Superior morphological characteristics of Kobura promising Robusta coffee clones from South Sumatera Province

I N A Wicaksono*, E Randriani, Dani, and T J Santoso

Indonesian Industrial and Beverage Crops Research Institute, IAARD, Sukabumi, West Java, Indonesia

Corresponding author email: ilham.ardhi80@yahoo.com

Abstract. Released new superior clones of Robusta coffee have an essential role as sources of high qualities planting materials. Each clone should have unique and distinctive morphological marker(s) which are easily visual-characterized. Assessment of morphological markers allows plant breeders to discriminate and identify the most promising genotypes for variety development. This study aimed to characterize morphological markers and reveal the superiority of 3 promising clones of Robusta coffee, i.e., Kobura 1, Kobura 2, and Kobura 3. The result of morphological characterization showed that the 3 promising clones have distinctive morphological characters. Shoot tip color of Kobura 1 and Kobura 2 clones is light green, whereas Kobura 3 is brownish-green. Kobura 1 clone has the largest flower size, whereas Kobura 2 and Kobura 3 clones have smaller flower sizes, respectively. Cherries disc of Kobura 1 is flat and large, differing from Kobura 2 and Kobura 3, which have small and slightly protruded cherries discs. Cherries of Kobura 1, Kobura 2, and Kobura 3 clones have roundish, oblong, and obovate shapes, respectively. The superiority of those 3 clones is cupping score, categorized as very good specialty to excellent specialty.

1. Introduction

Coffee is one of the plantation commodities that has a high economic value in Indonesia. The plant plays a vital role in strengthening the foreign exchange, as seen from the data on the production, export, and area of Indonesian coffee. Indonesia’s coffee production ranks 4th worldwide, after Brazil, Vietnam, and Colombia [1]. Indonesia’s coffee exports are approximately 0.359 million tons of coffee beans, and the area of Indonesian coffee plantations reached 1.2 million ha [2]. The area is dominated by smallholder plantations (96%), and only 4% are owned by private plantations and BUMN [2]. The dominance of smallholder plantations illustrates that coffee is a source of income for no less than one and a half million coffee farmers in Indonesia [3]. South Sumatra Province is the highest contributor of total coffee production in Indonesia and covers 20% of the total coffee land area in Indonesia (252.7 ha), with 26.77% of the total coffee production in Indonesia (199 thousand tons) [2]. Coffee cultivated in Indonesia is divided into three types, namely Arabica, Robusta, and Liberica coffee. The most widely grown species in Indonesia is Robusta coffee, especially in Bengkulu Province. Robusta coffee was introduced to farmers to replace the Arabica and Liberica species because it has a higher resistance to leaf rust disease and higher yield [4].

Morphological identification is used to identify Robusta coffee clones and is commonly done in the field. According to Hartvig [5], this identification is highly dependent on the availability of morphological characters, both vegetative organs (leaves, stems, and branches) and generative organs.
(flowers and cherries). The most simple, easy, and fast characterization is morphological characterization [6]. This characterization was carried out by observing the phenotypical appearance of the plant morphology, both in the vegetative and generative phases. Morphological identification can use quantitative and qualitative characters as tools to identify differences between cultivars [7]. The distinctive morphological characters of Robusta coffee are the wide corolla, high performance, wider canopy than Arabica coffee, and blunt leaf base. In addition, the leaves grow opposite the trunk, branches, and twigs [8]. Robusta coffee beans also have distinguished characters from other coffee beans. It has a higher yield than Arabica coffee, and the most prominent characteristic is the slightly rounded and thicker beans than Arabica coffee and almost flat [9].

