et al.*, 2023). This could also serve as a yardstick for selection. Matured berry colour ranges from orange-red to red colour, with 70% of the total accessions producing orange-red fruit colour. 20% of the accession produced red fruit colour, and the remaining 10% of the accessions produced fruits with red-purple colour. Adequate knowledge of mature berry colour could help in identifying the right time of harvest and also contribute to the postharvest seed quality (Bizimungu *et al.*, 2023). The accessions produced young leaf colour that ranges from 40% brownish to 10% reddish brown. The total numbers of the accessions have 70% leaf apex shapes that were apiculate, and the remaining 30% of the accessions have leaf apex shapes that were acuminate in shape.

Principal component analysis

The Principal Component Analysis (PCA) presented in Table 2 was used to determine the relative contribution of each character to the variation observed among the 10 Robusta coffee studied. The results showed that loaded PC1, PC2, PC3, and PC4 with eigenvalues greater than 1 were considered in explaining the maximum amount of variation observed among the Robusta coffee accessions. The first, second, third, and fourth Principal components accounted for 0.614% of the total variability in the data set. The other principal components load contribute a lower amount of variation in the data set. The relative discriminating power and the proportion of the variance explained by each PCA, as revealed by the eigenvalues was high in PC1 (2.77), PC2 (2.61), PC3 (1.82) and PC4 (1.38). The major contributors to variability in the PC1 were plant height at apex (0.04 cm), plant height at first branch (0.31 cm), berry weight (0.084 g), and seed weight (0.086 g). Adepoju *et al.*, (2020) stated a similar observation where it was reported that plant height was among the loading factors that contributed to the significant yield and variability. For PC2, the major contributors to the variations observed were leaf length (0.301 cm), leaf width (0.24 cm), berry weight (0.49 g), seed weight, and number of plagiotropic branches (0.33). The major characters that contributed to the variations observed in PC3 were leaf length (0.47 cm), leaf width (0.40 cm), and leaf apex shape (0.40). Numbers of plagiotropic branches (0.33), fruit shape (0.35), and young leaf colour (0.33) were the characters that contributed to the variations observed. This indicates that number of plagiotropic branches could contributed significantly to variation, and can be used as selection index for coffee improvement (Tounekti, *et al.*, 2017; Baba Nitsa *et al.*, 2020).

The result in Figure 1 shows the closeness between Principal Component 1 and Principal Component 2 in the scatter graph. The clustering of characters in the scatter graph showed how such characters were close. The scattered characters indicated that such characters were not related. In PC1, only the view characters were closed, whereas PC2 had more closely related characters. From the loading output, the characters that are close to each other have similar performance. Indicating that related variables have a similar contribution to the variability observed in each principal component. This clustering pattern aligns with the report of Adepoju *et al.*, (2020). The correlation results showed a

Journal of Genetics, Genomics & Plant Breeding 10(2)61-69
ISSN (Online): 2581-3293 10.63551/jggpb.vol.10.issue02.001

Table 1: Fruit and leaf characters of robusta coffee accessions

Qualitative traits characteristics	Score	Description	Total number of accessions	Frequency (%)
Leaf shape	3	acute	6	60
	4	acuminate	4	40
Fruit shape	1	roundish	5	50
	2	obovate	1	10
	3	ovate	2	20
	4	elliptic	1	10
	5	oblong	1	10
Mature berry colour	4	Orange-red	7	70
	5	red	2	20
	6	Red-purple	1	10
Young leaf colour	3	brownish	4	40
	1	greenish	3	30
	2	green	2	20
	4	Reddish brown	1	10
Leaf apex shape	5	apiculate	7	70
	4	acuminate	3	30

