Morphological characterization of some *Coffea arabica* L. varieties in Gayo Experimental Garden Bener Meriah

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Abstract. The research on the morphological characterization of arabica coffee varieties (*Coffea arabica* L.), has been carried out from June 2019 to October 2020 at the Gayo Experimental Garden (KP), Pondok Gajah, Bener Meriah Regency. The purpose of this study is to determine the morphological characterization of arabica coffee varieties (Gayo 1, 2, Ateng Super, C 47, and P 88). This research used a survey method, with purposive sampling by collecting 8 year old arabica coffee plants with a height of 1400-1425 meters above sea level, and each variety was obtained from different garden. To determine the characteristics of Arabica coffee varieties, identification and measurement were carried out. The results showed that there were several differences in the varieties of Gayo 1, 2, Ateng Super, P 88, and C 47. They have different stem diameters with the same height and taproot. Gayo 1, 2, Ateng Super, and P 88 have the same leaf size, while that of C 47 was smaller. The Gayo 1, 2, and Ateng Super have the same flower size, P 88 has larger, and that of C 47 was smaller than the coffee in general. Gayo 1, 2 have standard fruit sizes, while Ateng Super and P 88 has larger, and that of C 47 was smaller than the coffee in general. Gayo 1, 2, Ateng Super, and P 88 have standard bean sizes, while that of C 47 was smaller than the coffee in general.

1. Introduction

Coffee is one of the commodities with a high economic value among other plantation crops in Indonesia, playing an important role as a source of foreign exchange. This country is the fourth largest coffee producing country in the world, and more than 80% of their revenues is generated from smallholder plantations [1]. According to the data from [2], its plantation areas reached 1193.6 ha with a total production of 685.80 tons. Indonesian coffee is classified into two types, namely Arabica and Robusta. The advantage of Arabica includes a distinctive taste with a special market worth, while Robusta is a commodity with strategic value to empower the people's economy.

From the comparison of both based on their morphological characteristics, it is observed that Arabica is more adaptive to the environment than Robusta. Based on disease resistance, Arabica is susceptible to disease and should be carefully treated, while Robusta is defensive and easily cared for. The prospect for the Indonesian coffee commodity is very large, because it is supported by the availability of land for its development, and the geographical and climatic advantages that produce crops with a taste and aroma generally accepted by the world community [3].
For the residents of Central Aceh, Bener Meriah, and Gayo Lues Regencies, coffee is synonymous with life, because most of the population in the highland areas depends on this commodity. According to the Aceh Provincial Statistics Agency, the coffee plantations area in Aceh reaches 123,749 ha, with a total production of 68,493 tons. About 85% of the land area is planted with Arabica coffee, while the rest is Robusta. Bener Meriah and Pondok Gajah regencies are areas that do a lot of coffee cultivation. One of the companies cultivating this plant in Bener Meriah is the Gayo Pondok Gajah Experimental Garden (KP), originated from the IDAP project (1978-1986), which collaboration between the Indonesian government and the Netherlands kingdom. The management system is still very simple with productivity of approximately 500 kg for market coffee / ha / yr, and low quality because of improper processing. In 1984, this project began building a wet Arabica processing plant with a capacity of 15 tons of red bobbin coffee per day. This project aims to improve the products quality while increasing the income of the surrounding farmers [4].

The most widely cultivated collection of coffee plants in the Gayo Experimental Garden is Arabica with several varieties including Gayo 1, 2, Ateng Super, C 47, and P 88. The characteristics of these five varieties are identified to determine their morphological data and, needed to be further known and analyzed [5]. This information becomes the basis for plant breeders, and also for genetic improvement and development. The simplest, easiest, and fastest characterization is by morphology [6].

Arabica coffee is a type of plant that has been developed in the Gayo Experimental Garden (KP) area, Pondok Gajah. It is observed that this species has several other varieties, however, there is no new information regarding their morphological characters in this region. This research aims to obtain new data of Arabica coffee plant varieties, based on morphological characterization in the Gayo Experimental Garden (KP) area, Pondok Gajah.

