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Morphological characterization of Lanzones (*Lansium domesticum)* accessions at the fruit crops nursery, University of the Philippines Los Baños

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Abstract This study evaluated the morphological and physiological traits of 29 lanzones (*Lansium domesticum*) accessions from four varieties: 'Longkong', 'Duku', 'Mindanao', and 'Paete'. Most accessions exhibited verticillate and irregular branching, except 'Longkong 3', 'Longkong 4', and 'Mindanao 1', which showed pyramidal forms. All accessions had elliptic leaflets with broadly acuminate tips and cuneate bases, though leaflet size and area varied due to environmental factors such as light, soil type, and water availability. 'Longkong' accessions had the highest chlorophyll content, indicating greater photosynthetic efficiency and growth potential. In fruit morphology, 'Duku' produced the heaviest bunches, while 'Longkong' had more compact clusters. Taste differences were also observed, with 'Paete' being sweet to sour while 'Longkong' and 'Duku' mainly sweet. Significant variation occurred in fruit size, weight, peel thickness, aril characteristics, seed number, and total soluble solids. These variations are influenced by both genetic and environmental factors, including parthenocarpy, apomixis, and natural hybridization. While vegetative traits were mostly similar, differences in physiological and fruit traits provide essential information for cultivar improvement and enhanced lanzones production.

Keywords: Variety identification, *Lansium*, Morphological characteristics

Introduction

Lansium domesticum Correa is an important fruit tree and a highly variable species belonging to the family *Meliaceae* with different forms that have been classified by some taxonomists as distinct species. In Southeast Asia, the plant has numerous common names, which is known as *duku*, *kokosan* and *langsat* (Indonesia); *duku*, *langsak* (Burmese); *buahan*, *lansone*, *lansones*, *lanzon*, *lanzones* (Philippine); *langseh*, *langsep*, *lansa* (Malay); *duku*, *langsat*, *longkong* (Thai) and *Bòn-bon* (Vietnamese). It still occurs wild or naturalized in these areas and is one of the major cultivated fruits. The greatest producers of *Lansium. domesticum* are Malaysia, Thailand,

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Philippines and Indonesia. This tree is also cultivated on a small scale in countries such as Vietnam, Burma, India, Sri Lanka, Hawaii, Australia, Surinam, and Puerto Rico (Yaacob and Bamroongrugsa, 1991; Lim and Lim, 2012).

In the Philippines, lanzones are a popular dessert choice, loved for their sweet yet mildly tangy flavor that consumers never seem to tire of. However, the milky sap from the skin and the bitter seeds can sometimes discourage people outside the tropics from eating them. The most important cultivars of lanzones in the Philippines are 'Paete,' 'Jolo/Mindanao,' 'Duku' (Coronel, 1983), and Thailand's 'Longkong.'. It is now considered a priority High-Value Commercial Crops (HVCC) of the Philippines along with mango, pineapple, coconut, banana, vegetable, and rubber. In 2019, the Philippines recorded 19,974 metric tons of volume of production. For Calabarzon, the total area planted for lanzones was 4,384 hectares which is second only to Bangsamoro Autonomous Region in Muslim Mindanao (BARMM) (PSA, 2017).

Evaluation and characterization of crops are both significant to agriculture, especially in maintaining genetic resources for crop improvement. Characterization of crops through morphological, physiological, and agronomic traits has long been used in plant breeding for crop improvement (Lutatenekwa *et al.*, 2020). Characterization determines the expression of highly heritable traits which range from morphological to agronomic features. Additionally, evaluation is also described as the process of identifying traits that are crucial for crop improvement but are also susceptible to environmental effects.

Botanical descriptions of *L. domesticum* and its varieties have been made by several authors. Corner (1988) described and compared the gross morphology of the two better-known Malaysian varieties of this species, ‘Langsat’ and ‘Duku’. In his *Flora of the Malay Peninsula*, Ridley (1922) described the leaves of *Lansium domesticum* as glabrous, but he did not clarify whether this referred to the upper or lower surface of the leaves. Yee and Rao (2013) reported that the lower leaf surfaces of 'Langsat' are pubescent, while those of 'Duku' are glabrous. Quantitative traits, such as stem diameter, vary widely, likely due to environmental factors like location, treatment methods, and microclimatic differences. It is different from the qualitative characters that are not influenced by the environment, these characters are purely controlled by genetics (Sayetki *et al.*, 2021).

Some of the key factors for the improvement of lanzones production are the availability of improved planting materials and the addition of research and development by the government. Grafting is the common method of producing new vigorous and quality seedlings of lanzones cultivar. To ensure the quality of the planting materials, it is highly recommended to establish the identity and characteristics of the scion and seedling materials. Therefore, it is imperative to develop a reliable identification technique for the germplasm

collection of lanzones in the nursery to ensure a continuous supply of authenticated planting materials for fruit growers.

This approach may increase farm production, indirectly rehabilitate/replace the old trees in growing areas specifically in the CALABARZON, and hopefully meet the growing demand for lanzones in the years to come. Oftentimes, identification of a variety is difficult due to its similarity in appearance. Morphological criteria are usually employed to measure the similarities/differences among the species/varieties. It has been popularly used for taxonomic classification and diversity analysis in the germplasm of different crops by many researchers. This traditional approach of recording basic morphological characteristics is important for the registration of varieties and the primary requirements of Intellectual Property Rights (IPR) and the Plant Variety and Farmer's Right Protection Act (PVFRPA). Growers of this fruit routinely do the tasting of leaves as a way of screening before planting in the field. However, this technique is not reliable. The objective of this study was to distinguish and discriminate lanzones varieties based on morphological characterization.

Materials and methods

Experimental sites

This study was conducted at the Lanzones Orchard and Fruit Crops Nursery, Institute of Crops Science, College of Agriculture and Food Science, University of the Philippines Los Baños, College, Laguna with an elevation of 300 meters above sea level.

