Genetic diversity of cinnamon plants (*Cinnamomum burmanii* BL.) at various altitude based on morphological character

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Genetic diversity of cinnamon plants (*Cinnamomum burmanii* BL.) at various altitude based on morphological character

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Abstract. Morphological characters are markers that can be used to measure the magnitude of diversity in plants based on the phenotype character. The purpose of this research is to know the genetic diversity of *C. burmanii* germ plasm in Jambi Province at a different altitude of place based on morphological character. Exploration activities were conducted in several cinnamon production centers in Jambi Province, Indonesia (Kerinci Regency, Sungai Penuh, Merangin, Bungo, and Sarolangun) by using purposive sampling method. Samples were then collected, labeled and characterized by Descriptors for Cinnamomum sp. Similarity analysis was performed using the morphological data scores from descriptions to binary data. The magnitude of the similarity between individuals was analyzed using clusters analysis. The dendrogram results of 17 accessions of cinnamon plant based on morphological character showed that accession of cinnamon plant tested varied morphologically with similarity coefficient ranged from 79.11 to 100. At the similarity level of morphology 58.23, accessions were divided into two main groups which are separate based on qualitative and quantitative character differences.

1. Introduction

Recently, Indonesia is as one of the world's largest exporter of spices in which one of them is cinnamon [1]. Cinnamon has a lot of benefits other than used as raw materials in food and beverages where this product has benefits for medicine, industry cosmetic, drinks, bread, candy, and pesticide industry. According to Pribadi [2], the primary value of cinnamon is found in the skin of stems, branches, and twigs containing essential oils, especially cinnamaldehyde (60-70%) and eugenol (4-18%).

Indonesia cinnamon bark production is determined by cinnamon productivity in Jambi province due to 85% of Indonesian cinnamon exports come from Jambi area, with an area of 46,183 Ha and output of 56,275 tons. Cinnamon plant in Jambi Province spread in Kerinci Regency 40,762 Ha, Merangin 4,284 Ha, Sarolangun 584 Ha, Bungo 232 Ha and Sungai Penuh Town 321 Ha [3]. The location of cinnamon planting in Kerinci and Sungai Penuh is at an altitude of 938 meters above sea level (m asl), Merangin 87 m asl, Sarolangun 38 m asl and Bungo 48 m asl.

The growth and appearance of plants is strongly affected by the place altitude due to the appearance of a plant is primarily influenced by genetic factors, environment, and genetic interaction x environment. Genetic and environmental interactions represent the different responses of genotypes which planted from one environment to another [4][5]. The diversity caused by genetic factors and

environmental factors generally integrate with each other in causing the appearance variety (phenotype) of plants [6].

Several studies have shown that genetic and environmental interactions affect plant morphology, such as; on rose petals properties, thorn stems and spines on petioles influenced by genetic and environmental interactions [7]. Further, genetic and environmental interactions also determine plant height, monopodia plant, sympodia plant, bolls plant and seed cotton yield plant [8]. For instance, various potato cultivars provide different responses to different environmental conditions [9], and oil content in rapeseed seeds is also affected by genetic and environmental interactions [10]. According to Mangoendidjojo [11], the interaction of appearance of a genotype will be different from the different environments. Genetic interaction with this environment is an essential thing to know in breeding programs or the development of cinnamon plants.

Morphological characters are relatively easy-to-use, cheaper, and more straightforward markers. The morphological marker is a marker that can be used to measure the magnitude of plant diversity based on phenotype in the vegetative phase and generative phase [12]. There have been many studies of plant genetic diversity based on morphological characters, e.g. in *Mentha cervina* L. [13], *Sesamum indicum* L [14], *Uncaria gambier* (W. Hunter) Roxb [15] and *Etlingera elatior* (Jack) [16]. However, until now, there has been no report on the genetic diversity of *C. Burmanii* plant origin of Jambi Province. Therefore it is necessary to explore and characterize the morphology, which is searching, collecting, and researching the types of germplasm of cinnamon planted in diverse range areas of cinnamon production center located in Jambi Province. The purpose of this research was to find out the genetic germplasm diversity of *C. burmanii* in Jambi Province at various altitudes based on morphological character.