Table 2: Principal component analysis

Characters	PC1	PC2	PC3	PC4
Plant height at first branching (cm)	0.30	-0.33	-0.09	-0.23
plant height at apex (cm)	0.05	-0.15	-0.30	-0.46
Stem diameter (mm)	-0.22	0.22	-0.35	-0.18
Leaf length	-0.14	0.30	0.47	-0.29
Leaf width	-0.32	0.24	0.40	-0.07
Berry weight	0.08	0.49	-0.02	-0.70
Seed weight	0.09	0.49	-0.19	-0.12
Number of plagiotropic branches	-0.03	0.24	-0.39	0.33
Leaf shape	-0.43	-0.17	0.03	0.11
Fruit shape	-0.28	0.10	-0.11	0.35
Immature berry Colour	0.43	0.19	-0.01	-0.06
Mature berry Colour	0.15	-0.12	0.20	0.49
Young leaf Colour	0.37	0.23	-0.02	0.33
Leaf apex shape	0.33	0.01	0.40	-0.01
Eigenvalue	2.77	2.61	1.82	1.38
Difference	0.15	0.79	0.43	0.05
Proportion (%)	0.19	0.18	0.13	0.09
Cumulative (%)	0.19	0.38	0.51	0.61

significant relationship among some traits studied. The result in Table 3 indicated a significant positive relationship between leaf width and leaf length (r= 0.68).

Similarly, seed weight and berry weight correlate positively (r=0.73). This result is in accordance with the reports by Ebunola et al. (2026), as they reported a positive correlation between leaf length, broadness of leaves, and number of branches. Coffee seed weight correlated positively with coffee berry weight (r=0.20). This indicated that increase of the two variables are in the same direction. Other characters did not correlate with each other.

The results of genetic analysis on plant characters, as presented in Table 4, revealed that the value of phenotypic variance was higher than that of genotypic variance in all the traits. This implies the effects of environmental influence on the characters. Similarly, the phenotypic coefficient of variation (PCV %) values for some characters were higher. This includes plant height at first branch (88.17%), berry weight (49.76%), seed weight (27.33%), and number of plagiotropic branches (41.60%). The genotypic coefficient of variation (GCV %) was high on some traits like plant height at first branch (69.02%) and number of Plagiotropic branches (30.94%), whereas berry weight (17.06%) and stem girth (11.98%) showed moderate GCV% values, and dried seed weight (2.75%) recorded low genotypic coefficient of variation. Similar findings were observed by Baba Nitsa accessions (2021), with dried coffee seed weight indicating a low GCV% of 9.35%. Heritability in broad sense was generally low in all the characters studied. Genetic gain relies on the ability of heritable traits, which gives confidence in phenotypic trait values for selection. Based on these results, low heritability suggests that the traits are not heritable. Genetic advance was low in dried seed weight (0.25%) and number of plagiotropic branches (0.57%). These findings corroborate the observation by Baba Nitsa accessions (2021) as they reported low genetic advance (0.11%) in dried coffee seeds. Genetic advanced as mean indicated high genetic advance in plant height at apex (111.27%) followed by stem girth (17.44%) with moderate genetic advance as mean. This gives high confidence in the selection intensity.

