Journal of Spices and Aromatic Crops
Vol. 33 (1): 106-112 (2024)
10.25081/josac.2024.v33.i1.9143

Indian Society for Spices

Unveiling black pepper diversity: A morphological characterization of genotypes in Sylhet, Bangladesh

M D Moudud Ahmod, Masuma Ahmed, Sharifunnessa Moonmoon & M D Masudur Rahman*
Department of Crop Botany and Tea Production Technology, Sylhet Agricultural University, Sylhet-3100, Bangladesh
**Email: m.masudur@gmail.com*

Received 15 February 2024; Revised 11 June 2024; Accepted 18 June 2024

Abstract

Black pepper (*Piper nigrum* L.) is a valuable spice and despite having suitable climatic conditions, Bangladesh relies on imports to meet the demand. There is some homestead production of black pepper, but information available on the genotypes grown in Bangladesh is scanty. Here, we characterized black pepper genotypes in the Sylhet region for potential domestic production. Healthy, disease-free cuttings of eleven genotypes (G-1 to G-11) were collected and grown in nursery condition for characterization. Diverse traits were observed for lamina shape (ovate, ovate-lanceolate, ovate-elliptic, and cordate), leaf tip (acute, accuminate, and caudate), leaf base (cordate and rounded), shoot tip color (green, light green, yellowish-green, purple, and dark purple), and leaf margin (wavy and even). Quantitative parameters revealed substantial variation in leaf length (6.8 to 11.24 cm), leaf width (3.66 to 6.24 cm), leaf area (26.8 to 66.6 cm^2), petiole length (2.3 to 5.0 cm), internode length (1.93 to 6.2 cm), and leaf dry matter content (19.6 to 30.4%). Notably, G-8 exhibited superior values for leaf dimensions, area, petiole and internode lengths, along with relatively higher leaf dry matter content (23.9%). This study provides a baseline for selecting and breeding high-yielding black pepper varieties in Bangladesh, potentially boosting domestic production.

Keywords: Characterization, black pepper genotypes, morphology, black pepper production

Black pepper (*Piper nigrum* L.), 'The king of Spices' is a perennial climbing vine, famously known as "Black gold," is primarily cultivated for its prized mature fruits. Originating in the South India's western ghats (Krishnamoorthy & Parthasarathy, 2010; Wu *et al*., 2016), black pepper has become a global commodity with major distribution centers in South Asia and Central and South America (Gurung & Manivannan, 2020). Alongside piperine, black pepper contains essential oils, terpenes, vitamin C, phenolic compounds, and antioxidants (Bagheri *et al*., 2014).

Major black pepper production hubs are located in Vietnam, India, Brazil, Indonesia, Malaysia, China, and Sri Lanka, collectively contributing to 793,818 tons in 2021 (FAO, 2024). Notably, Vietnam emerged as the world's largest grower and exporter in 2020, responsible for a significant 36% of the global black pepper production, as reported by the Food and Agriculture Organization Corporate Statistical Database of the United Nations (UN). Despite favorable climatic and soil conditions in Bangladesh, particularly in the eastern hilly regions of Sylhet and Chottogram Hill Tracts (CHT), black pepper production in the country remains insignificant. Several factors contribute to this paradox, including the unavailability of suitable varieties, inadequate management technologies, and a limited interest among farmers in cultivating black pepper. Among these challenges, the lack of appropriate varieties emerges as a major obstacle to increase black pepper cultivation in Bangladesh. The tribal communities in Sylhet and CHT traditionally engage in black pepper cultivation, relying on locally available genotypes. Though Bangladesh Agricultural Research Institute released a variety known as "Jainthia Golmorich," in 1992, this variety has not gained widespread popularity among farmers, necessitating the development of new, high-yielding varieties.

Morphological traits such as leaf length, color, stem characteristics, and shoot tip color, play a pivotal role in identifying desirable traits for inclusion in breeding efforts (Prayoga *et al*., 2020). Recognizing the importance of morphological characterization in breeding programs, the research aims to fill a critical knowledge gap regarding the morphological features of existing black pepper genotypes. The outcome would lay the foundation for the development of high-yielding varieties through targeted breeding programs in the Sylhet region.

