

# Morphological Variation and Species Distribution of *Baccaurea dulcis* (Jack) Müll. Arg. in West Java, Indonesia

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## Abstract

*Baccaurea dulcis* is an underutilized plant, primarily grown for its fruit, distributed and cultivated only in Sumatra, Borneo and western part of Java Island, and its population is under threat. On the other hand, very few studies have been carried out of this species. The objective of this study was to estimate population distribution and ecology of *Baccaurea dulcis* in West Java, characterize plant morphological characters and correlate plant habitat of *B. dulcis* and the plant and fruit. In West Java *B. dulcis* is only distributed in the sub district Taman Sari of Bogor and sub district Cijeruk of Sukabumi. Even though the species in West Java has a restricted distribution, its morphological characters is quite varied, including size and nature of tree; color and texture of the bark; size and shape of leaves and fruits; color of fruit peel and pulp; and the size, shape and color of seeds. The species grow well in the low land (250 m - 610 m above sea level) of tropical region at neutral soil pH of regosol or latosol soil type and smooth rather coarse soil texture at land slope from 0 % until 45 %. Using 32 variables of trunk, leaf, fruit and seed, all samples could be clustered into 6 groups with the proportion correct 0.903 and with specific fruit characters in each group. There were some significant positive and negative correlations found between habitat and fruit characters and among tree and fruit variables.

**Keywords:** *Baccaurea dulcis*, underutilized tropical fruit, West Java, characterization, variation, clustering, correlation

## 1. Introduction

*Baccaurea dulcis* (Jack) Müll.Arg. is a dioecious plant species belonging to the family Phyllanthaceae (previously under Euphorbiaceae) (Haegens, 2000; Wurdack et al., 2004). Its common names are ketupa (English), cupa, tupa, kapul, menteng negri, menteng besar (Indonesian), tjupa, tupa (Malaysian). This species is distributed and cultivated only in Sumatra and western part of Java Island (Uji, 1992).

This species is primarily grown for its fruit. It is propagated mainly by seeds, but rarely by vegetative means. The tree produces fruits in high quantities and the fruits are usually taste sour or fairly sweet. The fruits can be pickled and used in stew or fermented to make wine (Uji, 1992; Munawaroh, 2001). The leaf of *B. dulcis* is boiled and the resulted decoction is used to treat stomachache during menstruation (Munawaroh, 2001). The tree trunk is used in construction (Heyne, 1987). The fruits of *B. dulcis* are rounded, with a diameter of 3.5 - 4 cm and brownish yellow in color. The edible arils are cream, white or reddish in color. Nutrition of fresh pulp of *B. dulcis* per 100 g were 82.3 g water, 0.4 g protein, 7.5 g saccharosa, 0.2 g fibers, 0.5 g ash, 5 mg vitamin C, 0 g vitamin B1 and B2 (Uji, 1992).

In general, the species is underutilized and used only locally. The species is usually grown in the home-yard and the fruits are usually self-consumed and rarely sold in local markets in West Java. Even though, the species is relatively known by the local people, but until now the distribution in West Java is only in very small areas. There is no information about the cultivation of the plant, reproductive period, growth pattern, pest and diseases and production and harvest of the species (Uji, 1992). Vegetative propagation of the species by shoot tip grafting could be applied, which almost 100 % success rate, whereas the airlayering propagation technique resulted only 27.5 % - 40 % of rooted shoot (Lestari, 2009, 2010). The risk of extinction of a fruit species is higher because there are not many people interested in the fruits and the fruits availability in the market is rare (Subekti et al., 2005). Field trips were conducted in West Java to study the species.

The aims of the study were (1) to find out the distribution of the species *Baccaurea dulcis* in West Java and to characterize the plants and fruits based on the morphology and qualitative parameter such as color and texture, (2) to find out the variation and clustering *B. dulcis* plants and fruits in West Java, and (3) to find out the correlation between the characters of the plants and fruits, and the plant's habitat.