Procedure

The experimental tools were a Royal Horticultural Society Color Chart, tagged ribbon, refractometer, SPAD, budding knife, ladder, tape measure, measuring ruler, digital caliper, camera, and plastic. Sampling was done using exploration using the purposive sampling method, followed by the inventory of plants. Specimens obtained in the field were taken especially from the main organs of the plants such as leaves and fruit for further identification. Selected morphological traits for the characterization of lanzones accessions were used as a guide in assessing the phenotypic differences among the varieties based on IPGRI (2002); Hanum *et al.* (2013); and Efendi *et al.* (2022).

Since morphological data are a mixture of both quantitative and qualitative information, the Gower index was used to determine the distance between each variety. The quantitative data was scaled using the use of library ‘agricolae’ (de Mendiburu, 2020) in R Statistical Software version 4.3.1 (Beagle Scouts). For qualitative characters, traits observed and collected

were the following: branching pattern, the surface of the stem, leaf color, leaf shape, leaf tip, leaf base, leaf surface, leaf variation, fruit shape, and fruit color. In quantitative characters such as leaflet length, leaflet width, chlorophyll content using SPAD, fruit TSS, fruit weight, bunch weight, fruit length, fruit width, peel thickness, peel weight, aril weight, aril thickness, number of seeds per fruit, and percent success of cleft grafting (Table 1). The mean and standard deviation of each quantitative character would also be calculated. For cleft grafting, twenty scions for each variety were collected from the scion trees and used in grafting in "Mindanao" lanzones seedlings as rootstock.

Nine scion trees of 'Duku' variety, 7 'Longkong' variety, 8 'Paete' and 5 'Mindanao' varieties of Lanzones that are available at the Fruit Crop Nursery and Lanzones Orchard of ICropS, UPLB were selected in this experiment. These scion trees were identified and tagged on the existing list accession numbers. Tagging of lanzones trees was done using color ribbons that corresponded to 'Duku', 'Longkong', 'Paete', and 'Mindanao' varieties.

Table 1. The qualitative and quantitative characteristics of *Lansium domesticum* were observed in the study

Organ	**Characters**	
	Qualitative	**Quantitative**
Stem	Branching Pattern	Stem Girth (cm)
	Surface of the Stem	Percent success on grafting
		Union graft diameter
		Number of leaves
Leaves	Leaf Shape	Leaf length (cm)
	Leaf tip	Leaf width (cm)
	Leaf base	Leaf area (cm^2)
	Leaf surface	
	Leaf variation	Chlorophyll Content Top (in $\mu g/cm^2$ leaf)
	Leaf Color	Chlorophyll Content Middle (in $\mu g/cm^2$ leaf)
		Chlorophyll Content Bottom (in $\mu g/cm^2$ leaf)
Fruit	Fruit Color	Bunch weight (g)
	Fruit shaped	Fruit Length (mm)
	Color of Aril	Fruit Diameter (mm)
	Taste of Aril	Fruit Weight (g)
		Peel thickness (g)
		Aril thickness (mm)
		Aril weight (g)
		Total Soluble Solid (^{o}Brix)
		Number of seeds per fruit

Data gathered

Percent of graft success. The number of successful grafts in each cultivar was counted at 30-day intervals up to 90 days after grafting. The emergence of shoots from the terminal buds of scions was considered a success of grafting. Grafted scions that produced shoots were counted and expressed in percentage using the formula below as described by (Khushi *et al*., 2019).

$$\text{Percentage of graft success} = \frac{\text{Number of successful grafts}}{\text{Total number of grafted rootstocks}} \times 100$$

Leaf chlorophyll content was measured from the top, middle, and bottom portions of the leaves using a SPAD-502 meter to assess chlorophyll levels across different parts of the canopy. Leaf color evaluated based on the Royal Horticultural Society Colour Chart to provide standardized color identification. Leaf width, length, and area were measured using a ruler to determine overall leaf size. Stem or trunk girth was recorded 20 cm above the soil surface using a tape measure to monitor plant growth. Fruit color was assessed using the Royal Horticultural Society Colour Chart for consistent color classification. Whole fruit weight was determined using a digital weighing scale and expressed in grams, while bunch weight—comprising 20 harvested fruits—was measured using a weighing scale and expressed in kilograms. Fruit length was measured along the longer axis, and fruit diameter was recorded across the widest part, both using a digital Vernier caliper in millimeters. Peel weight was obtained by separating the skin from the flesh and weighing it using a digital weighing scale. Peel thickness was measured at the midsection of the fruit with a digital Vernier caliper. Aril (flesh) thickness was also measured at the midsection after slicing the fruit longitudinally while keeping the seeds intact. Total soluble solids were determined by squeezing a few drops of juice from the midsection of the aril onto the prism of a handheld refractometer and reading the result in degrees Brix (°Brix). The number of seeds per fruit was manually counted, and their weight was measured after cleaning off any adhering aril using a digital weighing scale. Seed length, width, and thickness were measured on their respective axes using a digital Vernier caliper, providing detailed morphometric data on seed characteristics.

Results

Morphological characteristics of stem

Initial information obtained on the information from plant propagators was as follows: ‘Longkong’ and ‘Duku’ accessions were grown from clonal seedlings while ‘Paete’ and ‘Mindanao’ were grown from seeds.

In terms of percent success of cleft grafting, ‘Longkong’ had the highest success rate with 80% followed by ‘Duku’, and ‘Paete’ with a corresponding success rate of 75% and 65% (Table 2). Meanwhile, ‘Mindanao’ varieties showed zero success rate on cleft grafting, this may be due to disease and insect infestation before continuous rain on the experimental site. For union graft diameter, the ‘Duku’ accession showed the widest diameter with a mean of 10.04 mm followed by ‘Longkong’ and ‘Paete’ with corresponding diameters of 9.56 mm and 9.35 mm, respectively. In terms of the number of leaves, all three accessions had observed the same number of leaves which was six.