The superiority of an accession/clone is critical to be recognized because it is one of the conditions that determine its feasibility to be released as a new variety. The criteria for superior Robusta coffee include good flavor, high productivity, adaptability, and good physical quality of the beans. Good flavor is vital because it determines competitiveness in the market [10]. The composition of green beans is essential in aroma formation during the roasting process [11]. The Maillard reaction is the major pathway of aroma formation in coffee, amino acids, and reducing sugars react to form nitrogenous heterocycles and brown melanoidsins [12]. This non-enzymatic browning produces hundreds of volatile compounds and contributes to several sensory attributes of coffee. Controlling the precursors (sugars, amino acids) and the process will therefore enable control over the aroma generation and the final flavor of the coffee [13]. Previous studies have shown that Robusta has an earthy, spicy roast aroma [14]. The study aimed to obtain morphological characterization and investigate superior characters in the three Robusta coffee clones of Kobura 1, Kobura 2, and Kobura 3 from South OKU Regency, South Sumatra Province.

2. Materials and methods

This research was carried out in two locations, namely Talang Agung and Air Rupik Villages, Banding Agung District of the South OKU Regency, South Sumatra Province, from January to December 2020. The genetic material tested consisted of three local Robusta coffee clones of South OKU, namely Klon Kobura 1, Kobura 2, and Kobura 3, and used 1 local clone as a comparison (Bangkalan clone).

2.1. Morphological characterization

Observations were taken on qualitative and quantitative morphological characters as specific characteristics of each local Robusta coffee clone of South OKU. The observed morphological characters include branching type; leaf shape, size, color; flower shape, size, and color; cherries shape, size, and color; disc shape and size; and seed shape and size [15].

2.2. Yield analysis

The physical quality of the Kobura 1, Kobura 2, and Kobura 3 beans tested included several variables: percentage of normal beans, single beans, three beans, percentage of single seeds, percentage of hollow beans, yield, and the number of green beans per kg. The first to fifth variables were observed from a random sample of 100 ripe coffee cherries, which were then split crosswise. Observations were repeated 3 times. The yield variable is the percentage of green bean weight produced from 6 kg samples of ripe coffee cherries taken randomly from each clone. The weight value of 100 beans was taken from green coffee beans randomly. Observations were repeated 3 times.

The cupping test processed coffee cherries following dry processing standards of Winston et al. [16]. Coffee beans were dried until the moisture content reached 11–12%. The drying process entirely relied on the sunlight. Dried bean samples were used for cupping scoring, which was carried out by expert panelists. Samples of dried coffee beans were weighed as much as 500 g from each clone and then sent to the Testing Laboratory at the Indonesian Coffee and Cocoa Research Center (Puslitkoka) Jember for a cupping flavor test.
3. Results and discussion

3.1. Morphological characters identification

Each clone has several unique qualitative and quantitative morphological characters and is easy to distinguish from one another (Table 1, Figure 1). The branching types of the three clones are almost the same, dropping. The difference in the leaf shoots (flush) of Kobura 1 and Kobura 2 clones is clearly visible, which are light green, whereas Kobura 3 is brownish-green and Bangkalan (comparison) is brown (Figure 1A). The flowers of the Kobura 1 clone are medium in size; the Kobura 2 are rather large, while Kobura 3 is rather small (Figure 1D). The Kobura 1 and Bangkalan clones discs are large and flat, while Kobura 2 and Kobura 3 are small and slightly protruding (Figure 1B). Unlike the medium-sized clones of Kobura 1, Kobura 2, and Bangkalan, Kobura 3 is smaller. Cherries shape also varies, with Kobura 1 and Bangkalan clones having round cherries, Kobura 2 oblong, and Kobura 3 obovate (Figure 1C).

Each Robusta coffee clone was obtained from individual selection in a highly heteromorphic and heterozygous population. This population structure is due to self-incompatible nature of the species, so that the allele heterozygosity in the population is maintained [17].