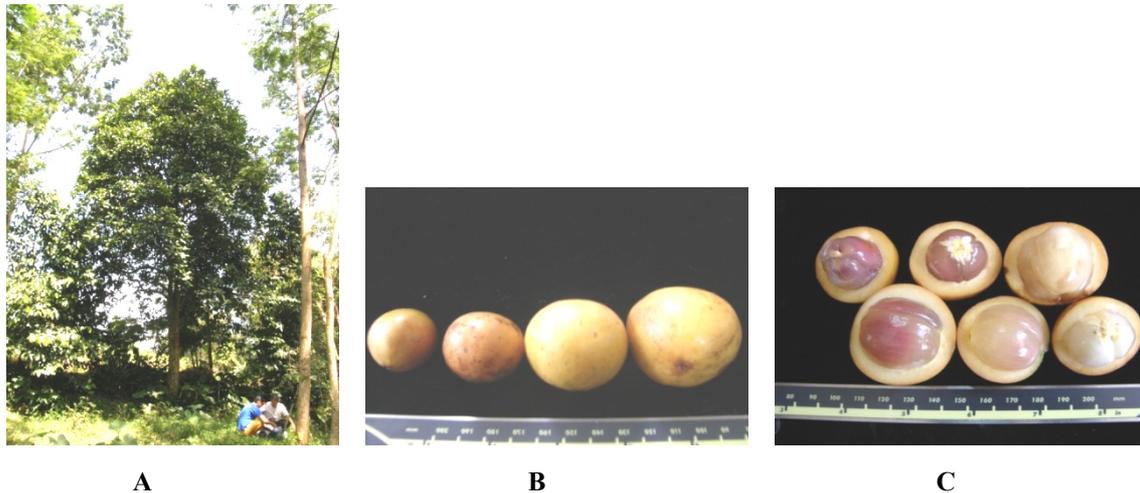


Figure 1. A. *Baccaurea dulcis* plant; B. and C. *B. dulcis* fruits

## 2. Materials and Methods

### 2.1 Distribution, Characterization and Variation of Plant and Fruit

Field trips, and ecological observations of *B. dulcis* focused on trees, fruits and their habitat and interviews with the farmers were conducted two days a week during the harvest period, starting from February until April 2008 mostly in Bogor, Cianjur, Sukabumi, Tangerang, Depok, Bekasi and Purwakarta of West Java, Indonesia (Figure 2).



Figure 2. Study site in West Java of Indonesia

The distribution of a total of 103 fruiting plants was recorded. The habitat of the plants and the variables of the tree and fruit were documented. The observation of the plant habitat included location of plant growth, altitude, longitude and altitude, air temperature, relative humidity, slope, light intensity, soil pH, soil relative humidity, soil type and soil texture/drainage. The distribution and habitat of the plant was also examined from the herbaria at the Bogor Herbarium (BO). Detail character variables of tree and fruit observed could be seen in Table 1.

As many as 30 fruits randomly were harvested from every plant observed, the minimum and maximum length and width of fruit and seed were measured. The fruits were grouped into 3 and each group of fruits was weighed to calculate the average fruit weight. Using kitchen knife, all of those fruits were peeled and then observed for the easiness to peel, the minimum and maximum amount of the pulp segment and the seed weight. The average of each of those parameters was calculated. The thickness of fruit peel and pulp, and soluble solid content of pulp were measured from 3 samples of fruits randomly. Some qualitative parameters were observed during the field trips and the result of the observation was ranked for the data analysis (Table 2).

Table 1. The Variables observed of trees and fruits of *B. dulcis* in West Java

No	Variables	No	Variables
1	Tree height	17	Fruit peel color
2	Trunk diameter	18	Easiness to peel the fruit
3	Canopy width	19	Thickness of fruit peel
4	Canopy condition (sparse/dense)	20	Peel weight per fruit
5	Lowest branch height	21	Pulp color
6	Bark color	22	The number of fruit segment
7	Bark texture	23	Soluble solid content of pulp
8	Leaf shape	24	Seed shape
9	Leaf length	25	Seed length
10	Leaf width	26	Seed width
11	The Ratio of maximum leaf length/leaf width	27	Ratio of the longest seed length/ seed width
12	Fruit shape	28	Seed weight
13	Fruit length	29	Percentage of peel weight per fruit
14	Fruit width	30	Percentage of pulp weight per fruit
15	The ratio of maximum fruit length/ fruit width	31	Percentage of seed weight per fruit
16	Fruit weight	32	<u>Seed color</u>

Table 2. Qualitative parameters and rank of qualitative number of the observation of *B. dulcis* trees, fruits and seeds in West Java

No	Qualitative parameter	Rank of Qualitative Number and Information
1	Canopy condition	(1) Dense, (2) Medium dense, (3) Sparse
2	Bark color	(1) Light brown/cream, (2) Medium brown, (3) Grey - medium brown, (4) Grey, (5) Browned - grey, (6) Grey, yellowed - medium brown, (7) Grey - dark brown, (8) Dark brown, (9) Browned - black
3	Bark texture	(1) Smooth, (2) Flaky - smooth, (3) Lenticelate, (4) Flaky - lenticelate, (5) Lump - flaky, (6) Flaky, (7) Flaky - fissured, (8) Flaky - rectangular
4	Fruit peel color	(1) Yellow, (2) Light orange/Yellowish orange, (3) Orange/ dark orange, (4) Reddish yellowish - orange
5	Easiness to peel the fruit	(1) Easy, (2) Medium, (3) Difficult
6	Fruit pulp color	(1) White, (2) Transparent - white, (3) Cream, (4) Pink, transparent - cream, (5) Pink, white - transparent, (6) Cream - transparent, (7) Pink - transparent, (8) Pinked/purpled lines - cream/white
7	Seed color	(1) Light brown, (2) Pink - light brown, (3) Brown, (4) Pink - brown, (5) Purplish - brown, (6) Light brown - Pink, (7) Pink