2. Methodology

2.1. Location, materials, and methods

The research sites are located in the center of cinnamon production in Jambi Province (Kerinci, Sungai Penuh, Merangin, Bungo, and Sarolangun) which have been implemented in September 2017 until March 2018. The materials and tools used were cinnamon plants, plastic bags, and paper label. The tools used are a measuring tape, digital camera, GPS (global position system), knife, calipers, and other stationeries.

2.2. Exploration and collection of specimens

The exploration method was carried out in stages, namely by extracting information from the Agricultural Service or other sources such as local people. This information was then developed when conducting exploration activities to the target location. Validating the information and at the same time performing the recording of passport data/ indigenous description. The research used survey method with purposive sampling. All variants are labeled (collection numbers), recorded the habitat, the height of place (m asl), status, history, and other necessary details.

Specimen collection activities performed in a way whereby each specimen was arranged on one side of the paper, covered with another paper, and then fastened and inserted into a plastic bag and sprayed with 70% alcohol and fed into the herbarium tool and grouped by morphological features.

2.3. Identification of morphological characters

Identification was carried out on 18 characters that were six qualitative characters and 12 quantitative characters. Characterization refers to Lizawati et al.[17], by observing canopy shape, leaf shape, shoot, apex folly, base, flower color, leaf size (cm2), leaf length (petiole) (mm), leaf length (cm), leaf width (cm), ratio Leaf width, fruit weight (g), fruit length (mm), fruit diameter (mm), ratio of fruit diameter length, bark thickness (mm) and length of flower stalk (mm). Characterization was undertaken by observing and measuring the object of the research directly.

Observation of quantitative and qualitative parameters was performed on sample plants with direct observation without repetition. Data then were averaged and taken middle value. For measurements of leaves, flowers, and fruits, the samples were taken from the middle sectors of the plant with four directions of the wind (West, East, North, and South). Each of the four samples of the leaf has been developed entirely, the flower that ready to harvest is already yellow, and the fruit is ripe, according to the character of the plant observed, the thickness of plant bark is measured and taken at the height of 1.50 m from the ground.

2.4. Identification of morphological characters

The observation and documentation data were presented in tabular form and analyzed descriptively. The analysis of phenotypic variability using standard deviation, as well as similarity analysis performed using morphological data scoring from description to binary data. The magnitude of the similarity between individuals is analyzed using clusters analysis.

3. Results and discussions

3.1. Exploration of cinnamon plants

The cinnamon exploration conducted in Jambi Province has collected 17 accessions of cinnamon which for Kerinci 5 accessions (GR 01, PH S1, SL S1, KA S1 and KA S2), Kota Sungai Penuh 2 accessions (RK S1 dan RK S2), Merangin District 3 accessions (DB 01, RA 01 and SL 01), Sarolangun 4 accessions (BB 01, BB 02 and BB 04) and Bungo 3 accessions districts (MB 01, MB 02 and MB 03). The data of the location completed with the coordinat points and the altitude above sea level are presented in Table 1.

Agroecological data indicated that cinnamon plants grown in Jambi Province are planted at various altitudes, from the lowlands up to highlands, at an altitude range of 67-1,400 meters above sea level (m asl). For instance, cinnamon plants cultivated in the Sungai Arang Village Bungodani Subdistrict Rantau Ikil Sarolangun Regency is located in the lowlands below 100 m asl whereas cinnamon grown at the Village of Tanjung Bungo Kayu Aro Kerinci Regency and Sungai Lalang Village District of Lembah Masurai Merangin Regency are located on the high plateau above 1,400 m asl.

Areas that located at 0-500 m above sea level categorized as lowland areas whereas an area situated at more than 600 m asl is defined as plateau area. Lowlands have climatic conditions, i.e., high temperatures, low humidity, and high intensity of sunlight which can affect the process of photosynthesis and other physiological activities. The same effects also might happen to plant growth in the highlands with condition low temperatures, high humidity, and less sun intensity. Exploratory results also showed the morphological differences and oil content in olives in various geographic distributions [18]. The same result was found for Enset plant (*Ensete ventricosum* (welw.) Cheesman) that was collected from nine different regions of Ethiopia [19].