The research on black pepper was started at the field laboratory of the Crop Botany and Tea Production Technology Department at Sylhet Agricultural University in March 2021. The area is characterized by an annual average rainfall of 5038 mm, a mean temperature of 23.6°C, and a relative humidity fluctuating between 47.98 and 90.40% (climate-data.org, 2023). During a field survey in Gowainghat and Jaintiapur, Sylhet district, cuttings from healthy and disease-free vines were collected. Subsequently, these cuttings were transplanted into a carefully monitored shade house. After one year of establishment, qualitative and quantitative characteristics of the black pepper vines were recorded. This observation adhered to the guidelines outlined in "Descriptors of Black Pepper"

(IPGRI, 1995), ensuring a standardized and systematic approach. Based on the variability among the cultivated vines, each genotype was distinctly denoted as G-1, G-2, G-3, G-4, G-5, G-6, G-7, G-8, G-9, G-10, and G-11. The shoot tip colors such as green, light green, dark green, light purple, and dark purple were visually assessed. Various lamina shapes, including ovate, ovate-lanceolate, ovate-elliptic and cordate were recorded based on the following characteristics:

Ovate: Exhibiting an egg-shaped form with the widest axis below the center and symmetrically curving borders.

Cordate: Oval in form with a sinus and surrounding lobes at the base.

Ovate-elliptic: Shaped like an ovum but with the widest axis at the middle.

Ovate-lanceolate: Characterized by being much longer than broad, with a wide base and a tapering tip.

Furthermore, the leaf margin and leaf base shapes were recorded. Leaf margins were categorized as either even (smooth border and no indentation or cut) or wavy (slight curling with or without insertions).

The quantitative parameters studied were leaf length, leaf width, leaf area, internode length, petiole length leaf, and leaf dry matter content. A measuring scale was used to measure internode and petiole length. Petiole length was measured in randomly selected five matured leaves from the base to the infusion with the leaf lamina. Leaf length, breadth and leaf area were measured by "Image J" software. High-resolution images were taken to perform the measurements. The dry matter content of the leaf was estimated by weighing the fresh weight (g) and the dry weight (g) of leaves after drying at 65^0C for 72 hours.

The average and standard error of the mean (SEM) were calculated for the quantitative data for each genotype. To visually represent the variability among the genotypes, a radar plot was generated based on the quantitative characters. In the radar plot, log-transformed data were used to address data skewness and achieving a more symmetrical distribution, ensuring that extreme values do not disproportionately influence the visualization.

Qualitative characteristics

Five distinct shoot tip colors were identified, indicating significant variability among the genotypes. The shoot tips of G-2, G-6, and G-7 were light green, while G-1, G-4, G-8, and G-10 displayed a purple coloration. G-3 and G-5 exhibited dark purple while G-9 showcased a green shoot tip, and G-11 exhibited a distinctive yellowish-green color. The observed range of shoot tip colors underscores the potential for categorizing black pepper genotypes, offering a practical and visually accessible method for differentiation. A comparative study in Uttarakhand, India, conducted by Hussain *et al*. (2017), identified light green, dark purple, and light purple shoot tip colors among the 22 genotypes studied. The spectrum of shoot tip colors found in the current study suggests a higher variability among the black pepper genotypes. This higher variability not only contributes to the phenotypic richness of the genotypes but also holds significance for potential breeding programs and the

development of black pepper varieties with distinct visual traits.

The leaf lamina forms revealed the presence of four distinct shapes: ovate, ovate-lanceolate, ovate-elliptic and cordate. The leaves of G-10 had ovate lamina shape. Genotypes G-2, G-6, and G-8 showcased ovate-elliptic lamina shape, while G-1, G-3, G-5, and G-9 exhibited a cordate leaf lamina. In contrast, G-4 and G-7 featured leaves with an ovate-lanceolate shape. The detected variations in leaf lamina shapes align with findings from previous studies. Prayoga *et al*. (2020) reported variations in the shape of black pepper leaves, including ovate-elliptic, ovate-lanceolate, and elliptic-lanceolate forms. Furthermore, Shango *et al*. (2021) and Hussain *et al*. (2017) also reported comparable types of leaf lamina shapes, further supporting the robustness and consistency of the observed morphological characteristics.

The leaf apex shapes in this study revealed three distinct forms: acute, acuminate, and caudate. Genotypes G-1, G-3, G-5, and G-10 were identified as having acute leaf tips. Accuminate leaf apex was observed in G-2, G-6, and G-8, while the remaining genotypes exhibited a caudate leaf apex. Interestingly, the findings align with a study conducted by Prayoga *et al*. (2020), which exclusively listed acute leaf tips among their native cultivars and landraces. The presence of multiple leaf apex shapes, including acuminate and caudate, in this study, suggests a broader range of morphological variations within the studied black pepper genotypes. This expanded diversity in leaf apex shapes adds nuance to our understanding of the phenotypic traits of black pepper and provides valuable information.

The leaf base shapes in the studied genotypes revealed two predominant types: rounded and cordate. The cordate leaf base shape was found in G-1, G-3, G-4, G-5, and G-9. The remaining genotypes exhibited rounded leaf bases. These findings closely align with the observations made by Prayoga *et al*. (2020) in their study, indicating consistency in the leaf base shapes among different black pepper genotypes. However, other studies, such as Hussain *et al*. (2017) and Shango *et al*. (2021), reported three types of leaf bases: acute, rounded, and cordate. The presence of variations in reported leaf base shapes across studies highlights the inherent diversity within black pepper genotypes and emphasizes the importance of comprehensive morphological assessments for a thorough understanding of the species.

