International Journal of Agricultural Technology 2026 Vol. 22(4):1935-1954
DOI: https://doi.org/10.63369/ijat.2026.22.4.1935-1954
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Exploration and morphological characteristics of Robusta Coffee in Bengkulu

Sridanti, I. L.[1*], Ganefianti, D. W.[2], Alnopri[2] and Herawati, R.[2]

[1]Doctor Program of Agriculture Science, University of Bengkulu. Jl. W.R. Supratman Bengkulu 38121 Indonesia; [2]Department of Crop Production, Faculty of Agriculture, University of Bengkulu.Jl. W.R. Supratman Bengkulu 38121 Indonesia.

Sridanti, I. L., Ganefianti, D. W., Alnopri and Herawati, R. (2026). Exploration and morphological characteristics of Robusta Coffee in Bengkulu. International Journal of Agricultural Technology 22(4):1935-1954.

Abstract The results of the exploration of robusta coffee from the mid- and highlands of Bengkulu (700-1200 m above sea level) are produced 24 robusta coffee accessions. All robusta coffee accessions can be characterized because the overall data on the plants (trees, branches, leaves, flowers, fruits, and seeds) can be observed. The results of the morphological characterization of the 24 coffee accessions produced dissimilarity coefficients ranging from 0.0 to 0.25. Based on the dendrogram, the highest dissimilarity coefficient was obtained in group 2 at 0.25, while the lowest was in group 1 at 0.23. Group 1 consisted of 23 accessions, namely SNTR3, SGR, SNTR1, MRD, TJA, LBR, PCU, LNU, BKO, AUG, BRT, THM, TLS, RBP, SHNC, MKR, SBS, CRQ, CRP, SNTR2 TPS CRR, and ERG. The accessions in group one had a dissimilarity of 0.23 (similarity of 0.77). This group had similarities in the angle of insertion of the primary branches on the main stem (semi-erect) and seed color (brown). Group 2 consisted of only one accession, namely TUR. In group 2, the similar characteristics are leaf shape (obovate), seed color (yellow), and seed shape (elliptical). Group 2 does not share any similarities with group 1 in terms of ripe fruit color (black), whereas group 1 has yellow-orange, orange, and red colors, and flowering on old wood is present, whereas group 1 does not meet these characters

Keywords: Robusta, Coffee, Character, Morphology

Introduction

Indonesia is the fourth largest coffee producer in the world and the third largest producer of robusta coffee (SCOPI, 2024). The largest coffee-producing regions in Indonesia are South Sumatra Province, Lampung Province, and Bengkulu Province, which are referred to as the coffee triangle region. Coffee cultivation in Indonesia is still concentrated in the highlands. According to BPS (2024), the area of lowland coffee plantations in Indonesia is 2,000 ha, while the area of highland coffee plantations has reached 77,000 ha. Bengkulu Province is located on the west coast of Sumatra Island, stretching from north to south

* **Corresponding Author**: Sridanti, I. L; **Email:** irmalisasridanti@gmail.com

between the Bukit Barisan Mountains and the Indian Ocean. The eastern part of Bengkulu has highlands, while the western part is lowlands. The total administrative area of Bengkulu Province is approximately 19,919.33 km2 (BPS. 2024), with an area of medium to high altitude (400-2000 meters above sea level) covering 5,450.74 km2, of which 72.11% is coffee plantation area. while the lowland area (0-400 m asl) covers 14,468.59 km2, of which only 23.71% is coffee plantation area. Based on this land distribution data, Bengkulu Province has the potential to develop Robusta coffee by expanding the coffee plantation area in the lowlands (Muhie, 2022).

Strategies for developing robusta coffee in Bengkulu include cultivating robusta coffee at various altitudes (Rodriguez-Camayo *et al.,* 2024; Campuzano-Duque and Blair 2022; Kath *et al.*, 2021). Adapting to agroclimate and developing adaptive robusta coffee in lowland areas (González *et al*., 2024; Abdelwahab *et al.,* 2024). This expansion is also one of the steps in plant breeding efforts. The goal of plant breeding is to provide and protect genetic diversity as the basis for producing new superior varieties (Guadalupe *et al*., 2024), to identify resistance genes in plants that are virulent to H. Vastatrix (Maniah *et al*., 2024), and to provide genes for coping with natural abiotic stresses (Sari *et al*., 2023). On the other hand, Zaidan *et al*. (2025) state that coffee cultivation is now also important as a concept of coffee conservation, a view supported by Iglesias *et al*. (2025) and Martinelli *et al*. (2025), who emphasize the concept of coffee cultivation prioritizing environmental conservation. Coffee cultivation is not only for economic gain, but also a form of concern for production and the products consumed by the community (Olsen *et al*., 2025; Nakayama *et al*., 2025). The stages of plant breeding to produce plants with superior characteristics begin with recording and grouping plants based on characteristics observed through exploration and characterization (Núñez *et al*., 2025). The importance of exploring and characterizing robusta coffee plants is an effort to maintain biodiversity (Diniz *et al.,* 2025), optimize the potential of plant genetic resources (Ngugi and Alukal, 2019), and strengthen sustainable agriculture in climate change mitigation (Cassamo *et al*., 2023).

