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Research Article

Morphological characterization and flower biology of *Hibiscus rosa-sinensis* L

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ABSTRACT

Hibiscus rosa-sinensis L. has broad and diverse potential, highlighting the importance of its continuous development and sustainable utilization. This study aimed to analyze the morphological characteristics and floral biology of H. rosa-sinensis. Information on morphological characteristics can serve as a basis for plant breeding programs, particularly hybridization. The study was conducted from February to December 2023 in Cipanas District, Cianjur Regency, Indonesia, at an elevation of approximately 1,100 m above sea level. Direct observations were carried out on eight accessions of H. rosa-sinensis. The evaluated traits consisted of eight qualitative and nine quantitative characteristics. The results showed that plant height ranged from 93.8 to 104.4 cm. Leaf color varied from moderate green and dark green to deep yellowish green. Leaf shape was ovate to obtuse, with obtuse to rounded leaf bases. Corolla color exhibited considerable variation, including deep purplish, white, moderate orange, pale orange-yellow, brownish orange, light purplish pink, vivid red, and strong orange. Flower diameter ranged from 7.8 to 8.8 cm, petal width from 3.13 to 3.80 cm, and petal length from 5.30 to 6.80 cm. The maximum leaf length and width were 5.23 cm and 5.10 cm, respectively. Flower buds emerged approximately 27–35 days after planting (DAP), flowers began to bloom at 59–67 DAP, and senescence followed by flower abscission occurred at 1–2 DAA.

Keywords: *characterization, floral biology, Hibiscus rosa-sinensis, morphology*

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INTRODUCTION

Hibiscus rosa-sinensis L. is an ornamental shrub widely distributed in tropical and subtropical regions. Since ancient times, it has been cultivated as a garden ornamental plant. The remarkable diversity of its floral characteristics, particularly in terms of flower color, shape, and size, has attracted considerable attention and encouraged further investigation into its unique morphological traits. Commonly known as Chinese hibiscus, *H. rosa-sinensis* also possesses various economic, medicinal, and cultural values. In the food industry, its flowers have been utilized as a natural colorant for foods and beverages (Essiett & Iwok, 2014; Oktiarni *et al*., 2013). In addition, numerous studies have reported its pharmacological properties, including antihyperglycemic activity in patients with diabetes mellitus (Sanadheera *et al*., 2021; Febriyani *et al*., 2022; Susanto *et al*., 2022; Ellis *et al*., 2022), as well as anti-inflammatory and anti-xerostomic effects (Gonzales *et al*., 2022). Furthermore, in Bali and India, *H. rosa-sinensis* flowers are traditionally used as religious offerings to the Hindu deities Kali and Ganesha (Magdalita *et al*., 2019).

The broad range of potential applications of *H. rosa-sinensis* highlights the importance of its continuous development and sustainable utilization. Morphological characterization of flowers is a fundamental step in understanding the diversity of floral traits and identifying characteristics that may be useful for breeding and conservation programs. Detailed characterization of floral morphology can facilitate the identification of distinctive phenotypic traits, provide valuable descriptive information on floral

structure and function, and support the selection of desirable parental lines for hybridization. In addition, studies on floral biology provide essential information on flowering behavior, anthesis, and flower longevity, which are important considerations in artificial hybridization and ornamental plant improvement. Therefore, this study aimed to analyze the morphological characteristics and floral biology of *H. rosa-sinensis*.

MATERIALS AND METHODS

Study Site and Experimental Period

The study was conducted from February to December 2023 in Cipanas, Cianjur Regency, West Java, Indonesia, located at an elevation of approximately 1.100 m above sea level.

Experimental Procedure

Eight accessions of *Hibiscus rosa-sinensis* L., designated HS1, HS2, HS3, HS4, HS5, HS6, HS7, and HS8, were used as the plant materials. The plants were propagated from stem cuttings (approximately 10 cm in length) and grown in 25-cm polybags filled with a 1:1 mixture of rice husk and bamboo humus. Supporting materials and equipment included a ruler, digital camera, digital caliper, and the Royal Horticultural Society (RHS) Colour Chart. The study employed a direct observational method to evaluate plant growth and flowers at full anthesis. Routine plant maintenance, including irrigation, was performed twice per week.