The leaf venation patterns among the studied genotypes revealed a consistent feature, with all genotypes exhibiting campylodromous venation. This uniformity in leaf venation patterns is a notable characteristic observed across the entire set of black pepper genotypes. This finding contrasts with observations made by Hussain *et al*. (2017) and Shango *et al*. (2021), who reported diverse venation patterns such as acrodromous, eucamptodromous, and campylodromous among the genotypes they evaluated. In the current study, the exclusive presence of campylodromous venation aligns with the findings reported by Prayoga *et al*. (2021). Only campylodromous venation in this study suggests a more uniform morphological trait within the black pepper

genotypes. While other venation patterns exist in the broader spectrum of black pepper varieties, the limited variation observed in the present study provides valuable insights into the leaf venation characteristics specific to this particular set of genotypes.

The leaf margins among the studied genotypes revealed the presence of two distinct types: even and wavy. Genotypes G-2, G-5, G-8, and G-10 exhibited a wavy leaf margin, distinguishing them from the remaining genotypes. The dichotomy between even and wavy leaf margins aligns with similar observations reported by Hussain *et al*. (2017), Prayoga *et al*. (2020), and Shango *et al*. (2021). The consistency across studies in identifying these two types of leaf margins underscores the reliability of this categorization in characterizing black pepper genotypes.

Quantitative variation

The leaf length exhibited a range from 6.8 cm to 11.24 cm. Notably, G-8 displayed the longest leaves at 11.24 cm, while G-1 exhibited the shortest at 6.8 cm. Comparable studies by Hussain *et al*. (2017) reported a broader range of leaf lengths, varying from 15.26 to 20.62 cm, while Shango *et al*. (2021) observed leaves ranging from 8.68 to 12.96 cm.

Leaf breadth among the genotypes spanned from 3.7 to 6.2 cm. G-8 displayed the widest leaves at 6.2 cm, whereas G-7 had the narrowest at 3.7 cm. Similar studies reported broader ranges, with Hussain *et al*. (2017) noting leaf breadths from 7.62 to 13.49 cm and Shango *et al*. (2021) observing leaves of 8.65 to 12.96 cm.

Petiole length varied from 2.3 to 5.0 cm. G-8 exhibited the longest petiole at 5 cm, while G-1 had the shortest at 2.3 cm. Consistent with the literature, petiole lengths in this study were within the reported range, with Hussain *et al*. (2017) noting lengths from 1.49 to 2.9 cm, Prayoga *et al*. (2020) reporting 1.2 to 1.9 cm, and Shango *et al*. (2021) finding lengths from 1.95 to 2.82 cm. Leaf area ranged from 26 to 66.6 cm^2, with G-8 having the largest leaf area and G-7 the smallest. Genotypes showed internode lengths from 1.93 to 6.2 cm, with G-8 exhibiting the longest and G-10 the shortest. Leaf dry matter content varied from 19.6% to 30.4%, with G-4 having the lowest and G-3 the highest.

Quantitative analysis suggests G-8 possesses favorable characteristics, including leaf length, leaf width, leaf area, petiole length, and internode length compared to other genotypes, along with the relatively consistent dry matter content (Fig. 1). This information is crucial for understanding the morphological diversity within black pepper genotypes and can guide breeding programmes for desired traits such as increased yield potential.