Table 2. The percent success rate of grafting on *Lansium domesticum* accessions

Accessions	Percent Grafting Success	Union graft diameter	Number of Leaves
Duku	75%	10.04	6
Longkong	80%	9.56	6
Paete	65%	9.35	6
Mindanao	0%	0	0

All accessions showed verticillate and irregular branching patterns except for “Mindanao 1” which had pyramidal branching patterns (Table 3). For the surface of the stem, most of the accessions had rough and very rough surfaces. The leaves of four varieties of lanzones trees were collected and observed for their morphological characteristics. In terms of leaf color, most of the colors observed on the Royal Horticultural Society Colour Chart were greyish olive green followed by dark yellow-green and moderate olive green (Figure 1). There was no significant difference on the leaf surface and leaf venation in the samples. Pinnate leaf venation was observed in which the veinlet was arranged at both sides of the midrib. While the leaf surface texture was smooth without any hair.

Figure 1. Representative photographs of leaf color on leaf samples of four varieties of lanzones using the Royal Horticultural Society Colour Chart

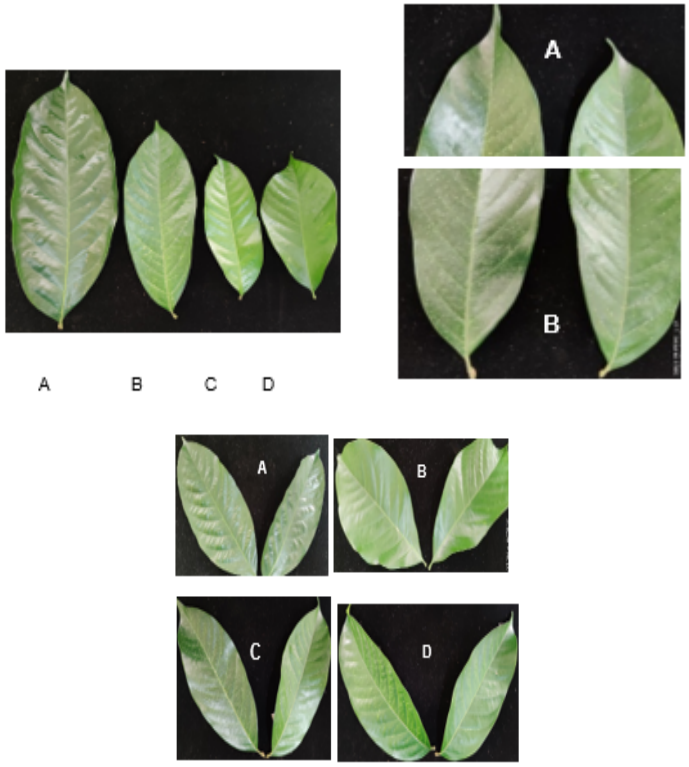

Figure 2. Lanzones leaflet size variations (A) 'Mindanao' (B) 'Paete' (C) 'Longkong' (D) 'Duku'; leaflet tip for the four varieties (A) Broadly acuminate; leaflet base (B) cuneate leaf shape (A to D) elliptic; Leaf surface and leaf variation and leaf shape (A to D) elliptic

Table 3. Recapitulation of vegetative morphological character of *L. domesticum*

Accessions	Branching pattern	Surface of the Stem	Leaf color	Leaf shape	Leaf tip	Leaf base	Leaf surface	Leaf variation
Paete 1	Verticillate	Very rough	Greyish Olive Green	Elliptic	Broadly Acuminate	Cuneate	Smooth	Pinnate
Paete 2	Verticillate	Very rough	Moderate Olive Green	Elliptic	Boadly Acuminate	Cuneate	Smooth	Pinnate
Paete 3	Verticillate	Rough	Greyish Olive Green	Elliptic	Boadly Acuminate	Cuneate	Smooth	Pinnate
Paete 4	Verticillate	Rough	Greyish Olive Green	Elliptic	Boadly Acuminate	Cuneate	Smooth	Pinnate
Paete 5	Verticillate	Rough	Moderate Yellow Green	Elliptic	Boadly Acuminate	Cuneate	Smooth	Pinnate
Paete 6	Irregular	Very rough	Greyish Olive Green	Elliptic	Boadly Acuminate	Cuneate	Smooth	Pinnate
Paete 7	Irregular	Very rough	Greyish Olive Green	Elliptic	Boadly Acuminate	Cuneate	Smooth	Pinnate
Paete 8	Verticillate	Rough	Greyish Olive Green	Elliptic	Boadly Acuminate	Cuneate	Smooth	Pinnate
Duku 1	Irregular	Rough	Greyish Olive Green	Elliptic	Broadly Acuminate	Cuneate	Smooth	Pinnate
Duku 2	Verticillate	Rough	Greyish Olive Green	Elliptic	Broadly Acuminate	Cuneate	Smooth	Pinnate
Duku 3	Verticillate	Rough	Greyish Olive Green	Elliptic	Broadly Acuminate	Cuneate	Smooth	Pinnate
Duku 4	Verticillate	Rough	Greyish Olive Green	Obovate	Obtuse	Cuneate	Smooth	Pinnate
Duku 5	Verticillate	Rough	Greyish Olive Green	Elliptic	Broadly Acuminate	Cuneate	Smooth	Pinnate
Duku 6	Irregular	Rough	Greyish Olive Green	Elliptic	Broadly Acuminate	Cuneate	Smooth	Pinnate
Duku 7	Verticillate	Rough	Greyish Olive Green	Elliptic	Broadly Acuminate	Cuneate	Smooth	Pinnate
Duku 8	Verticillate	Rough	Greyish Olive Green	Elliptic	Broadly Acuminate	Cuneate	Smooth	Pinnate