According to Jiang [20], Gonález et al.[21] that the existence of plant environment differences between lowland and highland will result in differences in plant genotype response because the genotype appearance of a plant is an expression of genetic factors, the environment and the interaction between genetic and environmental factors. Therefore, plant morphology will also adjust to environmental conditions with the intention that the plant physiology process can run optimally.

Table 1. Agroecological data of growing cinnamon at various altitude places in Jambi Province.

No	Code Access	Location	Coordinates	Altitude (m asl)
1	GR 01	Lempur Mudik village, Gunung Raya district	S 02^0 16' 42,8"; E101^0 33' 40,1"	1.076
2	RK S1	Ranah Kayu Embun village, Kumun Debai district	S 02^0 0,8' 37,4"; E101^0 23' 35,4"	1.272

Table 1.Cont.

3	RK S2	Ranah Kayu Embun village, Kumun Debai district	S 02^0 09' 38,9"; E101^0 23' 32,3"	1.335
4	PH S1	Pungut Hilir village, Air Hangat Timur district	S 02^0 01' 15,5"; E101^0 27' 42,6"	919
5	SL S1	Lubuk Nagodang village, Siulak district	S 01^0 55' 27,0"; E101^0 19' 12,4"	898
6	KA S1	Batu Ampar village, Kayu Aro district	S 01^0 49' 53,8"; E101^0 15' 39,5"	1.377
7	KA S2	Tanjung Bungo village, Kayu Aro district	S 01^0 46' 00,0"; E101^0 18' 02,6"	1.488
8	BB 01	Meribung village, Limun district	S 02^0 39' 34,9"; E102^0 27' 24,2"	190
9	BB 02	Meribung village, Limun district	S 02^0 39' 34,7"; E102^0 27' 52,0"	190
10	BB 03	Berkun Renah Alai village, Limun district	S 02^0 40' 06,3"; E102^0 31' 01,9"	431
11	BB 04	Meribung Dusun Tinggi village, Limun district	S 02^0 39' 46,5"; E102^0 27' 19,9"	189
12	MB 01	Sungai Arang village, Bungodani Rantau Ikil district	S 01^0 29' 27,7"; E102^0 04' 41,7"	67
13	MB 02	Renah Sungai Besar village, Limbur Lubuk district	S 01^0 33' 53,9"; E101^0 39' 49,5"	237
14	MB 03	Renah Sungai Besar village, Limbur Lubuk district	S 01^0 34' 02,1"; E101^0 40' 15,3"	217
15	DB 01	Baru village, Jangkat Timur district	S 02^0 34' 39,3"; E 101^0 55' 57,0"	1.147
16	RA 01	Renah Alai village, Lembah Masurai district	S 02^0 32' 41,3"; E101^0 49' 50,8"	1.400
17	SL 01	Sungai Lalang village,Lembah Masurai district	S 01^0 28' 40,0"; E101^0 49' 11,9"	1.438

3.2. Morphological characterization

The result of observation on qualitative character of cinnamon plant indicated the different forms of crown (Upright and Spreading), leaf shape (lanceolate and elliptic), shoot (red, red and yellow), and leaf base (Acute and Attenuate) while there is no difference at apex folly and flower color of the cinnamon plant for all accessions observed i.e., acuminate form for apex folly and light yellow for flower color (Table 2). This situation signifies that the qualitative character of the cinnamon plant is very little affected by the environment. The same result reported by Ferita, Tawarati, and Sharif [22] that the qualitative character of variability for arenga palm in Gayo Lues Regency is quite narrow because of the qualitative character less influenced by the environment and discrete (easy to distinguish grouping).

The observation of the quantitative character for the cinnamon plant leaf area varies from 9.70 to 37.60 cm^2 and into the small-leaved group of plants. The length of the petiole 6.80 to 11.20 mm, leaf length 6.58 to 12.3 cm, leaf width of 2.13 to 4.48 cm and the ratio of leaf length and length of 2.57 to 4.46 this size signifies that in general, the leaves of the cinnamon plant belong to the category of oblong or rounded elongated. Based on data of diameter length ratio of fruit turns fruit cinnamon plant is divided into three categories namely; round (> 1.71), ovoid or ovoid (<1.45) and the intermediate form (1.45 - 1.71).