2. Materials and Methods
The samples used were Arabica coffee plant varieties aged 8-16 years and over, which included Gayo 1, 2, Ateng Super, C 47, and P 88. They were examined for their morphological characteristics and diameter differences through identification. Sample identification of five varieties of Arabica coffee plants was carried out by observing each of its respective characters. In this study, observations were made on the morphological characteristics, such as the plant organs, namely roots, stems, leaves, flowers, fruits, and beans. The qualitative parameters were observed based on plant morphological characteristics, such as fruit colour, stem height, leaf and fruit diameter, root, branch, leaf, flower, fruit and bean shapes. The data obtained were presented descriptively in the form of figures and tables.

3. Results and Discussion
3.1 Root
Based on the research results, Gayo 1, 2, Ateng Super, P 88, and C 47 varieties had the same root type, namely taproot and beige-coloured (Figure 1). The deep taproot type is useful for supporting trees, therefore, it does not collapse easily and withstand drought conditions. Root growth was determined since the tree was removed from the nursery. For the coffee plant age, the longest (oldest) was the P 88 variety. The results also showed differences in root diameter. The Gayo 1, 2, Ateng Super, P 88, and C 47 varieties have a base diameter of 32 cm, 32.5 cm, 32 cm, 45.5 cm, and 38 cm, respectively. Root characteristics were shown in table 1.

| Variety name | Base diameter (cm) | Root type     | Root color |
|--------------|-------------------|---------------|------------|
| Gayo 1       | 32.0              | Tap root      | Beige      |
| Gayo 2       | 32.5              | Tap root      | Beige      |
| Ateng Super  | 32.0              | Tap root      | Beige      |
| C 47         | 38.0              | Tap root      | Beige      |
| P 88         | 45.5              | Tap root      | Beige      |
3.2 Stem

Based on the research, the Gayo 1, 2, Ateng Super, C 47, and P 88 varieties (Figure 2) have beige-colored stems. The growth type for each variety is different. The Gayo 1 has a wide and high habitus, and the leaf canopy covers the main stem to the ground. Gayo 2 has a high type of habitus growth, and the leaf canopy covers the main stem to the ground. Ateng Super has a lower shrub growth type and habitus. C 47 variety has a low habitus. Meanwhile, the P 88 variety of coffee has a shrub with moderate growth. All coffee varieties have an average stem height of 160 cm except P 88 (150 cm). The height of the P 88 variety was lower due to the cutting of the stem tips to facilitate the harvesting process of the coffee fruit.

Figure 1. Root morphology of the Gayo 1, 2, Ateng Super, P 88, and C47 varieties.

Figure 2. Stem morphology. (a) Gayo 1 (b) Gayo 2 (c) Ateng Super (d) P 88 (e) C 47.
The largest stem diameter was found in the P 88 variety with an average of 43.5 cm, while the smallest was in Gayo 2 (25.5 cm). The diameter of the P 88 stem was large, presumably because it was the oldest among other varieties (Table 2).

**Table 2. Stem Characteristics.**

| Variety Name  | Average stem height (cm) | Average stem diameter (cm) | Stem Color |
|---------------|--------------------------|-----------------------------|------------|
| Gayo 1        | 160                      | 25.9                        | Beige      |
| Gayo 2        | 160                      | 25.5                        | Beige      |
| Ateng Super   | 160                      | 32.8                        | Beige      |
| C 47          | 160                      | 27.5                        | Beige      |
| P 88          | 150                      | 43.5                        | Beige      |

3.3 Branch

The results showed that the highest number of branches was found in C 47 (41) and the least in Gayo 1 (13). Gayo 1, 2, Ateng Super, C 47, and P 88 varieties have several branches including canopy, primary, secondary, and tertiary (Figure 3). The primary branches grow on the main stem, while the flowers grow in each axillary. Secondary branches grow on the primary and are also the position where flowers develop. The tertiary branch is the part that grows on the secondary forming a fan-like dangling to the ground. A canopy branch is a whole part consisting of primary, secondary, and tertiary.