Accessions	Branching pattern	Surface of the Stem	Leaf color	Leaf shape	Leaf tip	Leaf base	Leaf surface	Leaf variation
Duku 9	Verticillate	Rough	Greyish Olive Green	Elliptic	Broadly Acuminate	Cuneate	Smooth	Pinnate
Longkong1	Verticillate	Rough	Dark Yellow Green	Elliptic	Broadly Acuminate	Cuneate	Smooth	Pinnate
Longkong2	Verticillate	Rough	Greyish Olive Green	Elliptic	Broadly Acuminate	Cuneate	Smooth	Pinnate
Longkong3	Irregular	Rough	Greyish Olive Green	Elliptic	Broadly Acuminate	Cuneate	Smooth	Pinnate
Longkong4	Irregular	Rough	Greyish Olive Green	Elliptic	Broadly Acuminate	Cuneate	Smooth	Pinnate
Longkong5	Verticillate	Rough	Dark Yellow Green	Elliptic	Broadly Acuminate	Cuneate	Smooth	Pinnate
Longkong6	Verticillate	Rough	Greyish Olive Green	Elliptic	Broadly Acuminate	Cuneate	Smooth	Pinnate
Longkong7	Verticillate	Rough	Dark Yellow Green	Elliptic	Broadly Acuminate	Cuneate	Smooth	Pinnate
Mindanao1	Pyramidal	Rough	Greyish Olive Green	Elliptic	Broadly Acuminate	Cuneate	smooth	Pinnate
Mindanao2	Verticillate	Very rough	Greyish Olive Green	Elliptic	Broadly Acuminate	Cuneate	smooth	Pinnate
Mindanao3	Verticillate	Rough	Greyish Olive Green	Elliptic	Broadly Acuminate	Cuneate	smooth	Pinnate
Mindanao4	Verticillate	Rough	Greyish Olive Green	Elliptic	Broadly Acuminate	Cuneate	smooth	Pinnate
Mindanao5	Verticillate	Rough	Greyish Olive Green	Elliptic	Broadly Acuminate	Cuneate	smooth	Pinnate

Morphological characteristics of leaves

Out of 29 accessions, only 20 accessions were collected for leaf length, leaf width, leaf area, chlorophyll content on leaves, and steam girth and showed differences among each other (Table 4). Observation in chlorophyll content on 20 accessions was measured using SPAD and showed a significant difference among 20 accessions. For the chlorophyll content, the canopy's top, middle, and bottom portions were assessed from four representative accessions on every variety. ‘Longkong 1’ accession had the

highest mean of 76.04 µg/cm^2 leaf chlorophyll content on the top of the canopy followed by the 'Paete 3' accession with a mean of 75.72 µg/cm^2 leaf and both had a significant difference with 'Davao 3', 'Davao 4', and 'Davao 5' accessions (Figure 3). For the middle portion of the canopy, the 'Longkong 1', 'Longkong 5', and 'Paete 3' accessions performed the best with mean chlorophyll content of 80.21, 75.18, and 74.66 µg/cm^2 leaf, respectively, and had a significant difference with 'Davao 3', 'Davao 4', 'Davao 5' and 'Duku 2' accessions (Figure 4). Moreover, on the bottom portion of the canopy where the leaves were more mature, the 'Longkong 1' with 77.43 µg/cm^2 leaf had the highest mean chlorophyll content followed by 'Longkong 5', 'Paete 3', 'Paete 5', and 'Duku 6' with mean values of 77.38, 75.75, 75.40 and 75.00 µg/cm^2 leaf, respectively (Figure 5). These five highest mean chlorophyll contents were significantly different as compared to the mean of 'Davao 3' and 'Davao 5' accessions.

Table 4. Mean values per plant for the Chlorophyll Content (Top, Middle, Bottom)

Treatment	Chlorophyll Content (in µg/cm^2 leaf)		
	Top	Middle	Bottom
Mindanao 1	70.61±2.8^{abcd}	70.42±4.5^{bcd}	71.84±6.3^{ab}
Mindanao 2	68.94±4.1^{abcde}	68.72±4.9^{bcd}	69.10±4.8^{ab}
Mindanao 3	61.93±8.9^{e}	63.30±6.9^{cd}	65.05±7.19^{b}
Mindanao 4	66.63±7.5^{cde}	65.14±6.4^{cd}	68.83±6.2^{ab}
Mindanao 5	63.75±6.1^{de}	65.00±5.2^{cd}	65.19±7.0^{b}
Duku 2	67.13±5.9^{bcde}	65.53±7.0^{cd}	68.86±7.5^{ab}
Duku 3	68.40±4.1^{abcde}	71.42±6.7^{abcd}	71.58±8.2^{ab}
Duku 6	73.57±4.9^{abc}	72.61±8.6^{abc}	75.00±8.0^{a}
Duku 7	69.78±5.6^{abcde}	73.04±5.2^{abc}	74.46±5.5^{ab}
Duku 8	70.96±7.4^{abcd}	69.93±9.9^{bcd}	70.48±6.7^{ab}
Longkong 1	76.04±7.3^{a}	80.21±5.2^{a}	77.43±8.1^{a}
Longkong 2	71.70±5.3^{abcd}	72.10±6.3^{abcd}	73.16±6.5^{ab}
Longkong 3	73.48±11.2^{abc}	71.04±11.0^{bcd}	73.10±12.4^{ab}
Longkong 4	68.09±5.3^{abcde}	70.91±4.0^{bcd}	72.42±4.7^{ab}
Longkong 5	70.70±9.3^{abcd}	75.18±6.9^{ab}	77.38±6.9^{a}
Paete 1	72.82±5.0^{abc}	72.08±6.9^{abcd}	72.04±7.4^{ab}
Paete 2	72.94±8.0^{abc}	72.35±9.4^{abcd}	73.29±8.4^{ab}
Paete 3	75.72±5.8^{ab}	74.66±6.8^{ab}	75.75±6.3^{a}
Paete 4	68.64±4.1^{abcde}	68.00±4.5^{bcd}	68.32±6.9^{ab}
Paete 5	71.34±5.8^{abcd}	73.00±7.4^{abc}	75.40±6.2^{a}