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Table 2. Morphological characters of cinnamon plant.

No	Code Access	Growth Habit	Leaf Shape	Shoot Color	Apex Folly	Leaf Base Form	Flower Color
1	GR 01	Upright	Lanceolate	Maroon	Acuminate	Acute	Light yellow
2	RK S1	Spreading	Lanceolate	Red	Acuminate	Acute	Light yellow
3	RK S2	Upright	Lanceolate	Red and Yellowish	Acuminate	Acute	Light yellow
4	PH S1	Spreading	Lanceolate	Red and Yellowish	Acuminate	Acute	Light yellow
5	SL S1	Spreading	Lanceolate	Red and Yellowish	Acuminate	Acute	Light yellow
6	KA S1	Spreading	Lanceolate	Red and Yellowish	Acuminate	Acute	Light yellow
7	KA S2	Spreading	Lanceolate	Red	Acuminate	Acute	Light yellow
8	BB 01	Spreading	Lanceolate	Red and Yellowish	Acuminate	Acute	Light yellow
9	BB 02	Spreading	elliptic	Red and Yellowish	Acuminate	Acute	Light yellow
10	BB 03	Spreading	Lanceolate	Maroon	Acuminate	Acute	Light yellow
11	BB 04	Spreading	Lanceolate	Red and Yellowish	Acuminate	Acute	Light yellow
12	MB 01	Spreading	Lanceolate	Red and Yellowish	Acuminate	Acute	Light yellow
13	MB 02	Upright	Lanceolate	Red and Yellowish	Acuminate	Attenuate	Light yellow
14	MB 03	Spreading	Lanceolate	Red and Yellowish	Acuminate	Acute	Light yellow
15	DB 01	Spreading	Lanceolate	Red and Yellowish	Acuminate	Acute	Light yellow
16	RA 01	Upright	Lanceolate	Red and Yellowish	Acuminate	Acute	Light yellow
17	SL 01	Upright	Lanceolate	Red	Acuminate	Acute	Light yellow

Information : Lempur Mudik Village, Gunung Raya District (GR 01); Ranah Kayu Embun Village Kumun Debai District (RK S1, RK S2); Pungut Hilir Village, Air Hangat Timur District (PH S1); Lubuk Nagodang Village, Siulak District (SL S1); Batu Ampar Village, Kayu Aro District (KA S1); Tanjung Bungo Village, Kayu Aro District (KA S2); Meribung Village, Limun District (BB 01, BB O2); Berkun Renah Alai Village, Limun District (BB 03); Meribung Dusun Tinggi Village, Limun District (BB 04) dan Sungai Arang Village, Kec. Bungodani Rantau Ikil District (MB 01).

The thickness of the bark also varies from thick to thin. The thickest stem bark located in the Renah Sungai Besar Village, Limbur Lubuk District (6.85 mm) while the thinnest bark was in the village of Batu Ampar Kecamatan Kayu Aro (1.13 mm). This difference is caused by differences in altitude of cultivated plants. It is in line with the study of Sudiarto, Ruhnayat, and Muhammad[23] that the total bark production of *C.burmannii* is higher in lowland areas than in the highlands, especially at 10 years of age but conversely in the *C. burmannii* grown in plateau produce higher essential oil content of stem bark than in lowland areas. This situation exemplifies that the growing environment of plants is an essential part of determining plant diversity. According to Syukur, Sujiprihati and Yunianti[24] that qualitative characters are controlled by simple genes (one or two genes) which are not or very little influenced by the environment whereas quantitative characters are mostly influenced by many genes and influenced by the environment.

The observed cinnamon plants are all in flowering stage with similar flower shape, crown, stamens, and stigma. Variations are found only in the size of the flower stalks ranging in size from 3.65 to 7.48 mm. This morphological difference in the cinnamon plant was also discovered by Lizawati et al. [17] in cinnamon plants grown in West Sumatra, where the morphological differences of cinnamon plants observed are assumed due to differences in growing conditions of the cinnamon plant, i.e., differences in altitude of the site, soil pH, and soil nutrient content. This is similar to some studies that have been done to chili papper[25], maize[26], and groundnut[27].