Exploration is the activity of searching for and collecting data, followed by identification, characterization, and documentation (Núñez *et al*., 2024). Plants discovered during exploration can become a source of germplasm and produce new superior varieties (Akpertey *et al*., 2022a; Koryati *et al*., 2022). Morphological and physiological characterization is important in identification because it affects the growth and development of robusta coffee in the selection of superior clones (Nurmayanti *et al*., 2025). Kinship analysis is conducted to determine the closeness of the relationship (similarity) between various robusta coffee samples based on their morphological characteristics (Camarillo *et al*., 2025). Kinship based on morphological traits is used for recognition and to display similarities within species (Ganefianti *et al*., 2025). The study by Unto *et al*. (2025) identified and characterized 45 local coffee accessions from the southern part of Seram Island. A similar study was conducted by Siahanan *et al*. (2024), which produced morphological diversity in plants and found distinguishing characteristics between robusta coffee samples in the Gunung Karang area. The research by Rahman *et al*. (2023) grouped accessions based on the similarity of qualitative and quantitative characteristics from the morphological characterization of robusta coffee in Kepahiang and Rejang Lebong. Giles *et al*. (2019) reported significant differences between 30 Coffea sp. genotypes for all morphological characteristics characterized. The greater the distance between samples, the smaller the similarity between samples (Guambi *et al*., 2024; He *et al*., 2024). his study aims to examine the morphological diversity of Robusta coffee plants in Bengkulu Province, which originate from mid- to high-altitude areas. The expected results will provide information on the cultivation areas of Robusta coffee in mid- to high-altitude areas (400-1200 m asl), the characteristics of Bengkulu Robusta coffee, and the grouping of similarity levels among the observed Robusta coffee accessions. Objectives of the study was to identify Robusta coffee distribution, characterize its morphological traits, to analyze diversity and group accessions, and to provide baseline data for breeding, conservation and development in Bengkulu Province.

Materials and methods

This research was conducted using exploratory and descriptive survey methods consisting of secondary and primary data collection to characterize the morphology of local Robusta coffee plants (*Coffea canephora).* This research was conducted in Kepahiang district, Rejang Lebong district, Kaur district, Lebong district, Seluma district, and North Bengkulu district. The research was conducted from July 2023 to March 2024. The tools used in the research were cameras, writing instruments, measuring tapes, GPS (Global Positioning System) Maps, altimeter applications to measure altitude, passport labels, rulers, calipers, medium and small plastic clips, and sticky notes. The materials used were local Robusta coffee plants at the research site. Local robusta coffee plant samples. The local robusta coffee plant samples used were local coffee plants that had been cultivated for generations.

The technique used in sampling for this study was purposive sampling, with specific criteria, namely a stem diameter of approximately 10–15 cm, a plant height of 2 m to more than 7 m, having borne fruit, and coffee plants that were still productive. Morphological characterization of plants at each research location took 3 samples, resulting in a total of 120 Robusta coffee plant samples. Observations of the morphological characteristics of local Robusta coffee plants were based on the coffee plant characterization guidelines from *Descriptors for Coffee* (IPGRI, 1996) and Plant Morphology (Tjitrosoepomo, 2011). Qualitative characterization consisted of plant stature, estimated visual plant height, vegetative development, angle of primary branch insertion on the main stem, leaf shape, leaf tip shape, young leaf color, mature leaf color, leaf stalk color, flower color, flower position, flowering on old branches, ripe fruit color, fruit shape, seed color, and seed shape. Meanwhile, the quantitative characteristics observed are: plant height, stem diameter, leaf length, leaf width, leaf stalk length, flower stalk length, corolla tube length, number of petals per flower, number of stamens per flower, fruit length, fruit width, seed length, seed width, weight of 100 wet seeds, and weight of 100 dry seeds. All data will be statistically analyzed using cluster analysis. Kinship or group analysis using PBSTAT-CL version 2.1 was used to group accessions with high morphological similarity and displayed in the form of a dendrogram.

Results

Research location

Exploration results from various altitudes (300-1200 m above sea level) in Bengkulu Province have produced 24 robusta coffee accessions. At an altitude of 300-400 m above sea level (lowlands), 5 accessions were produced (MRD, LNU, TJA, PCU, TLS). At an altitude of > 400 to 800 meters above sea level (mid-altitude), 11 accessions were produced (LBR, RBP, BRT, SGR, SHNC, CRR, CRP, CRQ, SBS, AUG, THM). Furthermore, there are 8 accessions found in highlands (>800 meters above sea level) (TPS, MKR, BKO, SNTR1, SNTR2, SNTR3, TUR, ERG) (Table 1) and (Figure 1).