## 2.2 Measurement Equipments

The equipment used during the observation were GPS Garmin (latitude), Termohyrometer Haar-Synth-Hygro, Germany (air temperature and relative humidity), Soil tester TEW Type 36, Demetra, Japan (soil pH and relative humidity), Clinometer, Suunto PM-5/360, Finland (slope), Light meter, LX-101 A, Lutron, Taiwan (light intensity), Altimeter (altitude). Other equipment used are to measure the tree height (BL 6, Carl Leiss, Berlin, Germany), the diameter of trunk, fruit and seed (diameter tape 20 m x 5 m, Tool No. D-5M, YAMAYO, Japan), canopy width (Tape measure, 50 m), the width of fruit and seed (Digital caliper, 200 mm, Mitutoyo CO., Japan), the fruit and seed weight (Balance, capacity 2 kg), Soluble solid content (Digital refractometer, Palette Series PR 101  $\alpha$ , ATAGO CO., LTD, Japan)

## 2.3 Statistical Analysis of the Data

As many as 32 tree and fruit variables observed from 103 numbers of *B. dulcis* in West Java were clustered to find out the groups based on the similarity characters using the MINITAB program version 14. The variables chosen were those that are not influenced by the age of the tree observed. Those variables were bark color and texture, maximum and minimum of leaf length and width, ratio of maximum leaf length and width, maximum and minimum of fruit length and width, ratio of maximum fruit length and width, fruit weight, peel color, easiness to peel the fruit, maximum and minimum of thickness of peel, peel weight, pulp color, maximum and minimum number of fruit segment, soluble solid content of pulp, maximum and minimum of seed length and width, ratio maximum seed length and width, seed weight, percentage of peel, pulp and seed weight per fruit and seed color. The qualitative parameters and detailed rank of qualitative number and information of the observation of *B. dulcis* trees, fruits and seeds for clustering are shown in Table 2.

The same variables were also tested by Linier Discriminant Analysis using the MINITAB program version 14 to find distinctive characteristic of each group. The correlations between the tree and fruit variables and its habitat as well as among the trees and fruits variables were tested using the statistical MINITAB program version 14.

## 3. Results and Discussion

### 3.1 Distribution, Characterization and Variation of *Baccaurea dulcis* in West Java

From the study of herbaria, it was known that *Baccaurea dulcis* is distributed in Sumatra, Borneo and Western part of Java. In Sumatra, the species is distributed in Palembang, Lampung, Riau, Payakumbu, Bangka, Siberut and Jambi, whereas in Borneo, the species was spread in Ketapang, Gunung Palung National Park, Sarawak, and West Samarinda. In West Java, the species was found in Batutulis and Kotabatu of Bogor. Most of the herbaria observed were collected by Dutch explorers long time ago, before or in the early to mid 1900's. Therefore, the distribution of the species at present including in Sumatra and Borneo may have changed. Indeed, increasing human population and land-use intensification resulted in the loss habitats and increasing species extinction rates. Several strong climate oscillation and disaster could affect vegetation shape and species distribution (Ounsavi & Sokpon, 2010). Whereas in West Java at the moment, there is no *B. dulcis* plant found in Batutulis and Kotabatu anymore.

From the field trips and observation in West Java, it is known that besides as collection in the botanical garden, the distribution of *B. dulcis* in West Java was only in sub districts Taman Sari of Bogor district and Cijeruk of Sukabumi district. The result showed that the occurrence of the species in West Java is only in very restricted areas. According to people in the local areas, the species used to abundant in the past, including in other villages of Bogor district. However, people usually cut the trees and used the trunk for many purposes such as material for building/house and equipments. On the other hand, the species is rarely planted. The plants usually grew from seeds that drop at the surrounding of the mother plants. The risk of extinction of the plant species is high because there were not many people interested in the fruits. Therefore, conservation and development of species to become more commercialized are needed.

The results of the characterization of trees and fruits of *B. dulcis* and plant habitat can be seen in Table 3. The plants were only found in the home-yard, small garden or botanical garden at an altitude range of 250 m - 610 m above sea level, this means that the species could grow well and be planted in relatively low lying areas. From Table 3, it is also known that the trees grow well in the tropical region at neutral soil pH of regosol or latosol soil type and smooth until rather coarse soil texture at land slope from 0% until 45%. From the study of herbaria, it is also known that the species grew well in gully river bank, in hillside of primary forest, swampy places, riverside and also cultivated at "kampoeng" or remote village. The plants could grow at the location until 1100 m above sea level at sandyloam soil and swampy places.

From the observation and measurement results, the morphological characters of *B. dulcis* were various (Table 3).