**Figure 3.** Types of branching (a) canopy (b) primary (c) secondary (d) tertiary.

The Gayo 1 variety had the largest canopy and primary branch values, respectively, 253 cm, 47.5 cm, and 33.3 cm. Meanwhile, the C 47 variety had the smallest as follows 170 cm and 20.3 cm (Table 3). The largest secondary branch was found in Ateng Super with an average of 29.1 cm and the smallest was in Gayo 2 (17.3 cm). The largest tertiary branch was found in Gayo 1 with an average of 33.3 cm, while the smallest was in Ateng Super (19 cm).
### Table 3. Characteristics of branches.

| Variety Name | Number of Branches | Canopy branches (cm) | Primary branch (cm) | Secondary branch (cm) | Tertiary branch (cm) |
|--------------|--------------------|----------------------|---------------------|-----------------------|----------------------|
| Gayo 1       | 13                 | 253                  | 47.5                | 25.5                  | 33.3                 |
| Gayo 2       | 23                 | 206                  | 30.0                | 17.3                  | 30.1                 |
| Ateng Super  | 32                 | 224                  | 25.5                | 29.1                  | 19.0                 |
| C 47         | 41                 | 170                  | 20.3                | 24.8                  | 20.8                 |
| P 88         | 14                 | 191                  | 22.5                | 25.9                  | 22.8                 |

3.4 Leaf

Based on the research, the leaves of Gayo 1, 2, Ateng Super, C 47, and P 88 have an ovoid shape, tapered tips, wavy edges, and smooth surfaces (Figure 4). The old leaves of each variety are dark green, while the youngs have differences. Gayo 1, 2, and C 47 are mostly brown and reddish-brown in colour. Meanwhile, for Ateng Super and P 88, the old and young leaves are dark and light green.

![Figure 4](image.png)

**Figure 4.** Leaf morphology (a) Gayo 1 (b) Gayo 2 (c) Ateng Super (d) variety C 47 (e) P 88.

Based on Table 4, the largest and smallest diameter were observed in Gayo 2 (20.9 cm) and C 47 (16.1 cm). Furthermore, the largest and smallest diameter were observed in Gayo 2 (9.12 cm) and C 47 (6.34 cm). The identification results of the lower leaf surface showed that it has a petiole and a part of the midrib consisting of the costa, nervus lateralis 1, 2, and veins.
Table 4. Average values of leaf characteristics.

| Variety Name  | Average diameter values | Leaf Color |
|---------------|-------------------------|------------|
|               | Long (cm) | Wide (cm) |
| Gayo 1        | 20.4      | 9.00      | Dark green |
| Gayo 2        | 20.9      | 9.12      | Dark green |
| Ateng Super   | 17.3      | 7.23      | Dark green |
| C 47          | 16.1      | 6.34      | Dark green |
| P 88          | 17.8      | 7.12      | Dark green |

3.5 Flower

Based on the research, Gayo 1, 2, Ateng Super, C 47, and P 88 varieties have the same flower colour (white), base, stalks, and stamen number (Figure 5). The stamen number of the five varieties was on the average of 5. The number of pistils on Gayo 2, Ateng Super, C 47, and P 88 was on the average of 1, while Gayo 1 has 2. The varieties with the same number of petal leaves were Gayo 1 and 2, Ateng Super, and C 47 with an average number of 4, while P 88 has 2. The results showed that flowers grow in each axillary on the primary and secondary branches. When blooming, the coffee flowers give off a fragrant smell.

![Figure 5. Flower morphology](image_url)

The flowers in each variety also differ in large diameter. Based on Table 4.5, the order of the largest flower diameter was P 88 with an average of 3.56 cm, while the smallest was Gayo 1 (2.94 cm).
Table 5. Average values of flower characteristics.

| Variety Name | Amount average | The average size of the flower diameter (cm) | Color |
|--------------|----------------|---------------------------------------------|-------|
|              | Pistil | Stamens | Leaf petals |                        |       |
| Gayo 1       | 2      | 5       | 4           | 2.94                  | White |
| Gayo 2       | 1      | 5       | 4           | 3.44                  | White |
| Ateng Super  | 1      | 5       | 4           | 3.35                  | White |
| C 47         | 1      | 5       | 4           | 3.12                  | White |
| P 88         | 1      | 5       | 2           | 3.56                  | White |

3.6 Fruit

Based on the results, young and ripe coffee fruit have different colours and shapes. The young coffee fruits of Gayo 1, 2, and P 88 have light green, while Ateng Super and C47 have a dark green colour. Ateng Super and P 88 varieties have a slightly rounded shape fruit, while Gayo 1 has an elongated rounded fruit shape, Gayo 2 is oval and C 47 is ovoid (Figure 6).