Significant at 5% level, values per parameter followed by the different letter superscripts are significantly different from each other at p-value = 0.05 by Tukey's Contrast test
Accessions with the highest values among 20 accessions(^{a})

Table 5. Mean values per accession for Leaf Length, Leaf Width, Leaf Area and Stem girth

Treatment	Leaf Length (cm)	Leaf Width (cm)	Leaf Area (cm^2)	Stem girth (cm)
Mindanao 1	16.55±1.8[a]	7.09±0.5[ab]	118.22±21.4[ab]	108
Mindanao 2	17.23±1.5[a]	7.66±1.0[ab]	132.31±23.3[ab]	78.6
Mindanao 3	18.00±1.3[a]	7.67±0.7[ab]	118.18±22.2[ab]	49.3
Mindanao 4	16.63±2.0[a]	7.78±0.7[ab]	130.26±26.0 [ab]	91.6
Mindanao 5	17.81±0.7[a]	7.00±0.4[ab]	124.73±11.1 [ab]	86.4
Duku 2	16.90±1.4[a]	7.59±0.[ab]	128.73±17.1[ab]	80.4
Duku 3	15.43±1.5[a]	6.76±0.4[ab]	104.61±15.5[a]	75.2
Duku 6	15.82±0.9[a]	7.30±0.4[ab]	115.56±11.35 [ab]	57
Duku 7	16.88±1.6[a]	7.79±0.8[ab]	132.72±26.6[ab]	70
Duku 8	15.73±2.6[a]	8.62±1.3[a]	138.27±38.0[b]	65.3
Longkong 1	17.70±2.2[a]	7.95±0.5[ab]	140.71±20.2[b]	70.8
Longkong 2	15.58±1.0[a]	6.99±0.9[ab]	109.28±19.1[ab]	56.7
Longkong 3	16.69±2.0[a]	7.28±1.2[ab]	121.02±21.9 [ab]	65.8
Longkong 4	15.90±1.4[a]	6.61±0.5[ab]	104.94±10.9 [a]	33
Longkong 5	16.06±1.3[a]	6.77±0.7[ab]	108.24±9.6 [ab]	54.4
Paete 1	15.64±1.4[a]	7.01±0.5[ab]	109.47±12.1[ab]	80
Paete 2	15.50±1.3[a]	7.18±0.6[ab]	111.16±12.6 [ab]	82.6
Paete 3	16.68±1.7[a]	7.31±0.6[ab]	122.10±17.7[ab]	53
Paete 4	16.38±1.7[a]	6.60±0.5[ab]	107.40±6.6[ab]	64
Paete 5	15.59±1.3[a]	6.97±0.4[ab]	108.18±5.6[ab]	83.7

Significant at 5% level, values per parameter followed by the different letter superscripts are significantly different from each other at p-value = 0.05 by Tukey's Contrast test
Accessions with the highest values among 20 accessions([a])

For leaf length there was not significantly differed among the 20 accessions, but 'Mindanao 3' followed by 'Mindanao 5' and 'Longkong 1' accessions had the highest leaf lengths with corresponding means of 18.00 cm, 17.81 cm, and 17.70 cm, respectively (Table 5). In contrast, the 'Duku 3' accession had the lowest length of the leaf with only 15.43 cm. In Leaf width, 'Duku 8' had a significant difference compared to 19 accessions with the highest mean of 8.62 cm. 'Duku 2', 'Duku 7', 'Longkong 2', 'Mindanao 2', 'Mindanao 3', and 'Mindanao 4' accessions with a corresponding mean of 7.59 cm, 7.79 cm, 7.55 cm, 7.66 cm, 7.67 cm, and 7.67 cm had no significant difference between each other but had a significant difference compared to 'Mindanao 1', 'Mindanao 5', 'Duku 3', 'Duku 6', 'Longkong 3', 'Longkong 4', 'Longkong 5', 'Paete 1', 'Paete 2', 'Paete 3', 'Paete 4', and 'Paete 5' accessions. In terms of leaf area (cm^2), 'Davao 3' and 'Duku 8' had significant differences as compared to 18 accessions with a corresponding mean of 138.62 cm^2 and 138.27 cm^2 respectively. The stem girth of Mindanao 1 had the highest value with 108 cm among the twenty accessions followed by Mindanao 4 and Mindanao 5 with corresponding value of 96.4 cm and 86.4 cm, respectively. Meanwhile, Longkong 4 showed the lowest value of stem girth with only 33 cm.