The observed variables included plant height (cm), measured from the surface of the growing medium to the apical growing point; leaf color, determined using the Royal Horticultural Society (RHS) Colour Chart; leaf shape; leaf base shape; leaf width (cm), measured at the widest part of the leaf; leaf length (cm), measured from the leaf base to the apex; time to flower bud emergence (days after planting, DAP); time to anthesis (DAP); flower diameter (cm), measured across fully opened flowers at the widest point; petal width (cm), measured at the widest portion of the petal; petal length (cm), measured from the petal base to the apex; flower color; stamen color; pistil color, all determined using the RHS Colour Chart; and flower longevity, expressed as the time from planting to flower senescence and abscission (DAP).

The data were subjected to analysis of variance (ANOVA) at a significance level of $P < 0.05$. When significant differences among accessions were detected, mean comparisons were performed using Duncan's Multiple Range Test (DMRT) at the 95% confidence level. Statistical analyses were conducted using IBM SPSS Statistics version 26 (IBM Corp., Armonk, NY, USA).

RESULTS AND DISCUSSION

Plant Morphology

Information on dominant morphological traits and genetic diversity is essential for supporting the development of new superior cultivars. Morphological characterization provides valuable information on species-specific traits, facilitates the discrimination of different plant genotypes, assists in the selection of superior parental lines, and improves the understanding of plant adaptation to specific environmental conditions (Fibrianty & Kurniati, 2022; Santana et al., 2021).

Observations of plant height revealed considerable variation among the eight *H. rosa-sinensis* accessions, ranging from 93.8 to 104.4 cm (Figure 1). Accession HS5 exhibited the greatest plant height (104.4 cm), significantly exceeding that of the other accessions. Morphologically, HS5 showed a vigorous growth habit characterized by long internodes (approximately 3.5 cm), relatively wide spacing between leaves, and a balanced proportion between leaf and flower size.

In contrast, HS6 had the shortest plants, with an average height of 93.8 cm. This accession exhibited a relatively compact growth habit with shorter internodes and closely spaced leaves. Although its flower size was comparable to that of HS5, its leaves were considerably smaller, with an average leaf length of 3.53 cm.

The observed variation in plant growth is likely associated with differences in genetic background and environmental conditions. Plant phenotypic variation is influenced by genetic factors, environmental factors, and the interaction between both, resulting in differences in growth and morphological characteristics among accessions (Chakraborty et al., 2023).



Figure 1. Plant height of different *Hibiscus rosa-sinensis* L. accessions. HS1 (*Hibiscus rosa-sinensis* accession 1); HS2 (*Hibiscus rosa-sinensis* accession 2); HS3 (*Hibiscus rosa-sinensis* accession 3); HS4 (*Hibiscus rosa-sinensis* accession 4); HS5 (*Hibiscus rosa-sinensis* accession 5); HS6 (*Hibiscus rosa-sinensis* accession 6); HS7 (*Hibiscus rosa-sinensis* accession 7); HS8 (*Hibiscus rosa-sinensis* accession 8)

Leaves are the primary plant organs that interact directly with the surrounding environment, and many physiological processes occurring within them are closely associated with growing conditions. Observations of *H. rosa-sinensis* leaves revealed three leaf color categories: moderate green, dark green, and deep yellowish green. Leaf shape varied from ovate to obtuse, while the leaf base was classified as obtuse or rounded (Table 1). In general, leaves of *Hibiscus* species are ovate with an obtuse leaf base, although some species exhibit an obtuse leaf shape. The adaxial leaf surface was smooth, and the leaf margins were serrated.

Leaf morphology represents an important adaptive response to light intensity. Variations in leaf morphology influence the interception of solar radiation, which in turn affects chlorophyll accumulation and leaf coloration. The green coloration of leaves reflects chlorophyll content, with darker green leaves generally indicating a higher chlorophyll concentration than lighter green leaves. Both leaf morphology and leaf color are determined by genetic factors and are further influenced by environmental conditions during plant growth (Ningsih & Daningsih, 2022).

Leaf size varied among the *H. rosa-sinensis* accessions, with leaf width ranging from 3.40 to 5.23 cm and leaf length from 3.60 to 5.10 cm (Table 2). Accessions HS4 and HS8 exhibited greater leaf width than the other accessions; however, their leaves were relatively shorter. In contrast, accession HS5 showed a nearly balanced proportion between leaf width and leaf length (Table 2).

Table 1. Qualitative characteristics of *Hibiscus rosa-sinensis* L. accessions.