Those included nature of tree, color and texture of the bark, size and shape of leaves and fruits, color of fruit peel and pulp and the size, shape and color of seeds. It is clear from the study that there is considerable phenotypic variation in almost every parameter observed and measured. Similar to another study on the variation of fruit of *Irvingia gabonensis*, an indigenous fruit tree of west and central Africa, there were significant variation in fruit, nut and kernel size and weight (Leakey et al., 2000). Differences were also identified in shell weight and brittleness, fruit taste, fibrousness and pulp color (Leakey et al., 2000). Salisbury (1942) mentioned that seed size varies tremendously among plant species and was investigated early as a life-history trait of obvious importance. Variation in seed size and weight of *Desmodium paniculatum* (Leguminosae) was also reported in a population in two locations in North Carolina, USA, which caused by environmental conditions and nutrient supply (Wulff, 1986). The result of other study on population of a single seeded fruit *Ocota tenera* (Lauraceae) from Monteverde, Costa Rica showed that the fruits that vary from 1.4 to 2.4 cm and much variation occurred within individual trees (Wheelwright, 1993). The relative size of fruits produced by different trees remained generally constant over an 11-year period despite slight differences between years in the average size of fruits produced by a given tree (Wheelwright, 1993)

Table 3. Character and variation of *B.dulcis* trees and fruits in West Java and the plant habitat

No	Data Recorded	Measurement/Description
<b>Habitat</b>		
1	Location of the plant	Homeyard, small people's garden, Botanical garden
2	Altitude	320 - 610 m above sea level
3	Longitude and Latitude	06° 34'49.7"- 06° 40' 06.9" and 106° 43' 55.9"- 106° 49' 25.0"
4	Air temperature	18 °C - 33 °C
5	Relative humidity	59 % - 100 %
6	Slope	0 % - 45 %
7	Light intensity	341 - 299,000 lux
8	Soil pH	5.8 - 7
9	Soil relative humidity	17 % - 90 %
10	Soil type	Brown regosol and red-brown latosol
11	Soil texture	Smooth-rather coarse
<b>Morphology of Tree and Fruit Measurement/Description</b>		
12	Tree height	4.5 - 21 m
13	Trunk diameter	10.5 cm - 80.5 cm
14	Canopy width	3.2 m - 13.2 m
15	Canopy condition	Sparse - Medium - Dense
16	Lowest branch height	0.55 m - 7.0 m
17	Bark color	Light brown/cream, Medium brown, Grey-medium brown, Grey, Browned-grey, Grey, yellowed-medium brown, Grey-dark brown, Dark brown, Browned-black
18	Bark texture	Smooth, Flaky-smooth, Lenticelate, Flaky-lenticelate, Lump-flaky, Flaky, Flaky-fissured, Flaky-rectangular
19	Leaves shape	Obovate, lanceolate
20	leaf length	7.7 cm - 30 cm
21	Leaf width	3.1 cm - 14.9 cm
22	Ratio maximum leaf length/maximum leaf width	2.01

23	Fruit shape	Rounded, slightly oval, or truncate at one end
24	Fruit length	2.4 cm - 4.6 cm
25	Maximum fruit width	4.8 cm
26	Ratio of fruit length/ fruit width	2.2 cm
27	Length of main fruits stalk	0.65 cm - 10.67 cm
28	Length of branch fruit stalk	2.02 mm - 14.7 mm
29	Fruit weight	7.0 - 38.33 g
30	Fruit peel color	Yellow, Light orange/Yellowish orange, Orange/dark orange, Reddish yellowish-orange
31	Easiness to peel the fruit	Easy-difficult
32	Fruit peel thickness	1.65 mm - 9.72 mm
33	Peel weight per fruit	4.17 gr - 23.67 gr
34	Pulp weight	1.56 mg - 15.26 mg
35	Pulp color	White, Transparent-white, Cream, Pink, transparent-cream, Pink, white-transparent, Cream-transparent, Pink-transparent, Pinked/purpled lines-cream/white
36	Fruit pulp segment	1 - 6
37	Soluble solid content of pulp	11 Brix - 20 Brix
38	Seed shape	Ovate, thin, 1 - 6 curves
39	Seed length	0.75 cm - 2.31 cm
40	Seed width	0.52 - 1.95 cm
41	Seed thickness	1 - 4 mm
42	Ratio of longest seed length/ seed width	1.18
43	Seed weight	0.12 mg - 0.74 mg
44	Percentage of peel weight per fruit	36.64 % - 78.31 %
45	Percentage of pulp weight per fruit	26 % - 63 %
46	Percentage of seed weight per fruit	1.17 % - 2.96 %
47	Seed color	Light brown, Pink-light brown, Brown, Pink-brown, Purplish-brown, Light brown-Pink, Pink
48	Fruit production per tree	5 kg - 200 kg

### 3.2 Clustering of *Baccaurea dulcis* Variation in West Java

Using 32 variables of trunk, leaf, fruit and seed, all samples could be clustered into 6 groups with the proportion correct 0.903 (Figure 4, Table 5). As can be seen at Table 4, the characters that belong to group 1 were small and light fruit, light fruit peel, small seed and sweeter fruit taste, whereas those of group 2 were fruit pulp color white/transparent, small seed, low portion of fruit pulp and high portion of fruit peel. Group 3 belongs to the tree and fruit of *B. dulcis* with the characters of big and heavier fruit, high portion of fruit pulp, more heavy seed, more segment of fruit pulp (Table 4). The characters of group 4 were thin and light fruit peel, more segment of fruit pulp, high portion of fruit pulp, low portion of fruit peel, color of fruit pulp reddish/purple. Group 5 were characterized by big and more heavy fruit, thick and more heavy fruit peel, fruit pulp color white/transparent, big seed and high portion of fruit pulp, whereas group 6 were characterized by light fruit, sour taste, small seed, color of fruit pulp reddish or purple (Table 4). Another study on the variation of pomelo (*Citrus grandis*) in Nepal found that from the multivariate analysis of the data produced five discrete groups, which differed significantly in fruit shape and size, pulp, juice, total soluble solids and acid content, seed number, leaf shape and size (Paudyal & Haq, 2008).