Ateng Super, C 47, and P 88 ripe coffee fruits have a dark red fruit colour, while Gayo 1 is red and Gayo 2 is maroon. The ripe coffee fruit on Ateng Super and P 88 has the same shape, which is slightly rounded, while Gayo 1 is elongated, Gayo 2 is oval, and C 47 is ovoid (Figure 7).

Figure 6. Morphology of young fruit (a) Gayo 1 (b) Gayo 2 (c) Ateng Super (d) C 47 (e) P 88.
Figure 7. Fruit morphology (a) Gayo 1 (b) Gayo 2 (c) Ateng Super (d) variety C 47 (e) P 88.

The coffee fruit has an outer (epicarp), pulp (mesocarp), and horn skin (endocarp). Furthermore, the young and ripe coffee fruits from the five varieties have differences in length and diameter (Table 6). The largest order of young coffee fruit lengths was found in Gayo 1 with an average of 1.88 cm, while the smallest was in P 88 (1.68 cm). The order of the largest diameter of young coffee fruits was found in Gayo 1 with an average of 1.42 cm, while the smallest was in C 47 (1.30 cm).

Table 6. Average value of young fruit characteristics.

| Variety Name | Average value | Color     |
|--------------|---------------|-----------|
|              | Fruit length  | Fruit width |      |
|              | (cm)          | (cm)       |      |
| Gayo 1       | 1.76          | 1.42       | Light green |
| Gayo 2       | 1.88          | 1.37       | Light green |
| Ateng Super  | 1.72          | 1.36       | Dark green  |
| C 47         | 1.72          | 1.30       | Dark green  |
| P 88         | 1.68          | 1.39       | Light green |

The results showed that the largest sequence of ripe fruit lengths was found in Gayo 1 with an average of 1.94 cm, while the smallest was in Ateng Super (1.58 cm). The largest diameter of ripe fruit was found in P 88 variety with an average of 1.56 cm, while the Gayo 1 has the smallest width (1.48 cm) (Table 7).
Table 7. Average values of ripe fruit characteristics.

| Variety Name | Average value | Color     |
|--------------|---------------|-----------|
|              | Fruit length (cm) | Fruit width (cm) |
| Gayo 1       | 1.94           | 1.48       | Red       |
| Gayo 2       | 1.74           | 1.52       | Maroon    |
| Ateng Super  | 1.58           | 1.55       | Dark red  |
| C 47         | 1.66           | 1.41       | Dark red  |
| P 88         | 1.68           | 1.56       | Dark red  |

3.7 Bean

Based on the research, the five varieties have similarities in the shape and colour of the beans. The beans have a round oval shape with a beige colour (Figure 8). The longest coffee bean was found in Gayo 1 with an average length of 1.38 cm, while the shortest was in C 47 (1 cm). The largest coffee bean width was found in C 47 with an average width of 1.14 cm, while the smallest was in Gayo 1 (0.98 cm). The average value of bean characteristics was shown in Table 8.

Table 8. Average value of bean characteristics.

| Variety Name | Average value | Color     |
|--------------|---------------|-----------|
|              | bean length (cm) | bean width (cm) |
| Gayo 1       | 1.38           | 0.98       | Beige     |
| Gayo 2       | 1.36           | 1.00       | Beige     |
| Ateng Super  | 1.24           | 1.08       | Beige     |
| C 47         | 1.00           | 1.14       | Beige     |
| P 88         | 1.32           | 1.10       | Beige     |

Figure 8. Bean morphology (a) Gayo 1 (b) Gayo 2 (c) Ateng Super (d) C 47 (e) P 88.
4. Conclusion
There are several varieties of Arabica coffee (*Coffea arabica* L.) grown in the experimental garden (KP Gayo) of Pondok Gajah, Bener Meriah Regency, such as Gayo 1, 2, Ateng Super, P 88, and C 47. They have similarities and differences in their morphological characteristics, such as they have different stem diameters with the same height. Gayo 1, 2, Ateng Super, and P 88 varieties have the same leaf size, while that of C 47 was smaller. Gayo 1, 2, and Ateng Super varieties have the same flower size, P 88 has larger, and that of C 47 was smaller than the coffee in general. Gayo 1, 2 varieties have standard fruit sizes, Ateng Super and P 88 have larger, while that of C 47 was smaller than the coffee in general. Gayo 1, 2, Ateng Super, and P 88 varieties have a standard bean size, while that of C 47 was smaller than the average coffee.

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