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Plant Description, Growth, and Flowering of Two Indonesian Jasmines

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ABSTRACT

Jasmine flowers **(***Jasminum sambac***)** are very popular in Indonesia and Asia because of their strong sweet fragrance. Jasmine flowers have been used to decorate weddings, houses of worship, and festivals and are included in aromatic products like candles, perfumes, soaps, and lotions. Despite its popularity, studies on morphology, growth, and flowering characteristics of various jasmine species are lacking. Our study aims to describe the morphology and flowering of jasmine cultivars from a relatively humid environment, Java Island (Emprit Bandar Arum), and a relatively drier environment, Madura Island (Ratoh Ebuh), Indonesia. Each cultivar has seven blocks of four plants each block. The study was conducted at Cikabayan, West Java, Indonesia, from April 2022 to February 2023. Java and Madura's jasmine have morphological similarities in their stem shape and color, leaf type, shape and arrangement, calyx structure, petal shape, and flower color. The two jasmine species differ in leaf size, leaf tip shape, stomatal size and density, and duration from floral bud initiation to anthesis. Madura jasmines produced about 20% more flowers than Java jasmines. Understanding the morphology and flowering of different types of jasmine is important to correctly identify the jasmine cultivars to determine the peak flowering season and flower production. A list of characters that can potentially be used for future studies of the two jasmine cultivars was described. The results of this study would benefit commercial growers in choosing the right type/cultivar to grow and predicting the time to harvest the flowers in a particular region.

Keywords: Floral morphology, *Jasminum sambac*, Java, Madura

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INTRODUCTION

The genus *Jasminum* (Oleaceae) includes approximately 200 species distributed in the tropical and subtropical regions of the world (Green & Miller, 2009; Jeyarani et al., 2018). Jasmines are characterized by highly fragrant flowers, especially *Jasminum grandiflorum, Jasminum sambac, and Jasminum auriculatum,* the three main species currently grown commercially for jasmine oil production (Yohanan et al., 2020). The genus *Jasminum* is known to have 40 species cultivated in India: among them, 20 species are cultivated in south India (Bhattacharjee, 1980; Chaitanya et al., 2020). Jasmine flowers have been used to decorate houses of worship, religious ceremonies, and festivals: flowers can be placed in water as part of the ritual worship of Hinduism (Ali & Sosa, 2015; Demole et al., 1962). Jasmine flower extracts are raw materials used in perfume production and as a drink made by blending jasmine flowers with loose-leaf green tea (Ali & Sosa, 2015; Atal & Kapur, 1982). In addition, jasmine flower extracts are effective as wound healers (Nayak & Mohan, 2007) and have antimicrobial activities (Shekhar & Prasad, 2015). In Indonesia, the production center of the jasmines is concentrated in Central Java (Hartati & Darsana, 2015) and Madura Island. Madura has a production area of 50 ha in Bangkalan Regency (Tamami, 2012). Emprit Bandar Arum is a *J. sambac* cultivar from Central Java, bred by Sri Rustini. It has been certified by the Ministry of Agriculture with the Decree of the Minister of Agriculture Number 6036/Kpts/SR.120/12/2012 (Musalamah et al., 2019). Emprit Bandar Arum flowers are white in color and highly fragrant. They are widely used for tea mixtures, export, and as raw material for the perfume industry (Palupi et al., 2019). Ratoh Ebuh is another *J. sambac* originating from Buluh Atas Village, Bangkalan Regency (M. Sari & Tamami, 2020). Like Emprit bandar Arum, Ratoh Ebuh has white and fragrant flowers that are longer lasting than the jasmines from Central Java and are well adapted to low to medium elevations (Marfirani et al., 2014). Ratoh Ebuh cultivar was registered by the Decree of the Minister of Agriculture Number: 515/Kpts/SR.120/12/2005 on December 26, 2005.

Despite the high demand for jasmine flowers, studies on the description, morphology, growth, and flowering pattern in different regions still need to be completed. Understanding the morphology and flowering of different types of jasmine has several implications for commercial production. It helps growers choose the right type/cultivar to grow and adapt to the right environment to maximize plant growth and flowering. The knowledge of jasmine morphology and flowering would help select the market suitability, e.g., flower bouquets, perfumes, or cosmetics, as the flower quality varies with cultivars. Jasmine production in Indonesia is primarily traditional, with little input and maintenance, as jasmine is considered an easy crop to grow. The objective of the present study is to provide the plant description and leaf morphology and study the growth and flowering of a

jasmine cultivar from Central Java (Emprit Bandar Arum) and Madura Island (Ratoh Ebuh). Java and Madura have different microclimates: Java (the western part of Indonesia) is generally more humid and has higher yearly rainfall than Madura Island. The results of this study will provide helpful information for the growers to identify and differentiate the two cultivars and to understand their growth habits and flowering for commercial production.