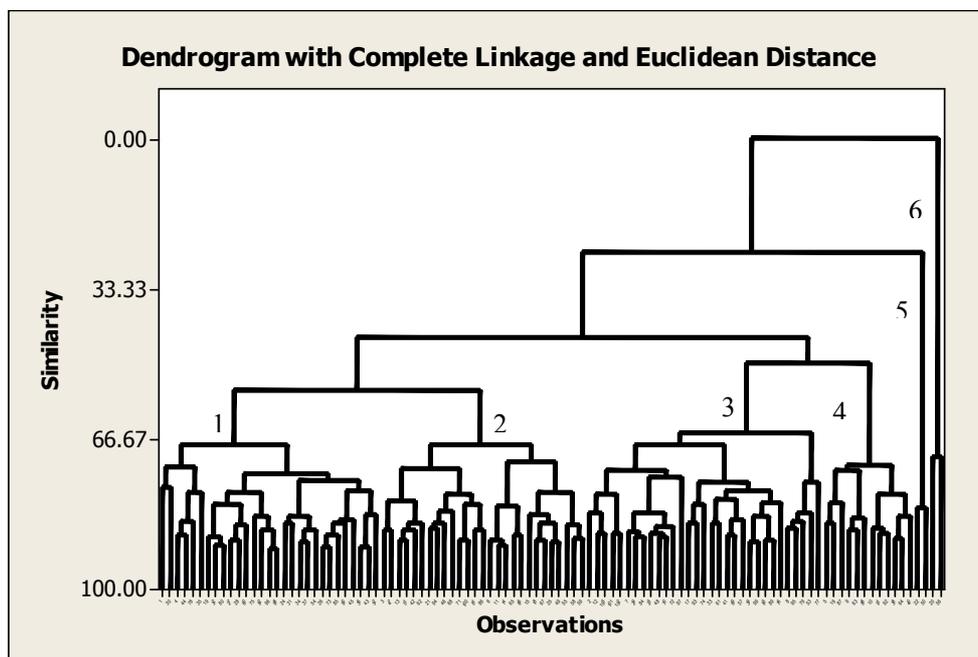


Figure 3. Dendrogram of *B. dulcis* in West Java based on the similarity variables

Table 4. Average value of characteristic component of 6 groups *B. dulcis* in West Java

Characteristic variable	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Population mean
Bark color	2.90	3.09	3.73	1.60	4.50	4.00	3.32
Bark texture	4.79	4.74	5.31	5.60	5.25	5.00	5.01
Leaf length	21.75	23.09	22.78	21.58	23.46	20.23	22.49
Leaf width	10.68	10.68	10.65	9.80	10.90	9.65	10.62
Fruit size	35.94	37.12	39.60	38.26	41.87	36.80	38.01
Fruit weight	18.44	21.18	26.44	22.95	31.96	20.01	23.03
Peel color	2.39	2.82	2.55	2.40	2.75	2.75	2.60
Peel thickness	6.50	6.94	6.27	5.29	7.87	6.39	6.65
Peel percentage	58.25	65.92	54.39	46.81	62.23	59.9	59.26
Pulp percentage	39.84	32.33	43.85	51.45	36.27	38.20	38.97
Minimum pulp segment	1.7	1.7	2.0	2.4	1.8	1.8	1.8
Maximum pulp segment	3.5	3.4	3.7	3.6	3.3	3.3	3.5
Pulp color	3.03	2.96	3.86	3.80	2.75	4.25	3.27
SSC*	16.51	15.55	15.82	15.72	15.69	14.69	15.88
Seed length	16.9	17.0	18.0	18.1	18.6	17.0	17.5
Seed width	12.6	13.0	14.1	13.9	14.1	13.6	13.4

\*SSC = Soluble solid content of fruit pulp.

Table 5. Results of test of correctness based on discriminant analysis for summary of classification

Put into Group	True Group					
	1	2	3	4	5	6
1	28	2	2	0	0	0
2	0	23	0	0	0	1
3	0	0	23	0	1	0
4	0	0	1	5	0	0
5	0	0	0	0	11	0
6	1	2	0	0	0	3
Total N	29	27	26	5	12	4
N correct	28	23	23	5	11	3
Proportion	0.966	0.852	0.885	1.000	0.917	0.750

Note: N = 103, N Correct = 93 and Proportion Correct = 0.903.