Table 1. Locations of 24 Bengkulu Robusta Coffee Accessions

Elevation (m asl)	Accession Code	Location
0 – 400	MRD, LNU, TJA, PCU, TLS	Muara Dua, Linau, Nasal, Tanjung Aur, Padang capo Ulu, Talang Sebaris
400 – 800	LBR, RBP, BRT, SGR, SHNC, CRR, CRP, CRQ, SBS, AUG, THM	Rimbo Pengadang, Batu Roto, Seguring, Bukit Sari, Sumber Sari, Bukit Sari, Tanah Hitam
800 – 1200	TPS, MKR, BKO, SNTR1, SNTR2, SNTR3, TUR, ERG	Topos, Mangkaurajo, Bengko, Suku IV Menanti, Tugu Rejo

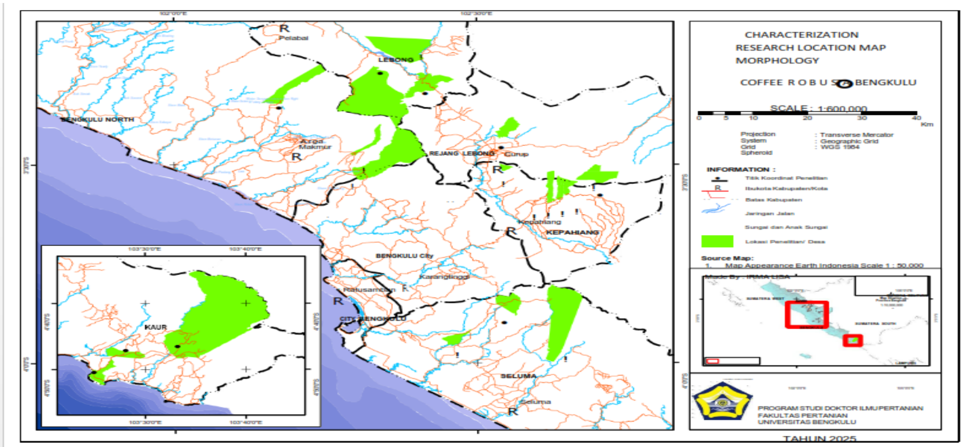

Figure 1. Robusta Coffee Plant Exploration Locations in Bengkulu

Morphological characterization of Bengkulu Robusta coffee

Tree morphology

The results of the characterization of 24 accessions showed tall and short tree characteristics, where there are 14 tall accessions (CRP, CRR, CRQ, SBS, SNTR2, SNTR3, SHNC, BKO, THM, BRT, AUG, PCU, LBR, LNU), and 10 short-character accessions (ERG, TUR, SNTR1, SGR, MKR, TPS, TLS, TJA, MRD) (Figure 2).

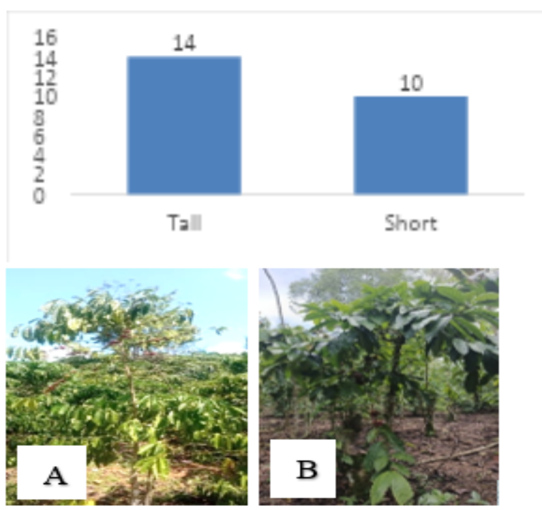

Figure 2. Tree Characteristics of 24 Bengkulu Robusta Coffee Accessions; (A) Tall (B) Short

The primary stem insertion angle characteristic consists of 3 characteristics, namely semi-upright, semi-upright drooping, and horizontal. Whereas for the semi-erect character there are 9 accessions (CRP, CRR, CRQ, BKO, PCU, LBR, TJA, LNU, MRD), 7 accessions have the semi-erect drooping character (SBS, ERG, TUR, THM, BTR, AUG, TLS) and 8 accessions have the horizontal character (SNTR1, SNTR2, SNTR3, SHNC, SGR, MKR, TPS, RBP) (Figure 3).

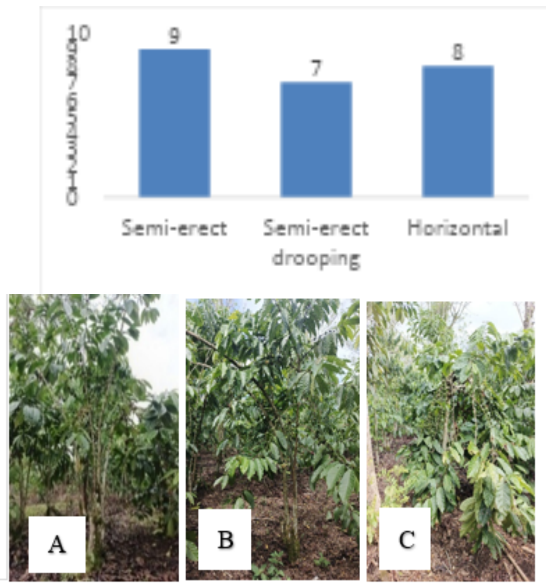

Figure 3. Primary Stem Insertion Angle Characteristic in the Main Stem of 24 Bengkulu Robusta Coffee Accessions; (A) Semi-Erect (B) Semi-erect drooping (C) Horizontal