MATERIALS AND METHODS

The study was conducted at the Cikabayan experimental field, Department of Agronomy and Horticulture, IPB University, from April 2022 to February 2023. The location has an altitude of 234 m above mean sea level, with an average monthly temperature of 29°C, average rainfall of 187 mm/month, and humidity of 55–95%. The plant materials are rooted cuttings with four nodes and four leaves per cutting, grown in 10 L polybags with media mixtures consisting of 20% (v/v) soil, 10% (v/v) husk charcoal, 20% (v/v) cocopeat, and composted 50% (v/v) bamboo leaves. Each plant was supplied with 2 g/L Osmocote Plus 8-9M (N:P:K = 17:11:10, Netherlands) at planting.

Treatments, Data Collection, and Analysis

The study was organized in a completely randomized block design with the jasmine cultivar as a single factor: each cultivar had seven blocks, which consisted of 4 plants per block, totaling 224 plants. The two jasmine cultivars were evaluated for the leaf, stem, and flower morphological traits, including stem shape, stem color, leaf shape and type, leaf arrangement, leaf tip, leaf bases, leaf shape, peduncle color, calyx structure, calyx color, petal color, and petal shape according to Clarke and Lee (2019). The morphological traits according Clarke and Lee (2019) are summarized as follows: leaf shape is either simple or compound; leaf arrangements are alternate, opposite, or whorled; leaf tips are obtuse, acute, aristate, acuminate, obtuse, truncate, retuse, or emarginate; leaf bases are attenuate, cuneate, obtuse, truncate, cordate, sagittate, hastate, oblique, or peltate; calyx (sepals) can be whole or partly united; corolla (petals) can be actinomorphic or zygomorphic.

Quantitative data were collected on the plant height, number of leaves, branches, and flower production, measured every two weeks between the first week of October 2022 and the end of February 2023. Plant height was measured on the main stem, from the stem base to the tip of the growing point, using a ruler. Leaf number is calculated based on the total number of mature, fully expanding leaves per plant. The branch number is calculated based on the total number of primary and secondary branches per plant. Plant height, leaf number, and branch number measurements were conducted on all plants (7 blocks of 4 plants per block). Leaf width and length were measured on one fully expanded leaf per plant and three randomly sampled plants per block. Flower production is the total number of fully opened flowers per plant, which were counted twice a week and then added for the duration of the study

(20 weeks). The average and standard error of all quantitative were calculated using Microsoft Excel.

Leaf anatomy was studied by measuring leaf thickness, stomatal density, and stomatal size using microscope Olympus CX 23 (Japan) with 100x magnification. Leaf thickness measurement was conducted on a mature, fully expanded leaf collected from the third node from the apex at 12 weeks after transplanting. Leaves were hand-sectioned using a sharp razor blade (Gillette, Germany). The stomatal observation was conducted to determine their number, density, and size. Measurement of stomatal density used a replica method, i.e., a technique to print the epidermal part of the leaf using transparent nail polish (D. P. Sari & Harlita, 2018). Clear nail polish was painted on the abaxial leaf, avoiding the veins to examine the stomata. Once the nail polish was dry, clear cellophane tape was placed on top of the polish and lifted off the leaf to have the replica of the leaf on the tape. The tape was placed directly on a microscope slide and observed under 40× magnification (Heyneke et al., 2013). The number, density, and area of stomata were calculated using Image J software (version 1.54). Data on the number of stomatal, stomatal density, and stomatal size were analyzed using Microsoft Excel.

RESULTS AND DISCUSSION

Plant Description

The Java jasmine (Emprit Bandar Arum) and Madura jasmine (Ratoh Ebuh) have morphological similarities in their stem shape and color, leaf type, shape and arrangement, calyx structure, petal shape, and flower color. Both jasmines have woody, cylindrical stem shapes: the young stems are green, which turns brown when matured. Both have simple leaves and green leaf color and entire leaf margins (Figures 1C and 1G). Both have partly united calyx with light green peduncles (Figures 1C and 1D). The flowers are actinomorphic with white ovate petals that consist of a single layer with a similar diameter size (25–40 mm) (Figures 1A and 1E)

The two jasmines differ in the leaf tip: the leaf tip of the Java jasmine is acute or less pointed (Figure 1C), whereas the Madura jasmine has an acuminated (pointed) leaf tip (Figure 1G). Both jasmines have a cordate leaf base (Figures 1B and 1E).