Figure 1: Scatter plot graph between principal component 1 and 2

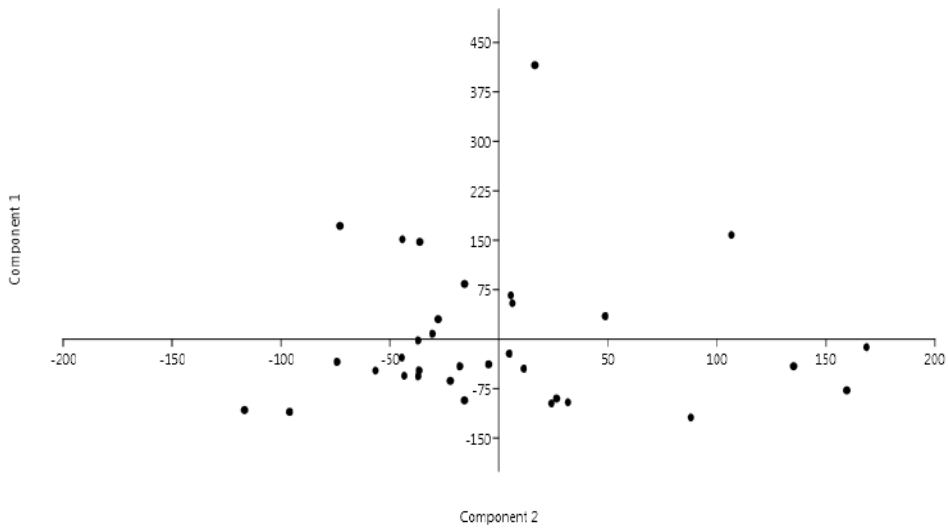

Table 3: Correlation coefficients

	Plant height to apex	Leaf number	Stem girth	Leaf length	Leaf width	Berry weight	Seed weight	Number of plagiotropic branches
Plant height to apex	1							
Leaf number	0.34ns	1						
Stem girth	-0.27ns	0.01ns	1					
Leaf length	-0.30ns	-0.11ns	0.08ns	1				
Leaf width	-0.35ns	-0.26ns	0.10ns	0.68**	1			
Berry weight	-0.26ns	0.01ns	0.03ns	0.31ns	0.17ns	1		
Seed weight	-0.35ns	0.07ns	0.18ns	0.18ns	-0.03ns	0.73**	1	
Number of plagiotropic branches	-0.21ns	0.02ns	0.27ns	-0.23ns	0.01ns	0.36ns	0.24ns	1

Table 4: Estimation of genetic parameters on growth characters

Traits	Mean	PV	GV	EV	PCV (%)	GCV (%)	ECV	H^2 (Broad sense)	Genetic advance (5 %)	Genetic advance as mean (5 %)
Plant height to apex	14.24	157.5	96.5	61.0	88.1	69.0	95.0	0.6	15.8	111.2
Leaf number	253.18	1726.4	168.4	1558.0	16.4	5.1	27.0	0.0	8.3	3.3
Stem girth	18.51	9.8	4.9	4.9	16.9	11.9	20.7	0.5	3.2	17.4
Leaf length	8.62	1.2	-3.1	4.4	5.5	8.6	17.7	-2.4	-5.7	-27.8
Leaf width	120.72	0.4	-0.5	0.9	7.3	8.5	19.4	-1.3	-1.7	-20.3
Berry weight	43.59	3608.2	-424.1	4032.3	49.7	17.0	91.1	-0.1	-14.5	-12.0
Seed weight	16.42	141.9	1.43	140.4	27.3	2.7	47.1	0.0	0.2	-47.4
Number of plagiotropic branches		46.6	-25.8	72.5	41.6	30.9	89.8	0.5	0.5	-47.4