Leaf morphology

Leaf characterization includes leaf shape and leaf tip characteristics. Leaf shape characteristics include 3 forms: obovate, lanceolate, and elliptical. 17 accessions produced an obovate shape (CRP, CRQ, SBS, ERG, SNTR3, SHNC, BKO, RBP, THM, BRT, AUG, PCU, LBR, TLS, TJU, LNU, MRD), lanceolate shape in 2 accessions (CRR and TUR), and elliptical shape in 5 accessions (SNTR1, SNTR2, SGR and TPS, CRR) (Figure 4).

The leaf tip character produces acute and apiculate shapes. Four accessions (CRP, CRQ, SNTR3, and SHNC) have acute leaf tips, while 20 accessions (CRR, SBS, ERG, TUR, SNTR1, SNTR2, BKO, SGR, MKR, TPS, RBP, THM, BTR, AUG, PCU, LBR, TLS, TJA, LNU, and MRD) (Figure 5).

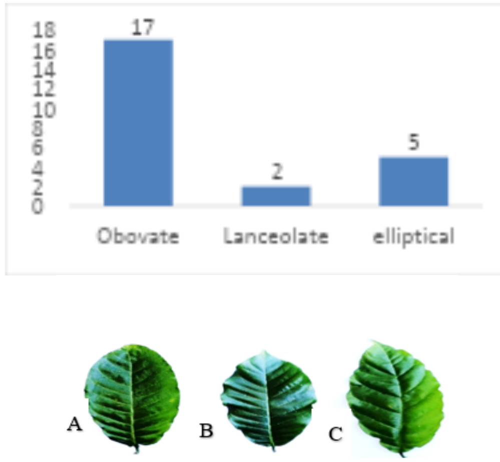

Figure 4. Leaf Shape Characteristics of 24 Bengkulu Robusta Coffee Accessions; (A) Obovate, (B) Lanceolate, (C) Elliptical

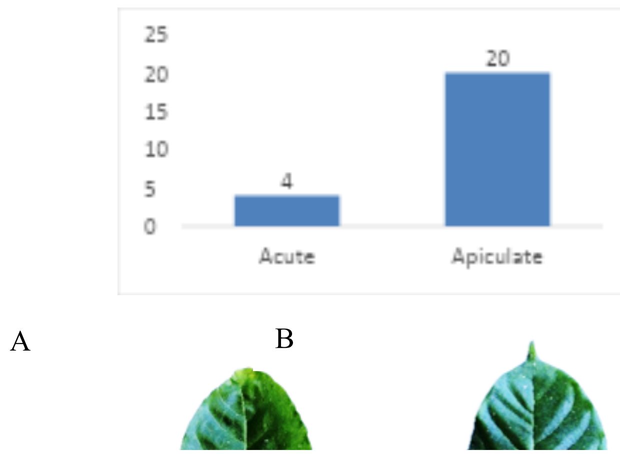

Figure 5. Leaf Tip Shape Characteristics of 24 Bengkulu Robusta Coffee Accessions; (A) Acute, B) Apiculate

Flower morphology

Flower characterization includes flower position, flower color, and flowering on old stems. The flower position and color characteristics of the 24 Bengkulu Robusta coffee accessions are the same, namely flower position in the leaf axils and white flowers. Meanwhile, the flowering characteristic on old stems is only found in the TUR accession (Figure 6).

Figure 6. Flower Characteristics of 24 Robusta Coffee Accessions; Flower Position (A), Flower Color (B), and Flowering on Old Stems (C) Fruit and Seed Morphology

Fruit shape characterization resulted in roundish, obovate, ovate, elliptical, and oblong shapes. Roundish shape was found in 4 accessions (CRP, CRR, ERG, TUR), obovate in 4 accessions (TPS, THM, PCU, TJU), ovate in 3 accessions (SNTR1, SNTR3, SGR), elliptical in 9 accessions (CRQ, SHNC, MKR, RBP, BRT, AUG, LBR, TLS, MRD), and oblong in 4 accessions (SBS, SNTR2, BKO, and LNU) (Figure 7).