Leaf Anatomy

The leaf size of the two cultivars differs, with the leaf lengths of Java jasmine being 8.2–9.9 cm and Madura jasmine 5.6–6.8 cm; the leaf width of Java jasmine 4.5–6.2 cm, and Madura jasmine 2.2–3.2 cm (Figures 1C and 1F). Leaf size varies with genotypes and cultivars: cell size and number are the dominant factors determining leaf area (Hu et al., 2020). The jasmine cultivars have a similar leaf thickness of around 185 µm (Table 1). Both jasmine cultivars have paracytic stomata, i.e., a stomatal type in which the two subsidiary cells are parallel to the long axis of the guard cells (Figure 2). However, the Madura jasmine has a higher stomatal

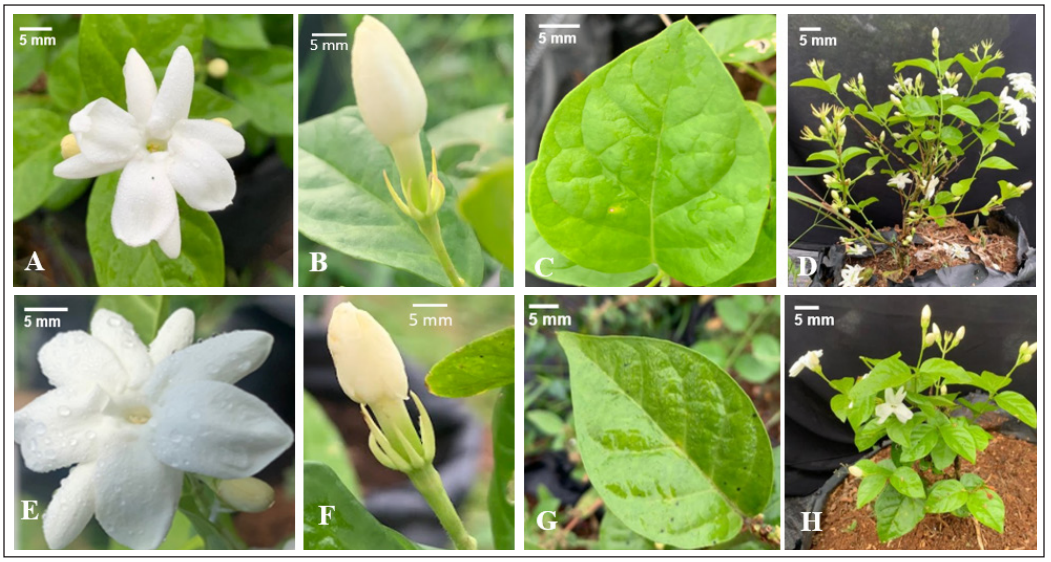

Figure 1. Morphology of a fully opened flower (A), tepal (calyx) (B), a mature leaf (C), and growth habit (D) of Java jasmine (*Jasminum sambac* Emprit Bandar Arum); a fully opened flower (E), tepal (calyx) (F), a mature leaf (G), and growth habit (H) of Madura jasmine (*Jasminum sambac* Ratoh Ebuh)

Table 1
Leaf thickness and stomatal characteristics of Java and Madura jasmines

Genotypes	Stomatal density (mm^2)	Stomatal length (µm)	Stomatal width (µm)	Leaf thickness (µm)	Leaf chlorophyll content (mg/g)
Java jasmine (Emprit Bandar Arum)	328.43 ± 31.70	32.08 ± 4.05	21.04 ± 2.66	185.05 ± 21.20	1.61 ± 0.23
Madura jasmine (Ratoh Ebuh)	377.07 ± 34.70	27.29 ± 2.50	23.75 ± 2.48	186.80 ± 7.00	1.67 ± 0.15

density (377.07 mm^2) than Emprit Bandar Arum (328.43 mm^2). The stomata of the Java jasmine are slightly longer than the Madura jasmine, but the stomatal width is similar (Table 1). Leaf thickness can vary with genotypes within the same species (Coneva & Chitwood, 2018), affecting transpiration and water uptake (Afzal et al., 2017). Genotypes with thick leaves have been reported to retain water during periods of water stress (Coneva & Chitwood, 2018).

