Identification morphological variability of six mangosteen (Garcinia mangostana L.) As a conservation strategy for local varieties

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Abstract. Morphological traits of six Mangosteen varieties were observed for two years from 2017 to 2019. This research aims to determine the growth and fruit characters of six mangosteen varieties in IP2TP Subang. The study was conducted in a randomized block design with 6 varieties: Kaligesing, Puspahiyang, Wanayasa, Ratu Kamang, Ratu Tembilahan, and Lingsar as a treatment and repeated 5 times. Each treatment unit is comprised of 6 trees. The observed characters comprised growth characters, leaf characters, and fruit characters. The results showed that the growth of several mangosteen varieties tested in relatively the same environmental conditions was quite varied, especially in the character of plant height and stem perimeter. Leaf character varied in leaf shape. Fruit characters also varied, especially characters fruit weight and plant with fruit. Ratu Tembilahan variety was the most adaptive variety because it had the highest growth ability and the highest fruit production.

1. Introduction

Mangosteen (Garcinia mangostana L.) is a highly favored tropical fruit because of its pleasant aroma and flavor. The mangosteen production center area spreads to almost all corners of the country. Most of the mangosteen plants that have been producing are forest or garden plants with relatively low productivity. The low production and productivity were caused by low maintenance; trees were old and irregular planting distance. Mangosteen fruit is the prima donna of fresh fruit exports because of its high export volume from year to year. However, the percentage of exports is still relatively low, ranging from 5.48 to 21.46%. The low percentage of exports is because of the inferior quality of the mangosteen fruit, especially the presence of yellow and dotted sap on the skin of the fruit [1][2]. The problems that exist in mangosteen need to be resolved immediately by increasing genetic variability and developing the existing superior varieties [3][4].

In recent years, Indonesia has exported mangosteen in large volumes, comparable to Thailand. The market prospects for mangosteen are very high for the export and domestic market. Mangosteen over the years has always outperformed other fruit for export commodities, because it has always produced the highest export values. From 2013–2017, mangosteen export is increasing from year to year. In 2013, mangosteen export volume was 7.648 tons with a value of 5.734,000 US$, it is increased over 4 times in 2015 (38.177 tons) and 2016 (34.955 tons) with a value of 17.212,000 US$ and 20.220,000 US$
respectively. The percentage of the mangosteen fruit that can be exported quite high, and it ranged between 5.48–21.46% from national production [5].

Indonesian Ministry of Agriculture has released 13 superior mangosteen varieties which derived from the selection of indigenous population in several areas in Indonesia. The varieties are: (1) Kaligesing variety of Purwerejo Central Java released in 1995 (2) Wanayasa variety of Purwakarta West Java released in 2006 (3) Lingsar variety of Mataram West Nusa Tenggara released in 2006 (4) Puspahiang variety of Tasikmalaya West Java released in 2007 (5) Malinau variety of Malinau East Kalimantan released in 2007 (6) Ratu Kamang variety of Bukittinggi released in 2009 (7) Ratu Tembilahan of Tembilahan Riau released in 2009 (8) Mareh variety of Rejang Lebong Bengkulu released in 2009 (9) Saburai variety of Tangelgum Lampung released in 2010 (10) Rava variety of Leuwiliang Bogor West Java released in 2010 (11) Sukarajo variety of Ogan Komering Ilir South Sumatera released in 2011 (12) Batu Kumbung variety of West Lombok West Nusa Tenggara released in 2012 and (13) Lotan variety of Bulukumba South Sulawesi released in 2012.

Six varieties mangosteen from several regions was collected at IP2TP Subang, which were: Ratu Kamang, Ratu Tembilahan, Wanayasa, Puspahiang, Kaligesing, and Lingsar, then propagated used shoot grafting method. The shoot of the six superior mangosteen varieties grafted to the rootstock that has been previously prepared [6]. Mangosteen propagation technique via grafting has been provided [7][8], with this technique, mangosteen plant can produce fruit quickly around 4-5 years. The plant height is lower so it is easier to manage (maintenance and fruit harvest), and the population per unit can be higher because of the dense planting distance. The six superior varieties were planted at IP2TP Subang as a germplasm collection and observed the growth and production patterns of each variety. Based on this, research has been carried out to determine the growth and fruit characters of six superior varieties in IP2TP Subang.