Qualitative Characteristics								
Flower Color	Deep purplish red A	White NN155D	Moderate orange 167C	Pale orange yellow 24D	Brownish orange 172C	Light purplish pink 65B	Vivid red 45B	Strong orange N25B
Pollen Color	Strong orange N25A	Orange yellow N25D	Vivid yellow 17C	Orange yellow N25D	Strong orange yellow 17A	Vivid yellow 17C	Light orange yellow 19A	Strong orange yellow 17A
Stigma Color	Deep red 60A	Moderate red 180B	Deep purplish red 59B	Moderate red 179A	Deep red 60A	Moderate purplish red 59C	Moderate red 181A	Strong purplish red 60B
Leaf Color	Moderate green 135B	Moderate green 135B	Dark green 135A	Deep yellowish green N134B	Dark green 136A	Deep yellowish green A	Deep yellowish green A	Deep yellowish green A
Leaf Shape	Ovatus	Obtusus	Ovatus	Ovatus	Ovatus	Obtusus	Obtusus	Ovatus
Leaf Base Shape	Obtusus	Rotundatus	Obtusus	Obtusus	Obtusus	Rotundatus	Rotundatus	Obtusus

Note: HS1 (*Hibiscus rosa-sinensis* accession 1); HS2 (*Hibiscus rosa-sinensis* accession 2); HS3 (*Hibiscus rosa-sinensis* accession 3); HS4 (*Hibiscus rosa-sinensis* accession 4); HS5 (*Hibiscus rosa-sinensis* accession 5); HS6 (*Hibiscus rosa-sinensis* accession 6); HS7 (*Hibiscus rosa-sinensis* accession 7); HS8 (*Hibiscus rosa-sinensis* accession 8).

Flower color is one of the most readily distinguishable qualitative traits in ornamental plants. Observations of the eight *H. rosa-sinensis* accessions revealed considerable variation in corolla color, including deep purplish, white, moderate orange, pale orange-yellow, brownish orange, light purplish pink, vivid red, and strong orange (Table 1). In contrast, pollen color was relatively uniform across all accessions. Accessions HS1 and HS3 exhibited a similar floral architecture, characterized by overlapping petals that were in contact with one another (Figure 2); however, they differed in stigma color (Table 1). Accession HS8 displayed overlapping petals with a predominant strong orange (RHS N25B) corolla color (Figure 2).

Flower color is primarily determined by the accumulation of anthocyanins and other pigments within petal cells. Anthocyanins belong to the flavonoid group of secondary metabolites and play a major role in the pigmentation of flowers (Oktavi et al., 2020). The vivid coloration observed in the petals of *H. rosa-sinensis* indicates the presence of anthocyanin pigments. Variation in anthocyanin concentration contributes to differences in flower color intensity, with higher anthocyanin content generally producing brighter and more intense floral coloration. Anthocyanins have been identified as the principal pigments responsible for corolla coloration in *H. rosa-sinensis* (Magdalita et al., 2022).

The floral phenotype of *H. rosa-sinensis* exhibited considerable variation among the accessions. In general, flowers with larger petals tended to have larger flower diameters. Observations of the eight *H. rosa-sinensis* accessions showed significant differences in flower diameter at full anthesis, ranging from 7.33 to 8.80 cm (Table 2).

Table 2. Quantitative characteristics of *Hibiscus rosa-sinensis* L.

Accession	Flower Diameter (cm)	Petal Width (cm)	Petal Length (cm)	Leaf Width (cm)	Leaf Length (cm)
HS1	8,30 ± 0,10 b	3,60 ± 0,20 a	6,60 ± 0,10 a	3,70 ± 0,20 c	4,80 ± 0,10 b
HS2	7,80 ± 0,07 c	3,13 ± 0,15 c	5,80 ± 0,17 c	3,90 ± 0,10 c	4,70 ± 0,10 b
HS3	8,70 ± 0,17 a	3,70 ± 0,20 a	5,40 ± 0,10 d	4,40 ± 0,20 b	3,70 ±0,20 c
HS4	7,53 ± 0,14 d	3,80 ± 0,10 a	5,30 ± 0,20 d	5,10 ± 0,17 a	3,60 ± 0,20 c
HS5	8,80 ± 0,10 a	3,40 ± 0,17b	6,80 ± 0,17 a	4,56 ± 0,12 b	5,10 ± 0,17 a
HS6	8,80 ± 0,10 a	3,20 ± 0,10 c	6,80 ± 0,20 a	3,53 ± 0,21 d	4,90 ± 0,10 a
HS7	7,80 ± 0,10 c	3,16 ± 0,06 c	6,30 ± 0,10 b	3,40 ± 0,10 d	4,73 ± 0,21b
HS8	7,33 ± 0,21 d	3,70 ± 0,07 a	4,93 ± 0,06 e	5,23 ± 0,21 a	3,80 ± 0,10 c

Note: Means followed by the same letter within a column are not significantly different according to Duncan's Multiple Range Test (DMRT) at the 5% significance level.