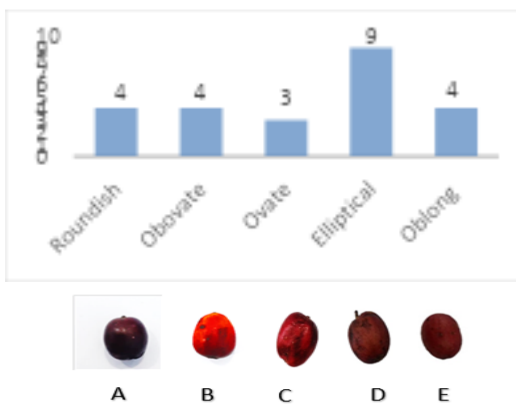

Figure 7. Fruit characteristics of 24 Bengkulu Robusta coffee accessions; (A) Roundish, (B) Obovate, (C) Ovate, (D) Elliptical, (E) Oblong

Characterization of ripe fruit color resulted in yellow-orange, orange-red, red, and black. Yellow-orange color was observed in 2 accessions (CRP, TJU), orange-red in 8 accessions (CRQ, ERG, SNTR1, SNTR2, SNTR3, SGR, LBR, TLS), red in 12 accessions (CRR, SBS, SHNC, MKR, TPS, RBP, THM, BRT, AUG, OCU, LNU, MRD), and black in 2 accessions (TUR, BKO) (Figure 8).

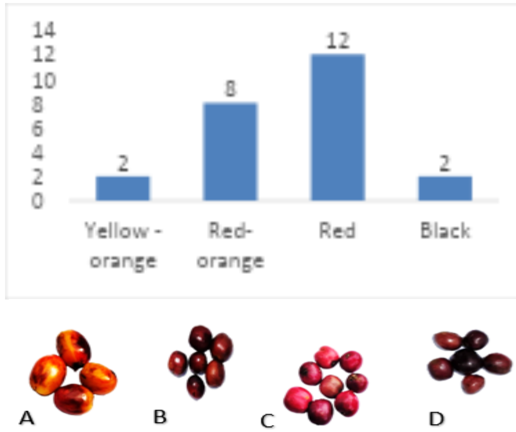

Figure 8. Fruit Color Characteristics of 24 Robusta Coffee Accessions; Yellow-Orange (A), Red-Orange (B), Red (C), Black (D)

Seed shape characterization resulted in roundish, obovate, egg-shaped, elliptical, and oblong shapes. There were 2 accessions with roundish shapes (SBS, AUG), 1 accession with an obovate shape (MRD), 7 accessions with egg-shaped shapes (CRQ, SNTR3, SHNC, SGR, TPS, THM, LBR), 6 accessions with an elliptical shape (CRR, ERG, SNTR2, RBP, TLS, TJA), and 8 accessions with an oblong shape (CRP, TUR, SNTR1, BKO, MKR, BTR, PCU, LNU) (Figure 9).

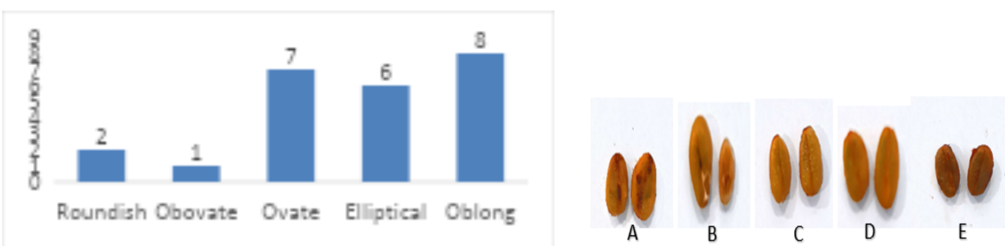

Figure 9. Seed Shape Characteristics of 24 Bengkulu Robusta Coffee Accessions; (A) Roundish, (B) Obovate, (C) Ovate, (D) Elliptical, (E) Oblong

Seed color characterization resulted in 2 characteristics, namely yellow and brown. Yellow color was observed in 17 accessions (ERG, SNTR1, SNTR3, SHNC, BKO, SGR, TPS, RBP, THM, BTR, AUG, PCU, LBR, TLS, TJU, LNU, MRD) and brown color in 7 accessions (CRP, CRQ, CRR, SBS, TUR, SNTR2, MKR) (Figure 10).

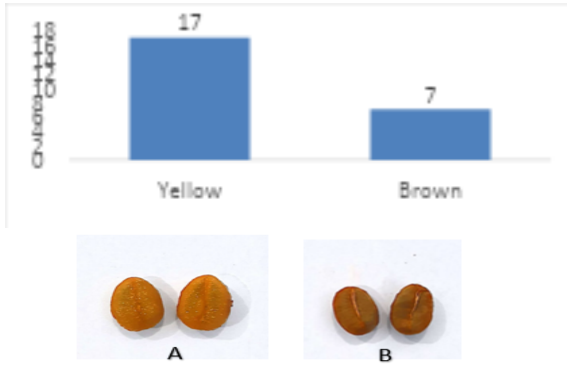

Figure 10. Seed Color Characteristic of 24 Bengkulu Robusta Coffee Accessions; (A) Yellow, (B) Brown

Accessions similarity

The results of kinship analysis from combining qualitative and quantitative characters produced two large groups with a dissimilarity level of 0.25. The range of dissimilarity coefficients obtained from the 24 accessions in this study was 0.0 to 0.25 (Figure 11).