2. Materials and Methods

The research performed at Indonesian Tropical Fruit Research Institute's research installation in Wera Subang (IP2TP Subang) at 180 meter above the sea level. Plant material was grafted seedling which had uniform rootstock and the scions from the six varieties single mother plant: Ratu Kamang (Bukittinggi), Ratu Tembilahan (Tembilahan), Wanayasa (Purwakarta), Puspahiang (Tasikmalaya), Kaligesing (Purwerejo), and Lingsar (Mataram), which were planted in 2010. The fruit characters were observed from 2017 until 2019 and the growth characters were observed in 2019. The research was conducted in a randomized block design with 6 varieties above as a treatment repeated 5 times, each treatment unit comprised 6 trees. The observed characters were: plant height measured from the ground until the top shoot, stem perimeter measured 30 cm from the ground, canopy width measured from outer part of the canopy from left to right. The percentage of plant survival counted from the number of living plants divided by the number plants planted multiplied by 100 %. The leaf characters: leaf length, leaf width, leaf petiole length, and leaf shape, were observed from ten leaves from three trees of each variety. The fruit characters: fruit number, fruit shape, fruit size, fruit weight, fruit flavor, and total soluble solid of the fruit flesh, were observed from ten fruits from each tree of each variety. Total soluble solid of fruit flesh (%) Brix) measured by hand refractometer. The characters were observed according to IPGRI Descriptors for Mangosteen.

3. Results and Discussion

Based on the growth data after 9 years planted in IP2TP Subang percentage of survival plant, plant height, stem perimeter and canopy width from the six varieties were varied. The variation of growth between the six varieties probably caused by the difference of adaptation ability of the varieties which planted in the relatively same condition. Several studies [9][10][11] show that there were variability in several morphological and anatomical characters of leaves. The difference in these characters might affect the response of the six mangosteen varieties adapting in IP2TP Subang environment.
Table 1. Growth Characters of Six Mangosteen Varieties

| Character           | Varieties          | Standard deviation |
|---------------------|--------------------|--------------------|
| Plant height (m)    | Ratu Kamang        | 1.36               |
|                     | Ratu Tembilahan    | 1.12               |
|                     | Wanayasa           | 1.15               |
|                     | Puspahiyang        | 0.99               |
|                     | Kaligesing         | 1.02               |
|                     | Lingsar            | 0.94               |
| Stem perimeter (cm) | Ratu Kamang        | 13.54              |
|                     | Ratu Tembilahan    | 11.95              |
|                     | Wanayasa           | 12.18              |
|                     | Puspahiyang        | 8.93               |
|                     | Kaligesing         | 10.38              |
|                     | Lingsar            | 9.57               |
| Canopy width (m)    | Ratu Kamang        | 1.20               |
|                     | Ratu Tembilahan    | 1.12               |
|                     | Wanayasa           | 1.02               |
|                     | Puspahiyang        | 1.03               |
|                     | Kaligesing         | 1.01               |
|                     | Lingsar            | 1.00               |
| Percentage of plant survival (%) | Ratu Kamang | 63.41          |
|                     | Ratu Tembilahan    | 88.89              |
|                     | Wanayasa           | 68.89              |
|                     | Puspahiyang        | 80.56              |
|                     | Kaligesing         | 81.08              |
|                     | Lingsar            | 68.52              |

The percentage of plants survival until 9 years showed that Ratu Tembilahan varieties had the highest percentage, followed by Kaligesing and Puspahiyang, while the other three (Ratu Kamang, Wanayasa and Lingsar) had low survival percentage (Table 1). Based on data of plant height, stem perimeter and canopy width, Ratu Kamang had the highest number. It is in accordance with results of Mulyono research [6], stating that three years after planted, Ratu Kamang and Wanayasa have higher plant height than the others. The origin of the scions were divers in elevation, Ratu Tembilahan, Lingsar and Puspahiyang from lowland (5, 26, 351 masl) while Kaligesing, Ratu Kamang and Wanayasa from highland (830, 930, 1200 masl) respectively. Ratu Kamang had the highest result for plant height, stem perimeter and canopy width even though it has the lowest percentage of plant survival. This is probably because this variety originates from the highland (930 masl) and was planted in the lowland (IP2TP Subang) so it has a lower viability.
The leaf shape of the six mangosteen varieties were obovate (Ratu Tembilahan and Wanayasa) and elliptic (Ratu Kamang, Puspahiang, Kaligesing and Lingsar) (Figure 2). Leaf length ranged between 13.45-16.08 cm. Leaf width ranged from 7.27 cm to 8.6 cm. Leaf petiole length ranged between 1.14-1.37 cm (Table 2).