**Table 1.** The diversity of qualitative and quantitative morphological character traits of three Robusta coffee clones of candidate varieties.

| Characteristics          | Clones       | Kobura 1 | Kobura 2 | Kobura 3 |
|--------------------------|--------------|----------|----------|----------|
| Branching                |              | Dropping | Dropping | Dropping |
| Branching type           |              | Dropping | Dropping | Dropping |
| Shape                    |              | Pyramidal| Pyramidal| Pyramidal|
| Leaf                     |              |          |          |          |
| Size                     |              | Medium   | Medium   | Medium   |
| Shape                    |              | Elliptic | Elliptic | Lanceolate|
| Flush color              |              | Light green | Light green | Brownish green |
| Immature color           |              | Light green | Light green | Light green |
| Mature color             |              | Dark green | Dark green | Dark green |
| Apex                     |              | Apiculate | Apiculate | Apiculate |
| Base                     |              | Apiculate | Apiculate | Apiculate |
| Glade                    |              | Wavy     | Wavy     | Wavy     |
| Surface                  |              | Wavy     | Wavy     | Wavy     |
| Flower                   |              |          |          |          |
| Shape                    |              | Medium   | Slightly large | Slightly small |
| Corolla                  |              | White    | White    | White    |
| Number of petals         |              | 5-6      | 5-6      | 5-6      |
| Amount of Stamen         |              | 5-6      | 5-6      | 5-6      |
| Cherries                 |              |          |          |          |
| Size                     |              | Medium   | Medium   | Smaller  |
| Shape                    |              | Roundish | Oblong   | Obovate  |
| Discs                    |              | Evenly large | Protruded small | Protruded small |
| Immature color           |              | Green, slightly grooved | Green, slightly grooved | Green, slightly grooved |
| Mature color             |              | Red      | Red      | Red      |
| Bean                     |              | Roundish | Oblong   | Obovate  |
3.2. Cup quality

The highest economic value of coffee is its cup quality. Consumers at global market would be willing to pay more for high quality coffee. In the past, Robusta coffee is more known as a low quality coffee. However, Robusta has entered a new level as a specialty coffee in recent years. Consequently, this high quality of Robusta coffee has got a higher price on the market, almost the same as Arabica. So that, it seems promising for substitution of Arabica with Robusta coffee in the future.

Due to the rising temperature and decreasing land that is suitable for Arabica, a more resilient coffee species is needed. Robusta grows well in low to medium elevations, even in high altitudes. Indonesia has a high potential to produce high-quality Robusta coffee. Several promising clones generated from farmers’ field, especially in major Robusta coffee producer of Sumatera, had been subsequently assessed for their quality profiles.

The cupping test was done through natural processing, following the SCAA protocol. The result showed that all three clones tested, namely Kobura 1, Kobura 2, and Kobura 3 clones, generated a final score of higher than 80, categorized as a very good specialty (Table 2). The fragrance/aroma character of each clone has its own specifications. The Kobura 1 clone is in the very good category (final score of 84.00), with a fragrance/aroma of caramelly, nutty (soybean), spicy, and vanilla. The Kobura 2 clone is in the excellent category (final score of 88.00), with a fragrance/aroma of caramelly, flowery, very sweet, vanilla. The Kobura 3 clone was in the excellent category (final score of 86.00), with a fragrance/aroma of caramelly, nutty, soybean, chili, vanilla. Interestingly, those three promising Robusta clones had a complex aroma with caramelly and vanilla as a common note. However, the last two clones had a better aroma and flavor according to Table 2.

Natural processing of coffee beans can produce a more complex flavor with a better body, lower acidity, and enhance a richer aroma. This technique is also relatively the easiest and cheapest, allowing the harvested yield dry naturally under sunlight. However, the challenge in this natural drying technique is to ensure that the harvested coffee cherries are dried immediately and evenly in a short period [18]. These challenges would be more intense at the area of high altitude and wet climatic conditions. However, to obtain optimal flavor quality, it is recommended to harvest only the red (mature) cherries or sort the harvested cherries immediately to separate the ripe red cherries from the green (immature) ones. In fact, immature cherries would result in a kind of defective beans and contribute to the astringency profile of cup quality [19].
Table 2. Comparison of the cupping score between the three Robusta coffee clones of Kobura 1, Kobura 2, and Kobura 3 from the South OKU Regency, South Sumatra Province.