### 3.3 Correlations Among Habitat, Plant and Fruit Variables

The result of the statistical data analysis for significant correlation between plant habitat and variables of tree and fruit could be seen in Table 6. There was one significant positive correlation and nine significant negative correlations known. The positive correlation was between slope and fruit pulp color, whereas significant negative correlation were between altitude and pulp weight; light intensity and pulp soluble solid content (SSC); soil pH and number of pulp segment; soil texture and trunk diameter, canopy width, pulp color, pulp weight, peel weight portion; drainage and number of pulp segment (Table 6).

This findings could indicate that higher slope the plant grow, the pulp color of the fruit tend to be pink or purple. On the other hand, higher the altitude of the plant position could correlate with less weight of the fruit pulp; more light intensity could correlate with less pulp SSC. Light intensity could have an effect on the pulp color and pulp SSC, while air temperature could affect the weight of fruit pulp.

The other significant negative correlation indicated that higher soil pH correlates with less pulp segment; more coarse the soil texture correlates with less trunk diameter, less canopy width, more white/transparent pulp color, less pulp weight, less peel portion; higher soil drainage correlates with less number of pulp segment. The soil texture and soil drainage could correlate with the soil fertility condition, which then could affect the size of the plant. Other study on pomelo (*Citrus grandis*) in Nepal found that yield related characters, such as fruit weight had positively correlated with tree size and soil fertility level, but none of these factors were correlated with fruit quality, such as percent of pulp and pulp SSC (Paudyal & Haq, 2008)

Table 6. Significant correlation between plant habitat and variables of *Baccaurea dulcis*

Plant/Habitat	Altitude	Slope	Light intensity	Soil pH	Soil Texture	Drainage
Trunk Diameter	-0.094	0.077	0.073	0.123	-0.199*	-0.098
Canopy width	0.011	0.029	-0.070	-0.081	-0.200*	-0.024
Pulp color	-0.213	0.226*	-0.056	-0.166	-0.205*	-0.137
Minimum number of pulp segment	-0.047	0.070	-0.133	-0.223*	0.180	0.006
Maximum number of pulp segment	0.120	-0.168	0.079	0.110	-0.004	-0.194*
Pulp soluble solid content	0.106	0.135	-0.208*	0.047	0.166	0.086
Pulp weight	-0.246*	0.007	0.058	-0.006	-0.261*	-0.154
Peel weight portion	-0.155	0.016	-0.071	0.093	-0.294*	-0.063

\* Significant correlation.

It could be seen at Table 7 that there was significant correlation among the variable of *B. dulcis* trees and fruits in West Java. Significant positive correlations were found between (1) Canopy diameter and trunk width; (2) Maximum fruit width and fruit weight, pulp thickness, peel color, peel thickness, pulp soluble solid content (SSC), seed length, seed width, seed weight; (3) Maximum fruit length and seed weight per fruit; (4) Fruit weight and peel color, peel thickness, pulp SSC, seed length, seed width, seed weight; (5) Pulp thickness and peel weight, pulp SSC, seed width, seed weight; (6) Easiness to peel and peel color; (7) Peel color and peel thickness; (8) Peel thickness and pulp SSC, seed length, seed width, seed weight, pulp portion; (9) Pulp color and seed weight, pulp weight; (10) Pulp SSC and seed width; (11) Maximum seed length and maximum seed width, seed weight; (12) Maximum seed width and seed weight.

The results of positive significant correlation among the variable of *B. dulcis* trees and fruits in West Java (Table 7) indicate that the trunk width is in accordance with canopy diameter; the fruit size is in accordance with size of seed, peel and pulp; more difficult to peel the fruit correlates with more red/orange peel color and more thick the peel.

On the other hand, the significant negative correlation among the variable of *B. dulcis* trees and fruits in West Java (Table 7) were between (1) Peel weight and tree height, trunk diameter, peel color, pulp color; (2) Pulp thickness and easiness to peel, peel portion; (3) Easiness to peel and pulp color, maximum pulp segment, pulp SSC, maximum seed length, seed weight per fruit, pulp weight per fruit; (4) Peel color and peel weight, pulp weight per fruit, peel portion; (5) Peel thickness and pulp weight, peel portion; (6) Pulp color and pulp SSC; (7) Maximum pulp segment and easiness to peel, pulp SSC, maximum seed width; (8) Seed weight and pulp weight per fruit; (9) Pulp weight per fruit and leaf length, leaf width, easiness to peel, peel color, peel thickness, pulp portion; (10) Peel portion and leaf length, leaf width, fruit length, fruit width, fruit weight, pulp thickness, peel color, peel thickness, seed weight per fruit.