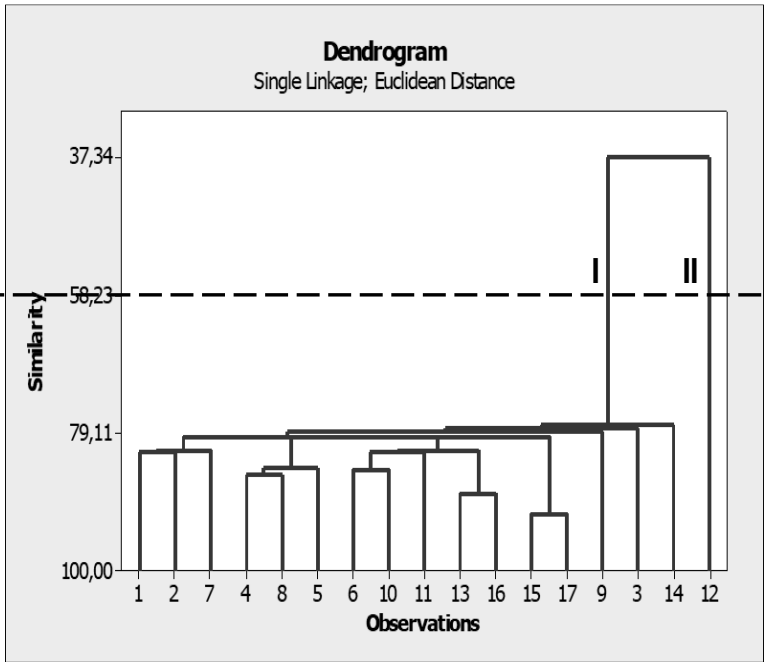

Figure 1. Dendrogram of 17 accessions of cinnamon plant based on their morphological character.

Morphological characters can be used to recognize and describe species-level similarities. Davis and Heywod[28] suggested that similarity analysis is used to determine the closeness of the similarity relationship between plants using the morphological properties of a plant. Therefore, cluster analysis (dendrogram) was conducted to see the similarity level of 17 accessions of the cinnamon plant in Jambi Province based on 18 morphological characters (Figure 1).

Dendrogram of 17 accessions of cinnamon plant based on morphological character indicates that the accessions tested varied morphologically with similarity coefficients ranged from 79.11 to 100. At the morphological similarity level of 58.23 accessions were divided into two separate main groups based on differences in morphological characters, where the group I consists of 16 accessions while in group II only consists of 1 accession. In Figure 1, it can be seen that the cultivation of cinnamon plants is usually based on different altitude places. Moreover, it is suspected that samples come from the same offspring and are also influenced by the environment to show similarities.

Morphological variation in varieties in the same species predominantly influenced by environmental factors rather than genotypes such as difference in altitude, latitude, temperature, humidity and soil [29][30][31]. The dendrogram result showed that the accession from Sungai Arang Village, Subdistrict of Bungodani Rantau Ikil (MB 01) has a considerable genetic distance compared to the accession of other cinnamon plants, i.e. 37,34. According to Kuswandi, Sobir, and Suwarno[32] that accessions whose far genetic distances are potential to being used as elders in plant breeding programs, whereas accessions of a small genetic distance should be selected only one as germplasm collection material if the collection garden is limited.

4. Conclusion

Cinnamon plants cultivated in Jambi Province grow at different altitudes, ranging from an altitude of 67-1,400 m asl. There is a morphology diversity of cinnamon which can be seen from the form of a canopy, shoot color, base, length of the petiole, leaf length, leaf width, leaf length ratio and fruit length and skin thickness. Dendrogram of 17 accessions of cinnamon plant based on morphological character indicates that the accession of cinnamon plant tested varies morphologically with similarity coefficient ranged from 79.11 to 100. At the level of similarity of morphology 58.23 accessions are divided into two separate main groups based on qualitative and quantitative character differences.

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