**Figure 2.** The leaf of the six mangosteen varieties, from left to right: Ratu Tembilahan, Ratu Kamang, Wanayasa, Puspahiang, Kaligesing, and Lingsar

| No  | Characters          | Ratu Kamang | Ratu Tembilahan | Wanayasa | Puspahiang | Kaligesing | Lingsar |
|-----|---------------------|-------------|-----------------|----------|------------|------------|---------|
| 1   | Leaf length (cm)    | 16,08       | 14,81           | 14,25    | 14,65      | 15,71      | 13,45   |
| 2   | Leaf width (cm)     | 8,6         | 8,44            | 8,19     | 7,59       | 7,98       | 7,27    |
| 3   | Leaf petiole length (cm) | 1,14 | 1,37 | 1,19 | 1,23 | 1,17 | 1,13 |
| 4   | Leaf shape          | Elliptic    | Obovate         | Obovate  | Elliptic   | Elliptic   | Elliptic |

Based on the data of fruit shape, fruit size, fruit weight and fruit flavor, can be seen that in general of all six varieties are quite varied (Table 3). The fruit shape is generally round, except for Kaligesing varieties which tends to be ellipsoid. The fruit size which is measured by the diameter of the fruit, ranged between 41 – 45.7 mm, except for Tembilahan which had fruit diameter of 36 mm. For the fruit weight, Wanayasa has the highest fruit weight (66 g) and Ratu Tembilahan was the lowest (25.31 g). From the data, the fruit size and the fruit weight were not directly proportional, which means that the fruit which had bigger size was not more severe compared to the fruit which was smaller.

**Figure 3.** The fruit of six mangosteen varieties, first line from left to right: Ratu Tembilahan, Wanayasa, and Ratu Kamang, second line from left to right: Kaligesing, Lingsar and Puspahiang
Table 3. Fruit characters of six mangosteen varities

|                  | Ratu Kamang | Ratu Tembilahan | Varieties           |
|------------------|------------|----------------|--------------------|
| Characters       |            |                |                    |
| 1 Plant with fruit | 4          | 22             | 1 Ratu            |
| 2 Fruit shape    | round      | round          | Round             |
| 3 Fruit diameter (mm) | 41        | 36             | 44 Wanayasa       |
| 4 Fruit weight (g) | 35.96     | 25.31          | 43 Puspa液压yang |
| 5 Fruit segments number | 5        | 5 - 8          | 5 Kaligesing      |
| 6 Fruit flavor   | moderate   | sweet          | 5-7 Lingsar       |
| 7 TSS (°Brix)    | 17.38      | 20             | 18 Wanayasa       |
|                  |            |                | 18 Puspa液压yang |
|                  |            |                | 18 Kaligesing     |
|                  |            |                | 17.71 Lingsar     |

Figure 4. Fruit shape, ellipsoid (left) and round (right)

Figure 5. Fruit segment number more than six

Total segments of the fruit ranged between 5 to 8 segments, although in average has 5 segments. Ratu Tembilahan has 5-8 segments and Kaligesing has 5-7 segments. Ratu Tembilahan has the highest total soluble solid (20 °Brix) compared to the other 5 varieties, which had total soluble solid ranged between 17.38-18 °Brix. Total soluble solid is one of the methods to determine the fruit quality. From the number of total soluble solid we categorized the fruit flavour, 17-18 °Brix was moderate and 20 °Brix was sweet. Ratu Tembilahan also has the highest number plant with fruit (22 fruit) compared to the other five varieties (1-7 fruit).
Differences in the growth and fruit characters between the varieties aligned with the conclusion of several studies that although mangosteen was obligate apomictic plants, there were diversity in the mangosteen plants [12][13][14][15][16][14]. Ellina et al. [17] in the research on the diversity of the mangosteen in Java and Sumatera, stated that the diversity found in 11 characters i.a: fruit shape and fruit segments number. It was aligned with the results of this research there were varieties of the fruit shape and fruit segments number even though all six varieties grown on the same environment.

4. Conclusions
From the results of the observations, it can be concluded that the growth of six mangosteen varieties was tested on relatively similar environmental conditions turned out to be quite varied, especially in plant height, stem perimeter, and canopy width. Leaf shape was obovate and elliptic. Fruit characters also varied in each of the mangosteen varieties. Plant with fruit ranged from 1 to 22 fruit per plant, fruit diameter ranged from 36 mm to 46 mm, fruit weight ranged from 25.31 g to 66 g, the fruit flavor was moderate to sweet, and total soluble solid ranged between 17 – 20 °Brix. The observations showed that the Ratu Tembilahan variety was the most adaptive variety because it had the highest growth ability and the highest fruit production.

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