The result of significant negative correlation among the variable of *B. dulcis* trees and fruits in West Java (Table 7) indicates the composition of fruit parts is in accordance; more weight of fruit peel correlate with smaller tree and more dull peel and pulp color; more thick the pulp, more difficult to peel the fruit; more red/purple pulp color less sweet of the pulp; more weight of pulp and peel portion correlates with less size of leaf. Other study regarding fruit variation of *Irvingia gabonensis*, an indigenous fruit tree of West and Central Africa found that there were very weak relationship between fruit size and weight with nut and kernel size and weight (Leakey et al., 2000).

Table 7. Significant correlation among the variables of *Baccaurea dulcis* trees and fruits from West Java

CODE	X1	X2	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19	X20	X21
X3	0.54	<b>0.67*</b>	0.135	0.149	0.082	-0.146	-0.042	-0.077	0.091	-0.082	0.049	<b>-0.24*</b>	-0.094	0.135	0.089	0.108	-0.106	0.009	-0.032	0.067
X9	0.01	-0.03	-0.18	0.18	0.08	0.72	<b>0.75*</b>	1	0.243	<b>-0.19*</b>	0.079	<b>0.22*</b>	<b>0.90*</b>	0.068	0.103	0.046	-0.109	<b>0.41*</b>	<b>0.52*</b>	<b>0.60*</b>
X10	0.05	0.14	0.13	0.04	-0.07	0.24	<b>0.22*</b>	0.24	1	<b>-0.30*</b>	0.08	<b>0.23*</b>	0.01	-0.01	-0.10	<b>0.32*</b>	0.11	<b>0.11*</b>	<b>0.18*</b>	0.01
X11	-0.18	-0.21	-0.08	0.08	0.10	-0.13	-0.16	-0.19	<b>-0.30*</b>	1	<b>0.20*</b>	-0.09	0.11	<b>-0.21*</b>	<b>-0.28*</b>	<b>-0.19*</b>	<b>-0.23*</b>	-0.06	<b>-0.27*</b>	<b>-0.20*</b>
X12	-0.08	-0.14	-0.13	0.08	0.18	0.32	<b>0.31*</b>	<b>0.22*</b>	0.08	<b>0.20*</b>	1	<b>0.39*</b>	<b>-0.18*</b>	-0.11	-0.03	0.07	0.07	0.06	-0.07	<b>-0.39*</b>
X13	-0.01	-0.02	<b>-0.17*</b>	0.25	0.18	0.69	<b>0.71*</b>	<b>0.90*</b>	<b>0.23*</b>	-0.09	<b>0.39*</b>	1	0.01	-0.03	-0.11	<b>0.33*</b>	<b>0.41*</b>	<b>0.48*</b>	<b>0.48*</b>	<b>-0.36*</b>
X14	<b>-0.19*</b>	<b>-0.22*</b>	-0.09	-0.07	-0.10	0.08	-0.06	0.07	0.01	0.11	<b>-0.18*</b>	0.01	1	<b>-0.23*</b>	-0.15	-0.06	0.08	0.10	0.12	0.14
X15	0.06	0.02	0.06	0.11	0.10	-0.02	0.12	0.10	-0.01	<b>-0.21*</b>	-0.11	-0.03	<b>-0.23*</b>	1	0.02	0.02	0.15	-0.02	<b>0.25*</b>	<b>0.28*</b>
X16	-0.12	0.07	0.09	-0.09	-0.04	-0.04	-0.02	-0.11	-0.10	<b>-0.28*</b>	-0.03	-0.11	-0.15	0.02	1	<b>-0.22*</b>	-0.09	<b>-0.18*</b>	-0.07	0.03
X17	0.18	0.13	-0.10	-0.03	-0.09	0.47	<b>0.33*</b>	<b>0.41*</b>	<b>0.32*</b>	<b>-0.19*</b>	0.07	<b>0.33*</b>	-0.06	0.02	<b>-0.22*</b>	1	0.11	<b>0.29*</b>	0.38	0.10
X18	0.00	-0.09	-0.06	0.08	0.10	0.43	<b>0.61*</b>	<b>0.52*</b>	0.11	<b>-0.23*</b>	0.07	<b>0.41*</b>	0.08	0.15	-0.09	0.11	1	<b>0.53*</b>	<b>0.49*</b>	0.13
X19	0.07	-0.06	-0.07	0.00	-0.07	0.40	<b>0.55*</b>	<b>0.60*</b>	<b>0.11*</b>	-0.06	0.06	<b>0.48*</b>	0.10	-0.02	<b>-0.18*</b>	<b>0.29*</b>	<b>0.53*</b>	1	0.13	-0.14
X20	0.03	-0.02	-0.13	0.04	-0.07	<b>0.54*</b>	<b>0.55*</b>	<b>0.82*</b>	<b>0.18*</b>	<b>-0.27*</b>	-0.07	<b>0.48*</b>	0.12	<b>0.25*</b>	-0.07	0.38	<b>0.49*</b>	<b>0.54*</b>	1	0.62
X21	0.02	-0.01	0.01	<b>-0.18*</b>	<b>-0.24*</b>	-0.02	-0.04	0.08	0.01	<b>-0.20*</b>	<b>-0.39*</b>	<b>-0.36*</b>	0.14	<b>0.28*</b>	0.03	0.10	0.13	0.13	0.62	1
X22	-0.02	0.01	-0.02	0.19	0.24	0.04	0.06	-0.05	-0.01	0.19	0.40	<b>0.39*</b>	-0.14	<b>-0.27*</b>	-0.03	-0.09	-0.13	-0.14	-0.60	<b>-1.00*</b>
X23	0.10	0.00	0.24	<b>-0.21*</b>	<b>-0.13*</b>	<b>-0.46*</b>	<b>-0.33*</b>	<b>-0.56*</b>	<b>-0.12*</b>	0.16	<b>-0.20*</b>	<b>-0.55*</b>	0.00	-0.14	-0.06	-0.19	-0.09	0.31	<b>-0.41*</b>	0.03