References

1. Adeleke, S., Nitsa, M.B., Oloyede, A. and Ogunjirin, O. 2023. Mechanical methods of coffee processing for large-scale seed production. World Academic J. Eng. Sci., 10(4):1-7.
2. Adepoju, A.F., Adenuga, O.O., Dada, K.E., Odey, C.F., Balogun, S.T. and Nitsa, M.B. 2020. Association and interrelationship of yield and agronomic characters in coffee (*Coffea sp.* L.). J. Plant Breed. Crop Sci., 12(4):299-309.
3. Alli, M.A., Adesanya, K.A., Agboola-Adedoja, M.O., Adelusi, A.A., Ogunwolu, Q.A., Ugwu, C.A. and Akinpelu, A.O. 2021. Review on coffee research and production in Nigeria in the last one decade (2009-2018). World J. Adv. Res. Rev., 9(1):31-36.
4. Andini, R., Zaelani, A., Sulaiman, M.I., Sembiring, E.R., Jaya, R., Gusain, M., Bhanot, D., Morghade, R.S., Gaafar, A.R.Z., Azis, A. and Widayat, H.P. 2025. Genetic diversity of cultivated Gayo Arabica coffee (*Coffea arabica* L.) based on morphological and microsatellite markers. BMC Plant Biol., 25(1):990.
5. Baba Nitsa, M., Chukwunweike, A., Odiyi, B., Akinyele, O.B., Aiyelari, O.P. and Fayeun, L.S. 2023. Genetic diversity of robusta coffee (*Coffea canephora* Pierre ex A. Froehner) using EST-SSR markers. J. Plant Mol. Breed., 11(1):17-27.
6. Baba Nitsa, M., Odiyi, A.C., Akinyele, B.O., Aiyelari, O.P., Dada, K.E., Fayeun, L.S., Anagbogu, C.F., Idrisu, M. and Ugioro, O. 2020. Phenotypic diversity studies of coffee (*Coffea canephora* Pierre ex. Froehn) landrace accessions and an accession from germplasm using morphological markers. Inter. J. Plant Breed. Genet., 7(10):1-7.
7. Baba Nitsa, M., Olasupo, F.O., Muyiwa, A.A., Idrisu, M., Olaniyi, O.O., Adepoju, A.F. and Ugioro, O. 2021. Genetic analysis of the seeds characteristics and plant growth habit of robusta coffee (*Coffea canephora* P. ex Fr.) accessions. In: Proceedings of the 39th Annual Conference of the Horticultural Society of Nigeria (HORTSON), CRIN 2021: The role of horticulture in food security and health in the era of climate change and COVID-19 pandemic, November 14-18, 2021, pp. 731-737.
8. Bizimungu, G., Ahouansou, R.H. and Semassou, G.C. 2023. Physical and mechanical properties of Arabica coffee (*Coffea arabica* L.) cherries and beans in Rwanda. Food Res., 7(5):283-296.
9. Davis, A.P., Govaerts, R., Bridson, D.M. and Stoffelen, P. 2006. An annotated taxonomic conspectus of the genus Coffea (Rubiaceae). Botanical J. Linnean Soci., 152:465-512.
10. Ebunola, T.E., Olawuyi, O.J., Odey, C.F., Askira, H.M. and Nyamkume, T.F. 2026. Phenotypic characterization of some Nigerian Coffea species using morphological characters. World J. Adv. Res. Reviews, 29(3):367-380.
11. Hamon, P., Grover, C.E., Davis, A.P., Rakotomalala, J.J., Raharimalala, N.E., Albert, V.A., Sreenath, H.L., Stoffelen, P., Mitchell, S.E., Couturon, E. and Hamon, S. 2017. Genotyping-by-sequencing provides the first well-resolved phylogeny for coffee (Coffea) and insights into the evolution of caffeine content in its species. Mol. Phylogenet. Evo., 109:351-361.

12. Ma'ruf, M.I., Ngo, D.M., Bacsi, Z. and Bozsilk, N. 2025. Evaluating the competitiveness of leading coffee-producing nations: A comparative advantage analysis across coffee product categories. Open Agri., 10(1):1-17.
13. Mustopha, F.B., Adesanya, K.A. and Aremu-Dele, O. 2022. Production trend of coffee in Nigeria: A review. World J. of Adv. Res. Reviews, 13(3):137-146.
14. Njihia, J.N., Muray, M.M. and Njogu, M.K. 2025. Characterization, evaluation and diversity studies of Cowpea germplasm (*Vigna unguiculata* L.). J. Genet., Genom. and Plant Breeding, 9(3):74-83.
15. Olaniyi, O.O., Kehinde, O.B., Oloyede, A.A., Adenuga, O.O., Ayegboyin, K.O., Mapayi, E.F., Nitsa, M.B., Sulaimon, F.O. and Ebunola, T.E. 2021. Variability analysis of some genotypes in Nigeria tea (*Camellia sinensis*) germplasm. World J. Adv. Res. and Reviews, 9(1):50-61.
16. Paredes-Espinosa, R., Gutiérrez-Reynoso, D.L., Atoche-Garay, D., Mansilla-Córdova, P.J., Abad-Romaní, Y., Girón Aguilar, C., Flores-Torres, I., Montañez-Artica, A.G., Arbizu, C.I., Guerra, C.A. and Quintana, J.L.M. 2023. Morphological characterization and diversity analysis of *Coffea arabica* germplasm collection from INIA, Peru. Crop Sci., 63(5):2877-2893.
17. Tounekti, T., Mahdhi, M., Al-Turki, T. and Khemira, H. 2017. Genetic diversity analysis of coffee (*Coffea arabica* L.) germplasm accessions growing in southwestern Saudi Arabia using quantitative traits. Natu. Res., 8:321-336.