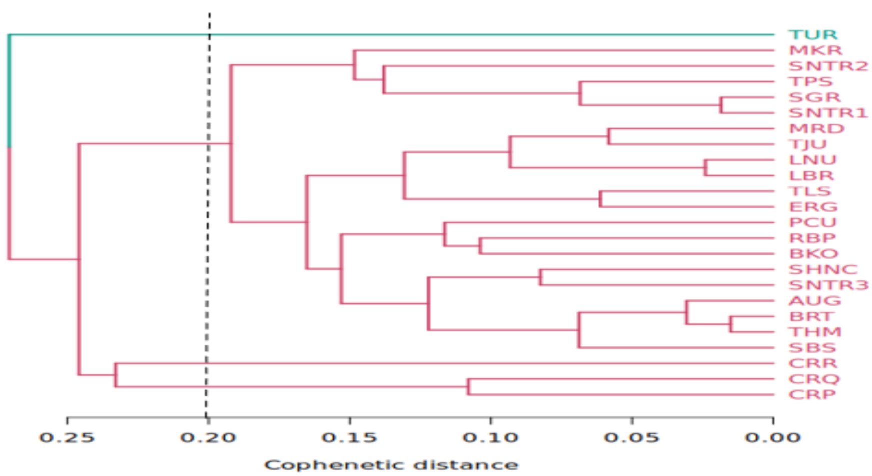

Figure 11. Dendrogram of Dissimilarity Coefficients Characterization of 24 Bengkulu Robusta Coffee Accessions

Based on the dendrogram results (Figure 11), the 24 robusta coffee accessions produced 2 groups with dissimilarity coefficients of 0.0 to 0.25. The highest dissimilarity coefficient was found in group 2, which was 0.25 in 1 accession (TUR), while the lowest was found in group 1, which was 0.23 in 23 accessions (CRR, CRQ and CRP, MRD, TJU, LNU, LBR, TLS, ERG, PCU, RBP, BKO, SHNC, SNTR3, AUG, BRT, THM, SBS, KMR, SNTR2, TPS, SGR, SNTR1). The overall results of the characterization of 24 Bengkulu robusta coffee accessions showed very close relationships, as evidenced by the fact that almost all of the characteristics characterized in the 24 accessions had similar characteristics, namely: vegetative development (simpodial), young shoot color (green), leaf stalk color (green), young leaf color (green), mature leaf color (green), flower position (leaf axil), flower color (white), number of petals (five), number of stamens per flower (five). The dissimilarity between the TUR accessions and the other 23 accessions is in the flowering on old stems, where the TUR accessions have flowering on old stems while the other 23 accessions do not appear.

Discussion

Morphological characteristics are the physical forms of plant structures that can be observed directly (Boumediene *et al*., 2025). These characteristics are influenced by genetic factors, environmental factors, or the interaction between genetic and environmental factors (Gomashe *et al*., 2025). This phenomenon can be seen in the morphological and physiological changes of a plant (Bollen *et al*., 2024). Bengkulu Province, as part of the coffee triangle region, makes Robusta coffee an important plantation crop to be developed. Coffee cultivation in Bengkulu Province is still centered in the middle and highlands (400-1200 m asl), namely in Kepahiang Regency, Rejang Lebong Regency, Kaur Regency, Lebong Regency, Seluma Regency, and North Bengkulu Regency.

From these locations, 24 accessions are produced and distributed throughout Bengkulu Province, namely 5 accessions originating from an altitude of 0-400 meters above sea level (MRD, LNU, TJA, PCU, TLS), 11 accessions between 400-800 meters above sea level (LBR, RBP, BRT, SGR, SHNC, CRR, CRP, CRQ, SBS, AUG, THM), and 8 accessions originating from 900-1200 m above sea level (LBR, RBP, BRT, SGR, SHNC, CRR, CRP, CRQ, SBS, AUG, THM). Of the 24 accessions taken at this research location, most came from an altitude of 400-800 m (mid-levels) and an altitude of 900-1200 m (highlands. Bengkulu has great potential for the future development of Robusta coffee, one of which is through the expansion of Robusta coffee cultivation from highlands to lowlands. According to Mehrez *et al*. (2023), one strategy for coffee development is to expand production areas, similar to what has been done in Colombia, Ethiopia, and Vietnam. This view is also supported by González *et al*. (2024), Abdelwahab *et al*. (2024), and Muhie (2022). According to Mamuye *et al*. (2025), Robusta coffee is generally cultivated in lowland to midland areas (0–

700 m above sea level), in line with Wicaksono *et al*. (2022), who state that Robusta coffee can grow optimally at low to high altitudes (0–2000 m above sea level). Manfarizah *et al.* (2025) conducted an adaptation test of Gayo coffee growth to different slope heights and land characteristics in Aceh Province. Siahanan *et al*. (2024) produced a morphological characterization of Robusta coffee plants (*Coffea canephora)* in the Karang Mountain area, Bangka. Researchers conducted a Markov chain analysis to predict coffee crop yields in South Sumatra Province. Rahman *et al*. (2023) also provided the results of their exploration and characterization of coffee plants in Kepahiang and Rejang Lebong districts. Plant reactions as a result of genetic relationships and interactions with the environment can be seen from the morphological appearance of plants (Boumediene *et al.,* 2025; Akpertey *et al*., 2022a; Ngugi and Aluka, 2019). Plants will respond to their specific needs during their life cycle if the environment in which they grow is not optimal (Zaidan *et al*., 2025; Afifah and Indah, 2023). This phenomenon can be seen in the morphological and physiological changes of a plant (Cassamo *et al*., 2023; Puspita *et al*., 2020).