| Characteristics          | Kobura 1 | Kobura 2 | Kobura 3 |
|-------------------------|----------|----------|----------|
|                         | Score    | Category | Score    | Category | Score    | Category |
| Fragrance/Aroma         | 8.00     | Excellent| 8.50     | Excellent| 8.50     | Excellent|
| Flavor                  | 8.00     | Excellent| 8.50     | Excellent| 8.50     | Excellent|
| Aftertaste              | 8.00     | Excellent| 8.50     | Excellent| 8.00     | Excellent|
| Salt/Acid               | 8.00     | Excellent| 8.50     | Excellent| 8.00     | Excellent|
| Bitter/Sweet            | 8.00     | Excellent| 9.00     | Excellent| 8.00     | Excellent|
| Mouthfeel/Body          | 8.00     | Very good| 8.00     | Excellent| 8.50     | Excellent|
| Uniform cups            | 10.00    | Outstanding| 10.00    | Outstanding| 10.00    | Outstanding|
| Balance                 | 8.00     | Excellent| 8.50     | Excellent| 8.00     | Excellent|
| Clean cup               | 10.00    | Outstanding| 10.00    | Outstanding| 10.00    | Outstanding|
| Overaall                | 8.00     | Excellent| 8.50     | Excellent| 8.50     | Excellent|
| Taints-faults           | -        | -        | -        | -        | -        | -        |
| Final flavour score     | 84.00    | Very good| 88.00    | Excellent| 86.00    | Excellent|

Note: *: Good = 6.00–6.75; Very good = 7.00–7.75; Excellent = 8.00–8.75; Outstanding = 9.00–9.75 (SCAA, 2015).
**: < 80.00 = Not specialty; 80–84.99 = Very good specialty; 85–89.99 = Excellent specialty; 90–100 = Outstanding specialty (SCAA, 2015) [20].

As seen in Table 2, the Kobura clone has superiority in brewing quality. The comparison of the cupping score with the yield resulted in values shown in table 3. The yielding of the three Kobura clones was above 1.5 tons/ha, far above the average value of national productivity. Whereas for the final score of cup quality, all three Kobura clones have higher scores than other Sumatranean Robusta varieties previously released by the Indonesian government. This flavor superiority is the highlight in the submission of the release of new superior varieties.

Table 3. Yield and flavor quality of superior Robusta coffee clones in Indonesia.

| Variety     | Yield (ton/ha) | Cup Quality Score |
|-------------|----------------|-------------------|
| Korolla 1   | 2.87           | 81.67             |
| Korolla 2   | 3.34           | 82.33             |
| Korolla 3   | 2.36           | 78.58             |
| Korolla 4   | 1.89           | 80.83             |
| Sintaro 1   | 1.70           | 78.67             |
| Sintaro 2   | 2.20           | 73.38             |
| Sintaro 3   | 1.80           | 75.63             |
| Sehasence   | 2.17           | 73.07             |
| Besemah 1   | 2.60           | 82.30             |
| Besemah 2   | 2.05           | 81.75             |
| Besemah 3   | 2.14           | 83.50             |
| Besemah 4   | 2.25           | 82.75             |
| Kobura 1    | 2.48           | 84.00             |
| Kobura 2    | 1.62           | 88.00             |
| Kobura 3    | 1.68           | 86.00             |
4. Conclusion
The morphological characteristics of the Kobura Robusta coffee clones were distinct from other superior coffee. The flush color of Kobura 1 and Kobura 2 clones was light green, while Kobura 3 was brownish-green. Kobura 1 clones have the largest flower size, while Kobura 2 and Kobura 3 clones have smaller and the smallest flower sizes, respectively. The cherries disc of Kobura 1 was flat and large, in contrast to Kobura 2 and Kobura 3, which have small and slightly protruding cherries. The cherries of Kobura 1, Kobura 2, and Kobura 3 clones have round, oval, and oval shapes, respectively. The superiority of the three clones was in the cupping score and categorized as very good specialty.

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