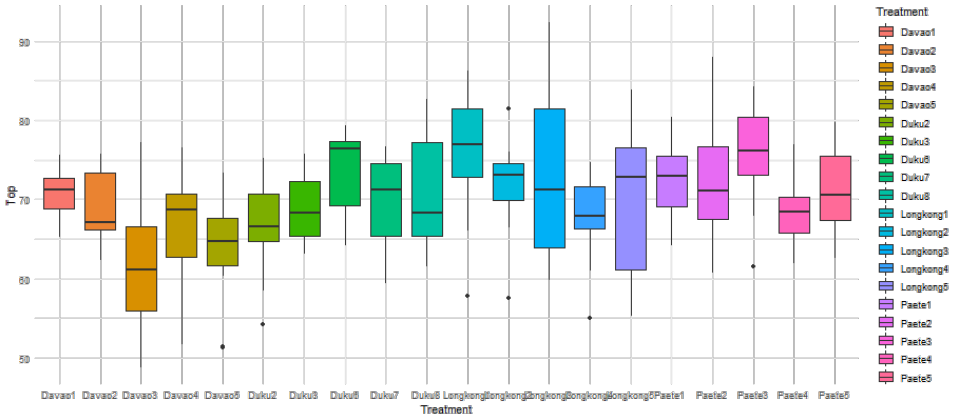

Figure 3. Chlorophyll reading at the top portion of the canopy

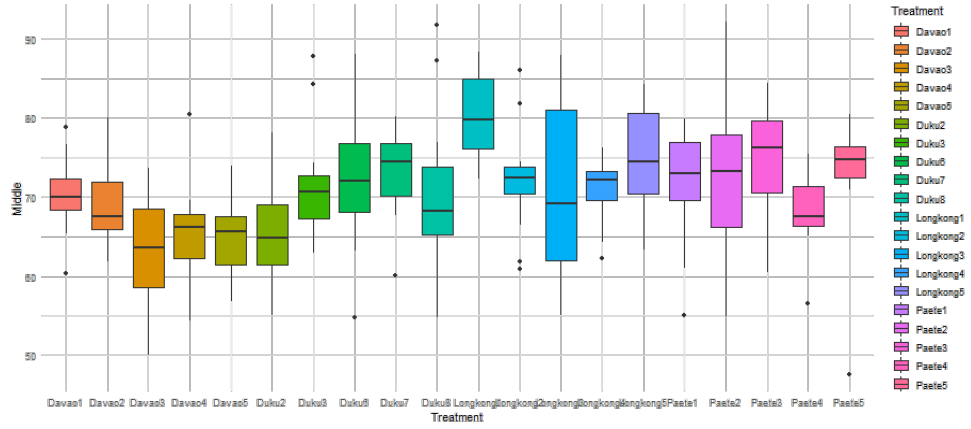

Figure 4. Chlorophyll reading at the middle portion of the canopy

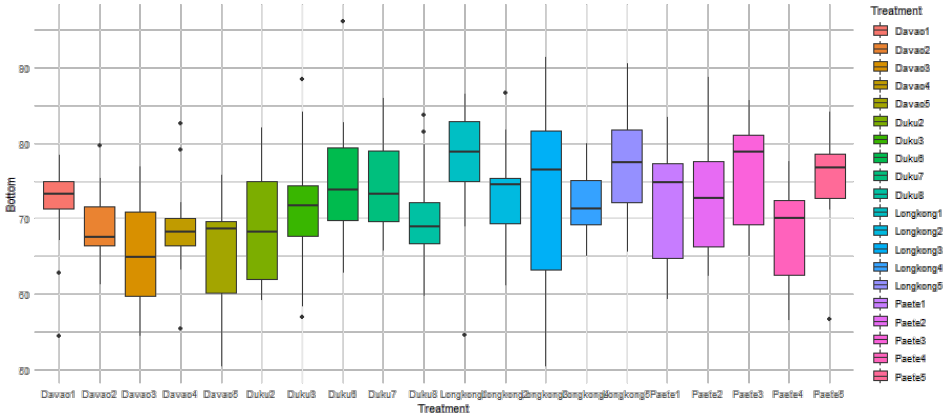

Figure 5. Chlorophyll reading at the bottom portion of the canopy

The stem girth was measured using a ruler, and 'Mindanao' exhibited the widest stem girth with a corresponding width of 108 cm followed by 'Mindanao 4', 'Mindanao 5','Paete 5', 'Paete 2', 'Duku 2', and 'Paete 1' with a corresponding width of 91.6 cm, 86.4 cm, 83.7 cm, 82.6 cm 80.4 and 80.0 cm, respectively. On the other hand, 'Longkong 4' had a small stem girth observed with only 33 cm.

Morphological characteristics of fruit

Out of 29 lanzones trees, only 16 trees (7 'Duku', 3 'Longkong, 4 'Paete', and 2 'Mindanao' accessions bore fruit, and variations were observed on fruit morphological characters such as TSS (°Brix), fruit length, fruit diameter, fruit-shaped, peel thickness, aril thickness, aril weight, number of seeds per fruit. However, similarities among the four varieties were shown in terms of fruit color, aril taste, and aril color (Table 6, Figures 6, 7, 8, and 9).

Duku

The morphological characteristics of the fruit were bunch weight ranges from 164.75 g to 191.35 g, fruit length 34.39 mm to 37.73 mm, Total soluble solid 18.14 °Brix - 19.80 °Brix fruit diameter 31.23 mm to 34.48 mm, fruit color light yellow fruit weight 19.66 g to 26.50 g, fruit shaped globose except for 'Duku 4' that was oval, peel thickness of 2.30 mm - 2.66 mm, aril thickness 7.44 mm - 10.05 mm, aril weight 16.88 g - 21.21 g, soft white translucent and sweet taste of aril, less water content of aril and number of seeds 0-1 per fruit.

Longkong

Three trees of 'Longkong' only bore fruits during the experimental period. The morphological characteristics of the fruit were bunch weight ranges from 164.33 g to 184.66 g, fruit length 34.50 mm to 36.99 mm, total soluble solid 17.14 °Brix - 18.25 °Brix, fruit diameter 27.82 mm to 34.93 mm, fruit weight 11.63 g – 18.06 g, fruit shaped oval, fruit color Brilliant yellow (peel thickness of 1.15 mm – 1.41 mm, aril thickness 4.11 mm – 5.78 mm, aril weight 7.62 g – 14.82 g, soft white translucent and sweet taste of aril, less water content of aril and the number of seeds 1-2 per fruit.