Leaf area is an important determinant of light interception, as larger leaves generally capture more solar radiation than smaller ones. Consequently, leaf area is widely recognized as an indicator of plant growth and physiological performance (Umam et al., 2023). Leaves are the primary organs responsible for photosynthesis, respiration, and transpiration, and differences in leaf size may influence photosynthetic capacity. Vaz Monteira et al. (2016) reported that plants with larger leaves intercept more solar radiation than those with smaller leaves, thereby potentially enhancing photosynthetic efficiency.

Flower diameter was closely associated with petal arrangement. For example, accessions HS2 and HS6 exhibited a similar petal arrangement but differed in flower diameter. This difference was attributed to petal orientation: in HS2, the petals curved downward, whereas in HS6 they were arranged nearly parallel to the floral plane. These findings are consistent with those of Pascual et al. (2017), who reported that flower diameter is positively correlated with petal length, petal width, and petal arrangement.

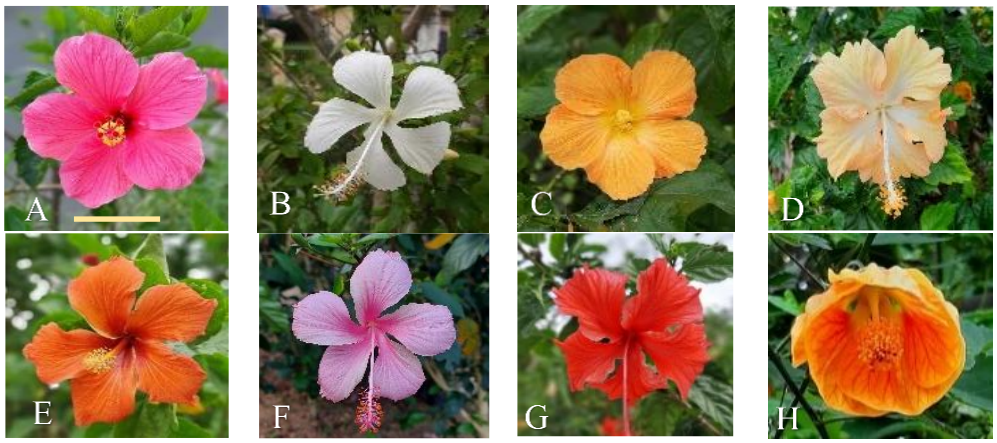


Figure 2. Variation in corolla color among *Hibiscus rosa-sinensis* L. accessions: (A) Deep purplish red A (HS1), (B) White NN155D (HS2), (C) Moderate orange 167C (HS3), (D) Pale orange yellow 24D (HS4), (E) Brownish orange 172C (HS5), (F) Light purplish pink 65B (HS6), (G) Vivid red 45B (HS7), and (H) Strong orange N25B (HS8). Scale bar = 5 cm.

Hibiscus rosa-sinensis bears perfect flowers, in which both the pistil and stamens are present within the same flower. The floral structure consists of sepals that protect the developing flower, petals that attract pollinators, a pistil as the female reproductive organ, and stamens that produce pollen. This complete floral structure enables successful pollination and fertilization, thereby classifying *H. rosa-sinensis* as a perfect flower (Chakraborty et al., 2023).

Floral Biology

Flower development comprises a series of developmental stages, beginning with flower bud emergence, followed by flower opening (anthesis), and ending with flower senescence and abscission. In *H. rosa-sinensis*, the period from flower bud emergence to full anthesis ranged from 27 to 69 days after planting (DAP) (Table 3). Initially, the flower bud was elongated and completely enclosed by dark green sepals. As development progressed, the flower bud gradually enlarged, accompanied by an increase in bud length and a change in sepal color from dark green to light green. Subsequently, the developing bud gradually emerged from the sepals. Continued bud enlargement was followed by petal expansion, culminating in full flower opening (anthesis).