There are two types of robusta coffee trees in Bengkulu province, namely tall and short, while according to IPGRI (2019) there are four types, namely tall, very tall, short, and very short. These categories are based on the type/variety of coffee (robusta, arabica, and liberica). Based on Wicaksono *et al.* (2022), the height of superior Robusta coffee varieties can reach 7-10 meters, but the average height of Robusta coffee trees planted by farmers in Indonesia is generally aroundish 2 to 4 meters because pruning is often carried out to facilitate harvesting (Atikah *et al*., 2024). These results are in line with the research by Kurnia *et al*. (2023) and Sakiroh *et al.* (2021), which found that the stature of local Bangka and Lampung robusta coffee tends to be short, less than 5 meters. The different characteristics of trees in terms of stature and the angle of insertion of the primary stem in the main stem (crown) are influenced by genetic factors, the growing environment, and the interaction between the two (Akpertey *et al*., 2022b). These differences are key variables in the plant breeding selection process, as they are significantly related to the growth capacity, resources, and productivity of robusta coffee plants (Giles *et al.,* 2019; González *et al*., 2024). Good plant traits, including height and branching structure, play an important role in light penetration, photosynthetic efficiency, ease of harvesting, and cultivation systems (Silva *et al*., 2024). Growth traits can vary due to different genotypes, growing environments, and technical maintenance cultures (Sarvina *et al*., 2020). Recent research also shows that phenotypic variations such as height and canopy shape can be used as early indicators in identifying superior accessions (Gebreselassie *et al*., 2024).

The characteristics of the leaves also vary in terms of leaf shape and leaf tip. According to IPGRI (1996), leaf shapes consist of obovate, ovate, elliptical, and lanceolate, while research on 24 accessions of Bengkulu robusta coffee produced obovate, elliptical, and lanceolate shapes. Differences in characteristics were also found in the shape of the leaf tips, namely acute and apiculate, where according to IPGRI (1996) leaf tip shapes consist of roundished, obtuse, acute, acuminate, apiculate, and spatulate. Research by Kurnia *et al.* (2023) in the Bangka Islands produced lanceolate, elliptical, and ovate leaf characteristics, while leaf tip characteristics produced acute, apiculate, and acuminate shapes. Rustiati *et al*. (2024) reported a phenotypic study through the identification of coffee leaf morphology to determine genetic diversity at a plantation location in Lampung. The morphology of the leaf tip shape of coffee plants observed differs in each region (Mariana *et al.,* 2023). Leaf shape can become smaller when in an environment lacking water and mineral nutrients (Bollen *et al*., 2024). The ability of leaves to change their phenotype is a response that indicates environmental changes (Chen *et al*., 2018). This variation is also influenced by the age of the leaves on the phytochemical profile and bioactivity of the leaves (Aroca-Trujillo and Perez-Ruiz, 2025), as well as the activity of peroxidase enzymes in the leaves (Alnopri *et al.* 2009). The flower characteristics of the 24 Bengkulu robusta coffee accessions were similar in terms of flower position, flower color, number of corolla flowers, and number of stamens. Coffee plants have flowers located in the leaf axils, forming a clustered arrangement called compound flowers, and the number of flower buds on each leaf is limited (Sakiroh *et al*., 2021; Erdiansyah *et al*., 2014). Flowering characteristics on old stems are produced by the TUR accession. The TUR accession originates from the village of Tugu Rejo, Kabawetan subdistrict, Kepahiang district, at an altitude of 1045 meters above sea level. Flowering on old stems is a common phenomenon in robusta coffee (Dermawan *et al*., 2018), where flowering and fruiting are influenced not only by genetics but also by environmental factors, including rainfall and air temperature (Kath *et al.,* 2021; Hafsah *et al*., 2020; Towaha *et al.* 2014). According to Campuzano-Duque and Blair (2022), altitude is highly correlated with several factors that influence plant development, such as temperature, humidity, and sunlight intensity. The higher the location, the lower the temperature tends to be, which will certainly affect the physiological processes of plants (Siahanan *et al*., 2024). Coffee plants require three consecutive months of dry weather followed by sufficient rainfall. This dry period is necessary for the formation of flower primordia (Kath *et al*., 2021; Hafsah *et al*., 2020).