In leaves with the same thickness, a larger leaf surface can capture more light energy for photosynthesis and leaves with more photosynthetic pigments can absorb more light energy (Li & Kubota, 2009; Nguyen et al., 2019). Leaves are crucial photosynthetic organs, and the carbon produced from photosynthesis provides energy for plant growth and development. Stomatal size and density are highly affected by the environment, including light intensity (Haworth et al., 2014, 2023), water availability (Haworth et al., 2023; Heyneke et al., 2013), salinity (Haworth et al., 2023; Shabala et al., 2013),

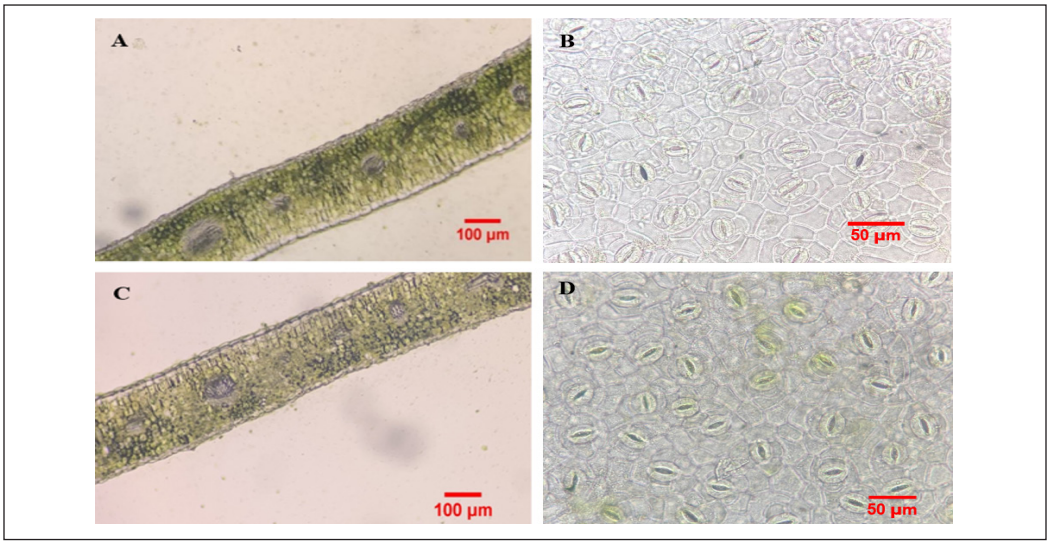

Figure 2. Leaf cross-section (A) and stomata (B) of Java jasmine (*Jasminum sambac* Emprit *Bandar* Arum); leaf cross-section (C) and stomata (D) Madura jasmine (*Jasminum sambac* Ratoh Ebuh)

and temperatures (Beerling et al., 1993; Haworth et al., 2023) as these factors affect cell expansion and cell formation. Plants grown in a dry environment with high light intensity have been reported to have many small stomata compared to those grown in cooler and shaded environments (Bertolino et al., 2019). This statement agrees with our finding: Ratoh Ebuh from Madura, which has a drier climate compared to Central Java, has a higher stomatal density (377 per mm^2) than Emprit Bandar Arum (328 per mm^2).

Growth and Flowering

The highest growth parameters, plant height, number of branches, and number of leaves were found in Madura jasmine. The Madura jasmines have more branches (Figure 3B) and consequently more leaves (Figure 3C) than the Java jasmine. In terms of growth habits, Madura jasmine (Figure 1F) tends to be shorter and has more branches than Java jasmine (Figure 1C), so the plants look denser.

Java jasmine flowers have fewer total inflorescence (35) than Madura jasmine (45; Table 2). For fresh flower markets, which determine the flower value based on the flower weight, heavier flowers could be obtained from the Madura jasmines, as both cultivars have a similar flower weight of around 200 mg (data not presented). Both jasmine cultivars have their peak flowering in October (week 0) and January (week 10): the Madura jasmines produced more flowers than Java jasmines (Figure 3D). The duration of Madura jasmines from floral bud initiation to anthesis was slightly shorter (less than 14 days) compared to the Java jasmine, which can take more than 14 days.