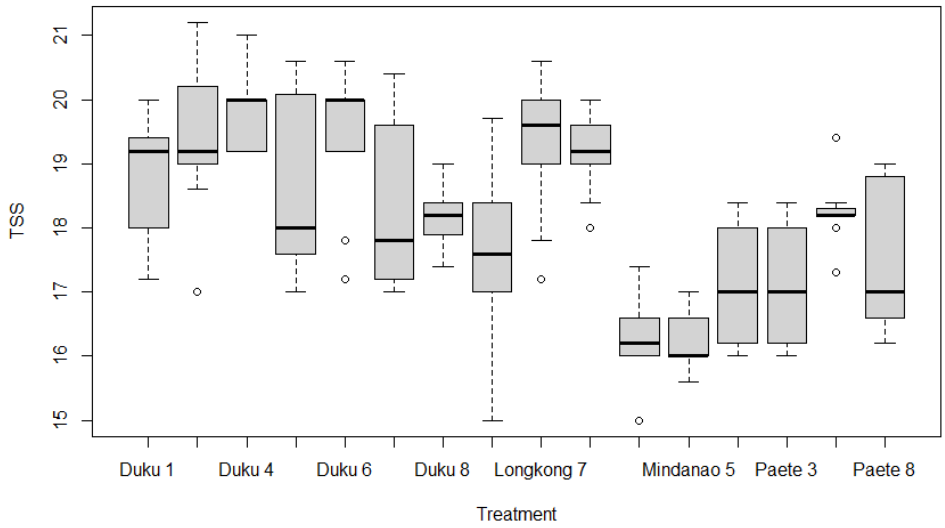

Figure 6. Total soluble solids reading of fruits on the sixteen accessions

Mindanao

Only two trees of 'Mindanao' varieties bore fruits during the experimental period. The morphological characteristics of the fruit were bunch weight ranges from 125.62 g to 149.48 g, fruit length 39.75 mm to 40.47 mm, Total soluble solid 16.24 °Brix - 16.26 °Brix, fruit diameter 34.56 mm - 35.44 mm, fruit weight 28.16 g - 28.86 g, fruit shaped globose, fruit color Light yellow, peel thickness of 1.62 mm – 1.74 mm, aril thickness 11.34 mm – 11.74 mm, aril weight 21.85 g – 22.03 g, soft white translucent and sour taste of aril, more water content of aril and mostly number of seeds 5-6 per fruit.

Based on the data on fruit morphology, quantitative characteristics variers among varieties showed the different fruit densities. The 'Duku' variety showed the highest bunch weight of 191.35 grams while "Paete" exhibited the lowest bunch weight of 112.14 grams. Among the 16 accessions, the 'Duku 4' accession had the highest total soluble sugar with a mean of 19.80 °Brix followed by 'Duku 2', 'Longkong 7', and 'Longkong 8' with a mean of 19.37 °Brix, 19.26 °Brix, and 19.17 °Brix respectively. Both 'Paete 2' and 'Paete 3' had the same mean of Fruit TSS with a mean of 17.14 °Brix. Meanwhile, 'Mindanao 4' and 'Mindanao 5' fruits recorded the lowest amount of total soluble solids with a mean of 16.26 °Brix only.

For the fruit length and fruit diameter among the sixteen accessions, 'Mindanao 4' had a significant difference in terms of fruit length with the highest mean of 40.47 mm except for "Mindanao "5 with a mean of 39.75 mm, followed by 'Paete 5' and 'Duku 4' with a fruit length of 37.92 mm and 37.73 mm, respectively. For the 'Duku' accessions, except for 'Duku 4', 'Duku 1' had a higher mean of fruit length of 36.81 mm than 'Duku 2', 'Duku

5', 'Duku 6', 'Duku 7', and 'Duku 8' with a mean of 34.39 mm, 34.67 mm, 34.80 mm, 34.39 mm, and 36.41 mm, respectively. For 'Longkong' accessions, both 'Longkong 6' and 'Longkong 8' had a mean of 36.99 mm and 36.12 mm with a significant difference on 'Longkong 7' with a mean of 34.50 mm. For the 'Paete' accessions, 'Paete 2' recorded the lowest fruit length with only 33.47 mm only.

In terms of fruit diameter, 'Mindanao 4', 'Paete 5', and 'Mindanao 5' had a significant difference on the remaining thirteen accessions with a mean of 35.44 mm, 34.93 mm, and 34.56 mm, respectively. Among the 'Duku' accessions, 'Duku 1' had a significantly wider fruit diameter with a mean of 34.48 mm compared to 'Duku 2', 'Duku 4', 'Duku 6', 'Duku 7' and 'Duku 8'. Meanwhile, 'Longkong 7' had a 30.29 mm diameter only compared to 'Longkong 6' and 'Longkong 8'. For 'Paete' accessions, 'Paete 2' and 'Paete 8' recorded the lowest fruit diameter with a mean of 27.94 mm and 27.82 mm. The highest peel thickness was shown in 'Duku' varieties with 2.66 mm among the sixteen accessions while the lowest peel thickness was observed in 'Paete' with a mean of 1.12 mm, respectively.

Figure 7. Representative photographs of fruits: (A) 'Mindanao', (B) 'Paete', (C) 'Duku' and (D) 'Longkong' varieties

Table 6. Mean values on morphological characters in fruits of *Lansium domesticum*