Following flower initiation, the tip of the flower bud began to split, indicating the onset of anthesis. Flower opening occurred gradually. At approximately 07:00 h, the petals were partially opened, whereas by around 08:00 h, after exposure to sunlight, the flowers reached full anthesis. Observations of the flowering cycle of the eight *H. rosa-sinensis* accessions revealed variation in the timing of flower bud emergence. Accession HS6 produced flower buds earlier (27 DAP) than the other accessions (Table 3). These differences in flowering initiation suggest that each accession exhibited a distinct flowering response, which was likely influenced by interactions between genetic and environmental factors. Flowering is regulated by both internal factors, such as genetic background, and external environmental conditions, including air temperature, relative humidity, rainfall, and nutrient availability (Navas-López et al., 2019; Triadiati et al., 2021). The *H. rosa-sinensis* accessions evaluated in this study produced single flowers with a single whorl of petals. The petals were relatively thin, and flower longevity ranged from one to two days (Table 3).

Variation in flowering duration and flower senescence was observed among the accessions. In accession HS2, flowers reached anthesis, senesced, and abscised on the following day. In contrast, flowers of accession HS5 remained open longer and senesced before abscising approximately two days after anthesis. During senescence, the petals gradually closed, while the pollen and stigma became desiccated before the entire flower abscised.

Tabel 3. Flowering phenology of *Hibiscus rosa-sinensis* L. accessions

Accession	Days After Planting (DAP) / Days After Anthesis (DAA)		
	Flower Bud Emergence (DAP)	Flowering (Anthesis) (DAP)	Flower Senescence/ Abscission (DAA)
HS1	30 ± 1,00 bc	63 ± 3,00 ab	2 ± 1,00 b
HS2	29 ± 1,00 ab	59± 2,00 a	1 ± 0,00 a
HS3	33 ± 3,00 cd	67 ± 2,00 bc	2 ± 1,00 b
HS4	28 ± 2,00 ab	60 ± 2,00 a	1 ± 0,00 a
HS5	35 ± 1,00 d	69 ± 2,00 c	2 ± 1,00 b
HS6	27 ± 2.00 a	60 ± 3,00 a	1 ± 0.58 a
HS7	28 ± 1,00 ab	60 ± 4,00 a	1 ± 1,00 a
HS8	31 ± 1,00 bc	62 ± 2,00 a	1 ± 0.58 a

Note: Means followed by the same letter within a column are not significantly different according to Duncan's Multiple Range Test (DMRT) at the 5% significance level. DAP (days after planting), DAA (days after anthesis).

Agustin and Garvita (2021) reported that flowers generally undergo senescence and abscission when fertilization does not occur. Similarly, Valdoz et al. (2017) suggested that flower senescence and abscission are associated with increased ethylene production during the onset of the abscission process.

Knowledge of floral structure provides fundamental information for understanding morphological changes during flower development. Flowers are the reproductive organs of plants and play a central role in sexual reproduction. Morellato et al. (2016) emphasized that studies on floral biology provide essential information for plant breeding, regeneration, and conservation. In *H. rosa-sinensis*, the reproductive organs are located within a single flower, which is classified as a solitary flower because each peduncle bears only one flower. The brightly colored petals are characteristic of *H. rosa-sinensis* and function to attract pollinators. In general, hibiscus flowers possess five petals and exhibit considerable variation in petal morphology (Malinowski et al., 2019).

The anthers of *H. rosa-sinensis* are the sites of pollen production and play an essential role in sexual reproduction. The filaments are of relatively uniform length, forming a characteristic staminal column surrounding the style. Pollen is released when the flower reaches anthesis and remains viable for only a limited period before losing its viability (Pramesti, 2021). The stigma serves as the receptive surface for pollen during pollination and is positioned centrally within the flower, surrounded by the stamens. The style extends from the base of the flower and terminates in a stigma that is predominantly moderate red in color, while the ovary is located at the base of the flower. The ovary contains the ovules, where fertilization occurs following successful pollination (Rostina et al., 2021).

CONCLUSIONS

Accessions HS3, HS5, and HS6 showed considerable potential for further development because they exhibited superior morphological characteristics, including greater plant height, larger flower diameter at full anthesis, and more vibrant flower coloration than the other accessions.

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