Note: \* Significant correlation.

X1 = Tree height, X2 = Trunk diameter, X3 = Canopy width, X4 = Lowest branch height, X5 = Maximum leaf length, X6 = Maximum leaf width, X7 = Maximum fruit length, X8 = Maximum fruit width, X9 = Fruit weight, X10 = Pulp thickness, X11 = Easiness to peel, X12 = Peel color, X13 = Peel thickness, X14 = Peel weight, X15 = Pulp color, X16 = Maximum pulp segment, X17 = Pulp SSC, X18 = Maximum seed length, X19 = Maximum seed width, X20 = Seed weight per fruit, X21 = Pulp weight per fruit, X22 = Pulp portion, X23 = Peel portion

#### 4. Conclusion

This paper explored the distribution and variation of *Baccaurea dulcis* (Jack) Müll. Arg. in West Java, Indonesia. The population of the species is under threat. The species has restricted distribution, however the morphological characters were various. Therefore, its conservation is needed. Further study on the influence of genetic and environment aspects to the variation of the species is also important. Moreover, other interesting topic should be gaining high quality of fruits to become more commercialized one.

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## Supplemental Tables

Supplemental Table 1. Linear Discriminant Function for Groups

Variables	Groups					
	1	2	3	4	5	6
Constant	-1.919	-2.066	-3.039	-8.559	-7.571	-6.580
C42	-0.701	-0.243	0.497	-0.123	1.011	0.612
C43	0.138	-0.279	0.046	1.101	-0.265	0.003
C44	-0.261	1.509	-0.645	-3.309	-0.209	0.669
C45	0.716	-3.269	1.334	<b>10.999</b>	1.320	<b>-9.505</b>
C46	-0.278	-0.887	0.650	1.976	0.651	-0.648
<b>C47</b>	-0.952	3.241	-0.800	<b>-11.732</b>	-1.707	<b>10.016</b>
<b>C48</b>	-1.293	2.705	-0.626	<b>-8.412</b>	-0.576	<b>7.426</b>
C49	-1.914	0.208	-0.190	2.227	3.198	1.330
C50	<b>-4.671</b>	<b>-3.609</b>	<b>6.154</b>	<b>8.508</b>	<b>4.450</b>	<b>-5.760</b>
C51	0.394	-1.632	2.082	0.206	-1.029	-2.545
C52	3.520	3.502	-5.073	-7.086	-4.258	5.448
C53	3.893	2.359	-3.890	-7.533	-4.531	4.152
<b>C54</b>	<b>-7.480</b>	<b>-4.515</b>	<b>18.165</b>	<b>23.060</b>	<b>-10.383</b>	<b>-31.038</b>
C55	-0.480	0.501	-0.218	-0.889	0.629	0.742
C56	0.151	0.421	-0.730	0.411	0.044	0.167
C57	0.271	-0.621	0.065	0.541	0.443	-0.203
C58	-0.446	0.468	-0.049	-1.910	0.835	0.274
<b>C59</b>	<b>5.645</b>	<b>6.563</b>	<b>-21.309</b>	<b>-26.441</b>	<b>16.976</b>	<b>35.403</b>
C60	-0.337	-0.352	0.742	1.158	-0.446	-0.112
C61	-0.100	0.609	-0.255	-0.398	-0.581	0.513
C62	0.223	-0.062	0.091	-0.813	0.007	-0.792
C63	0.362	-0.779	0.318	0.320	0.405	-1.047
C64	-0.398	-0.417	0.057	0.212	1.121	1.701
C65	<b>-0.587</b>	<b>1.870</b>	<b>-3.977</b>	<b>-3.173</b>	<b>5.852</b>	<b>3.893</b>
C66	-0.317	0.176	-0.681	-2.298	2.935	-0.393
C67	0.442	-1.600	2.808	3.369	-4.489	-1.398
C68	0.899	-1.967	4.179	3.417	-6.527	-5.095
C69	1.965	-1.866	1.869	-0.756	-3.015	-3.816
C70	40.719	-21.741	12.235	1.751	-60.747	-47.938
C71	38.601	-21.998	18.918	8.233	-67.798	-61.238
C73	-0.658	0.215	0.307	0.604	0.063	0.383

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