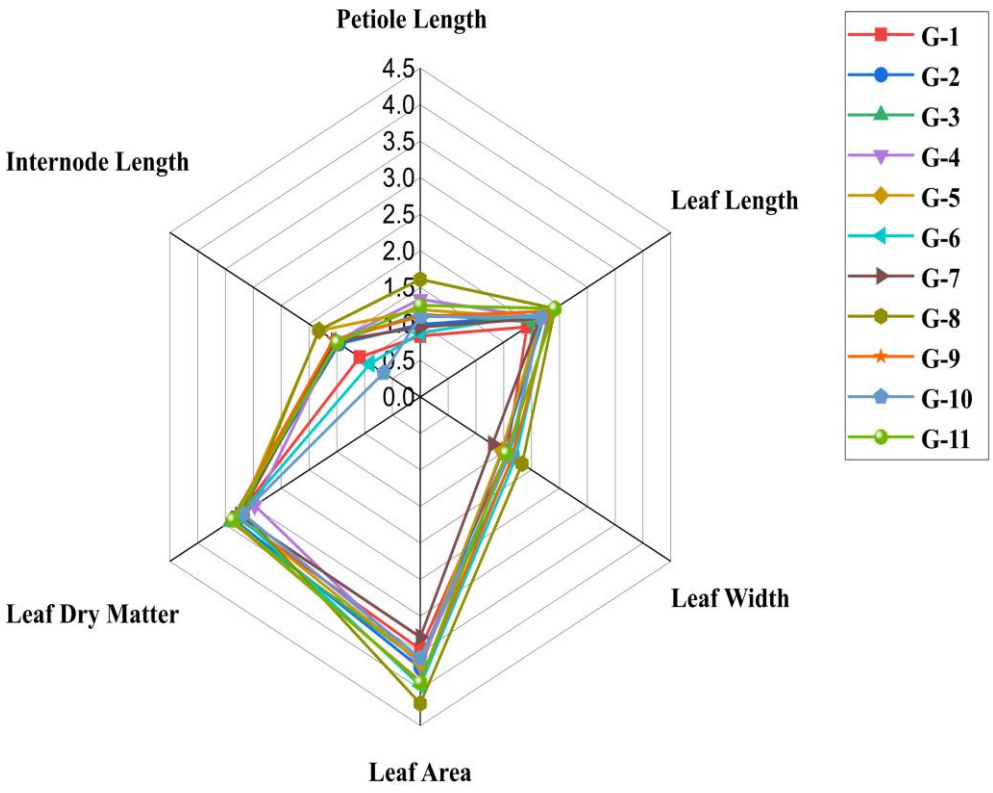

Fig. 1. Inter-relationship between various parameters

In conclusion, the study was conducted to characterize the morphological features of available black pepper genotypes in Sylhet region. The collected morphological data on black pepper genotypes is of paramount importance for advancing research, and facilitating breeding programmes. For farmers, the information serves as a practical guide for choosing varieties that align with local environmental conditions, ultimately optimizing cultivation practices. This diversity is vital for genetic studies, aiding researchers in pinpointing unique traits that can enhance plant performance. Overall, these morphological insights contribute to the conservation of genetic resources and deepen our understanding of black pepper's adaptability, fostering sustainable and successful cultivation practices.

Acknowledgement

This research has been financed by the Bangladesh Academy of Sciences under BUEP Code No.: BAS-USDA/SAU-CR-06. Ms. Masuma Asha received National Science and Technology (NST) fellowship from the ministry of science and technology, Bangladesh during the research work.

References

Bagheri H, Abdul Manap M Y Bin & Solati Z 2014 Antioxidant activity of *Piper nigrum* L. essential oil extracted by supercritical CO2 extraction and hydro-distillation. Talanta, 121: 220–228. https://doi.org/10.1016/J.TALANTA.2014.01.007.

Climate-data.org 2023 https://en.climate-data.org/asia/bangladesh/sylhet division/sylhet-3248/.

FAO 2024 FAOSTAT of Food and Agriculture Organization of the United Nations. Rome, Italy. Retrieve from https://www.fao.org/faostat/en/ #data/QCL on 11 June 2024.

Gurung K & Manivannan S 2020 Morphological characterization and secondary metabolites profile of black pepper (*Piper nigrum* L.) genotypes from Sikkim. Journal of Spices and Aromatic Crops, 29(2): 98–104. https://doi.org/10.25081/josac.2020.v29.i2.6347.

Hussain M D S 2017 Evaluation of Local Black Pepper (*Piper nigrum* L.) Genotypes for Yield and Quality under Areca nut Based Cropping System. International Journal of Pure & Applied Bioscience, *5*(5): 1396–1400. https://doi.org/10.18782/2320- 7051.5809.

IPGRI 1995 Descriptors of Black pepper (*Piper nigrum* L.). International Plant Genetic Resources Institute, Rome, Italy.

Krishnamoorthy B & Parthasarathy V A 2010 Improvement of black pepper, CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources, 5 (January 2009). https://doi.org/10.1079/PAVSNNR20105003.

Prayoga G I, Ropalia Aini S N, Mustikarini E D & Rosalin Y 2020 Diversity of black pepper plant (*Piper nigrum*) in Bangka Island (Indonesia) based on agro-morphological characters. Biodiversitas, 21(2): 652 - 660. https://doi.org/10.13057/biodiv/d210230

Shango A J, Majubwa R O & Maerere A P 2021 Morphological characterization and yield of pepper (*Piper nigrum* L.) types grown in Morogoro District, Tanzania. CABI Agriculture and Bioscience 2(1): 1- 13. https://doi.org/10.1186/s43170-021-00028-9.

Wu B D, Fan R, Hu L S, Wu H S & Hao C Y 2016 Genetic diversity in the germplasm of black pepper determined by EST-SSR markers. Genetics and Molecular Research, 15(1): gmr.15018099. https://doi.org/10.4238/gmr.15018099.