The characteristics of interest are those of the fruit and beans, because coffee fruit and beans are important parts of the coffee plant that have high economic value (Saputera, 2021). The Robusta coffee trade chain is highly dependent on coffee fruit and beans (Mehrez *et al*. (2023). The fruit characteristics produced by 24 Bengkulu robusta coffee accessions are fruit shape and fruit color (Figure 7 and Figure 8). The fruit characteristics of the 24 robusta coffee accessions are roundish, obovate, ovate, elliptical, and oblong. Based on (IPGRI, 1996), the fruit shapes consist of roundish, obovate, ovate, elliptical, and oblong, and the fruit colors are yellow-orange, orange-red, red, and black. Meanwhile, the results of research conducted by Rahman *et al*. (2023) show that the fruit shape characteristics produced are elliptical, roundish, and oblong, while the research by Afifah and Indah (2023) shows that the fruit shape characteristics produced are roundish and oval. As for the color characteristics of ripe fruit, the results of 24 Bengkulu robusta coffee accessions varied, namely yellow-orange, red-orange, red, and black. According to Widyasari *et al.* (2023), the color of coffee fruit at harvest can affect the taste of coffee. Bastian *et al*. (2025) reported that the potential for germination metabolism is influenced by the level of fruit ripeness. Fruit ripeness also affects coffee seedling growth (Bollen *et al*. 2024). In addition to the shape and color of robusta coffee fruit, the shape and color of the beans are also important factors in coffee flavor (Moccand *et al*., 2023). Robusta coffee beans are widely used as raw materials for toppings or beverage mixes to enhance the flavor of coffee (Widyasari *et al*., 2023). The bean shape characteristics produced by 24 Bengkulu robusta coffee accessions are roundish, obovate, oval, elliptical, and oblong, and the bean color characteristics are yellow and brown (Figure 9 and Figure 10). These characterization results are in accordance with IPGRI (1996). The varying characteristics of the beans and bean color can be influenced by physiological, environmental, and genetic factors (Kath *et al*., 2021). Coffee plants begin to bear fruit at 1–4 years of age, with a fruiting frequency of 2–3 times per year, mainly in June–July, October–November, November–December, and December–January. This cycle illustrates that the frequency and timing of Robusta coffee fruiting are greatly influenced by agroforestry conditions (Abdelwahab *et al*., 2024; Kahsay *et al*., 2023) and fertilization practices (Nurmayanti *et al*., 2025; Unto *et al.,* 2025). Additionally, warm nighttime temperatures can accelerate the fruit ripening process, while daytime temperature variability influences flowering initiation and fruit development (Iglesias *et al*., 2025).

Dissimilarity Coefficients Characterization Of 24 Bengkulu Robusta Coffee Accessions are presented in the form of a dendrogram. The analysis was based on quantitative data (plant height, stem diameter, leaf length, leaf width, petiole length, pedicel length, corolla tube length, number of petals per flower, number of stamens per flower, fruit length, fruit width, seed length, seed width, weight of 100 wet seeds, and weight of 100 dry seeds) and qualitative data (plant habit, visual estimate of plant height, vegetative development, angle of primary branch insertion on the main stem, leaf shape, leaf tip shape, young leaf color, mature leaf color, leaf stalk color, flower color, flower position, flowering on old branches, ripe fruit color, fruit shape, seed color, and seed shape. The dendrogram results produced two groups, where group 1 consisted of 23 accessions, namely: CRR, CRQ and CRP, MRD, TJU, LNU, LBR, TLS, ERG, PCU, RBP, BKO, SHNC, SNTR3, AUG, BRT, THM, SBS, KMR, SNTR2, TPS, SGR, and SNTR, with a dissimilarity distance of 0.23 or 20% and a similarity character of 0.77 or 77%. Similar characteristics in group 1 are young leaf color, mature leaf color, leaf stalk color, flower color, flower position, number of flower corollas, and number of stamens. Group 2 with a dissimilarity distance of 0.25 or 25% and a similarity character of 0.75 or 75% is the TUR accession. In Group 2, almost all characters are similar to Group 1, with the exception of flowering on old stems. The TUR accession has flowering on old stems, while the other 23 accessions do not. According to Unto *et al*. (2025), kinship analysis aims to determine the similarity distance between plant genotypes using their morphological characteristics. According to Guambi *et al*. (2024) and Ganefianti *et al*. (2025), plant morphological traits can be used for recognition and to show similarities in accession types and determine the similarity distance between plant genotypes using their morphological traits. EL-Araby *et al*. (2025) reported that several Arabica coffee groups in Saudi Arabia formed similar phenotypic clusters despite originating from different regions due to similar ecological pressures. These findings are further supported by Alemayehu *et al*. (2025), who report that the morphological clusters of local Amaro coffee reflect genetic diversity that does not always align with geographic origin but rather results from local agronomic selection. The greater the distance between samples, the smaller the similarity between samples (Giles *et al.,* 2019; He *et al.,* 2024; Diniz *et al*., 2025). Overall, this dendrogram analysis confirms that the morphological diversity of Bengkulu robusta coffee is still very low, and an expansion and increase in the number of accessions are needed for exploration and characterization, as part of efforts to identify superior parents, genetic conservation strategies, and the development of varieties that are adaptive to the agroecological conditions of Bengkulu Province.

Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper

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(Received: 30 September 2025, Revised: 20 June 2026, Accepted: 7 July 2026)