Understanding the morphology and flowering of different types of jasmine has several implications for commercial production: it helps growers choose the

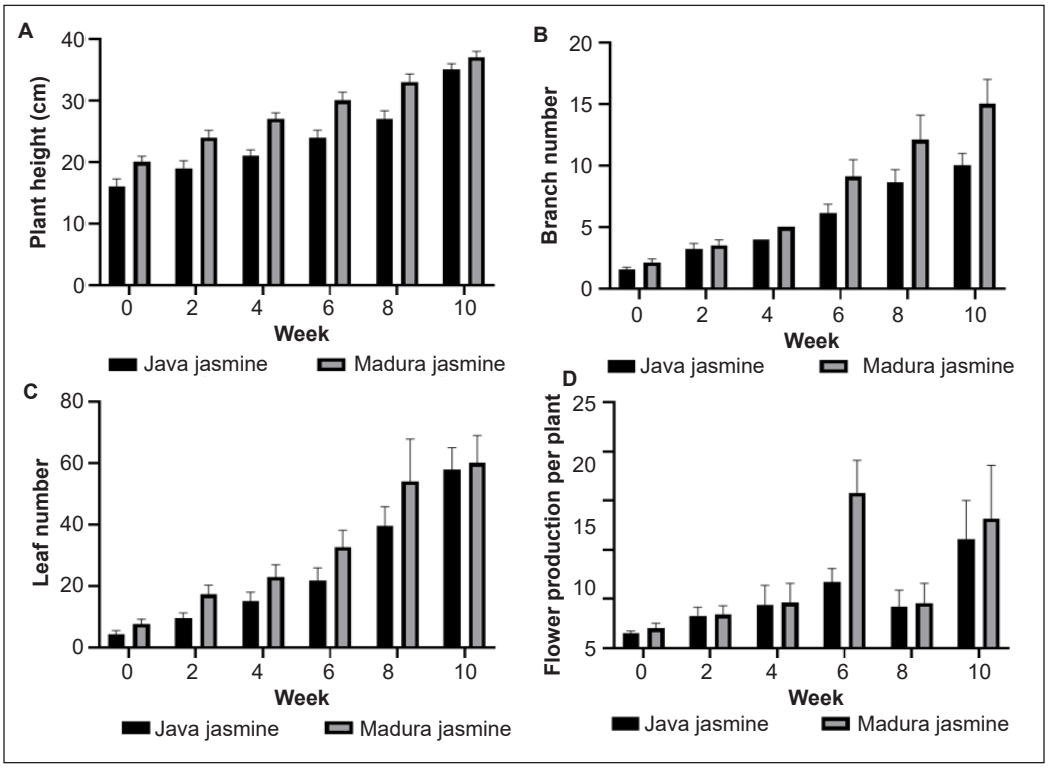

Figure 3. Vegetative growth and flower production of Java and Madura jasmines: plant height (A), branch number (B), leaf number (C), and flower production per plant (D)
Note. Data are averages ± standard errors

Table 2
Flowering characteristics of Java and Madura jasmines

Genotypes	Time of flowering	Total number of inflorescence per plant*	Number of flowers per inflorescence
Java jasmine (Emprit Bandar Arum)	October, November, December, January, February	35	2-5
Madura jasmine (Ratoh Ebuh)	October, November, December, January, February	45	1-6

**Note*. Total inflorescence per plant from October 2022–February 2023

right type/cultivar to grow to determine the peak flowering production and adapt the right environment to maximize plant growth and flowering. The knowledge of jasmine morphology and flowering would help select the market suitability, e.g., flower bouquets, perfumes, or cosmetics, as the flower quality varies with cultivars. Short plant postures with many branches are more suitable as potted ornamental plants than plants that tend to grow tall. Combining knowledge of jasmine morphology and flowering with proper cultivation techniques and suitable environmental settings can result in

jasmines having higher quality flowers and maximum yields, thus increasing profits for the growers.

CONCLUSION

Java and Madura jasmine have morphological similarities in their stem shape and color, leaf type, shape and arrangement, calyx structure, petal shape, and flower color. The two species differ in the leaf size, the shape of the leaf tip, the stomatal size and density, and the duration from floral bud initiation to anthesis. Java jasmines have larger leaves, less pointed leaf tips, larger stomata, and lower stomatal density than the Madura jasmines. Madura jasmines produced about 20% more flowers than Java jasmines in the West Java environment.

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