Accessions	Bunch Weight (g)	TSS (°Brix)	Fruit Length	Fruit Diameter	Fruit Weight	Fruit shaped	Peel thickness
Mindanao 4	125.62	16.26±0.68^{d}	40.47±1.31^{a}	35.44±0.48^{a}	28.86±2.19^{a}	globose	1.74±0.05^{cd}
Mindanao 5	149.48	16.24±0.50^{d}	39.75±0.69^{a}	34.56±0.75^{a}	28.16±0.98^{a}	globose	1.62±0.07^{d}
Duku 1	181.43	18.66±1.02^{abc}	36.81±0.97^{bc}	34.48±1.36^{ab}	25.66±2.42^{ab}	globose	2.56±0.07^{a}
Duku 2	176.47	19.37±1.22^{ab}	34.39±0.34^{de}	32.16± 0.42^{cde}	22.33±0.51^{cd}	globose	2.32±0.05^{b}
Duku 4	164.75	19.80±0.58^{a}	37.73±2.26^{ab}	33.80±1.20^{abc}	26.50±1.87^{ab}	oval	2.66±0.11^{a}
Duku 5	188.64	18.52±1.48^{abc}	34.67±0.36^{cde}	32.29±0.46^{cde}	22.16±1.32^{cd}	globose	2.30±0.06^{b}
Duku 6	175.31	19.42±1.15^{ab}	34.80±0.75^{cde}	31.23±0.39^{de}	19.66±0.51^{def}	globose	2.55±0.11^{a}
Duku 7	169.12	18.37±1.32^{abc}	34.39±2.35^{de}	32.15±0.48^{cde}	24.16±2.31^{bc}	globose	2.31±0.08^{b}
Duku 8	191.35	18.14±0.45^{bc}	36.41±0.63^{bcd}	32.31±1.09^{cde}	21.83±1.45^{cd}	globose	2.40±0.10^{b}
Longkong 5	164.33	17.52±1.34^{cd}	36.99±1.57^{bc}	32.55±1.29^{bcd}	20.94±1.46^{cde}	spheroid	1.87+0.07^{c}
Longkong 6	184.66	19.26±1.11^{ab}	34.50±1.35^{de}	30.29±1.24^{e}	16.73±1.80^{fgh}	spheroid	1.89±0.04^{c}
Longkong 7	174.12	19.17±0.64^{ab}	36.12±0.74^{bc}	32.49±1.07 ^{bcd}	19.68±1.70^{def}	spheroid	1.84±0.04^{c}
Paete 2	156.35	17.14±0.95 ^{cd}	33.47±1.03^{f}	27.94±1.94^{f}	13.90±2.02^{hi}	oval	1.15±0.07^{f}
Paete 3	112.14	17.14±0.95^{cd}	36.19±0.72^{bcd}	30.59±0.51^{de}	11.63±0.93^{i}	oval	1.15±0.06^{f}
Paete 5	124.32	18.25±0.53^{abc}	37.92±0.78^{ab}	34.93±0.51^{a}	18.06±1.57^{efg}	oval	1.41±0.05^{e}
Paete 4	132.1	17.53±1.09^{cd}	34.39±1.01^{ef}	27.82±1.12^{f}	15.83±1.32^{gh}	oval	1.12±0.03^{f}

Significant at 5% level, values per parameter followed by the different letter superscripts are significantly different from each other at p value = 0.05 by Tukey's Contrast test
Accessions with the highest values among 16 accessions(^{a})

Table 7. Mean values on morphological characters in fruits of *Lansium domesticum* *(continuation.)*

Accessions	Aril thickness	Aril Weight	Fruit color	Color of Aril	Taste of Aril	Number of seeds per fruit
Mindanao 4	11.74+2.81[a]	22.03±0.16[a]	Light yellow C	white translucent	sour	6
Mindanao 5	11.34+1.59[a]	21.85±0.71[a]	Light yellow B	white translucent	sour	5
Duku 1	9.65±1.21[c]	20.33+1.14[c]	Light yellow B	white translucent	sweet	1
Duku 2	8.42±0.52[d]	18.19±1.63[d]	Light yellow B	white translucent	sweet	1
Duku 4	10.05±0.10[b]	21.21±0.22[b]	Light yellow B	white translucent	sweet	0
Duku 5	8.13±1.21[d]	18.05±0.05[d]	Light yellow B	white translucent	sweet	1
Duku 6	7.44±1.11[e]	16.88±0.44[f]	Light yellow B	white translucent	sweet	0
Duku 7	9.33+0.96[c]	21.07±1.77[b]	Light yellow C	white translucent	sweet	1
Duku 8	7.66±2.05[e]	17.52±2.33[e]	Light yellow C	white translucent	sweet	0
Longkong 5	5.12±1.35[g]	16.01±0.24[g]	Brilliant Yellow B	white translucent	sweet	1
Longkong 6	4.36±1.61[h]	12.26±1.55[j]	Brilliant Yellow B	white translucent	sweet	1
Longkong 7	5.04±0.89[g]	14.54±0.72[h]	Brilliant Yellow B	white translucent	sweet	1
Paete 2	4.11±1.15[h]	9.42±1.47[k]	Light yellow B	white translucent	sweet-sour	2
Paete 3	4.19±0.52[h]	7.62±1.45[l]	Light yellow C	white translucent	sweet-sour	2
Paete 5	5.78±2.34[f]	14.82±2.33[h]	Light yellow B	white translucent	sweet-sour	1
Paete 4	4.43±0.23[h]	11.59±0.76[efg]	Light yellow C	white translucent	sweet-sour	2

Significant at 5% level, values per parameter followed by the different letter superscripts are significantly different from each other
at p value = 0.05 by Tukey's Contrast test
Accessions with the highest values among 16 accessions([a])

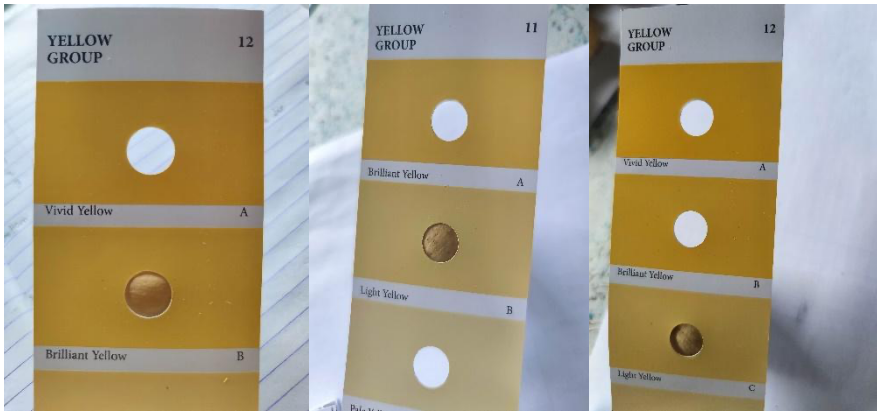

Figure 8. Representative photographs of fruit samples of four varieties of lanzones using theRoyal Horticultural Society Colour Chart

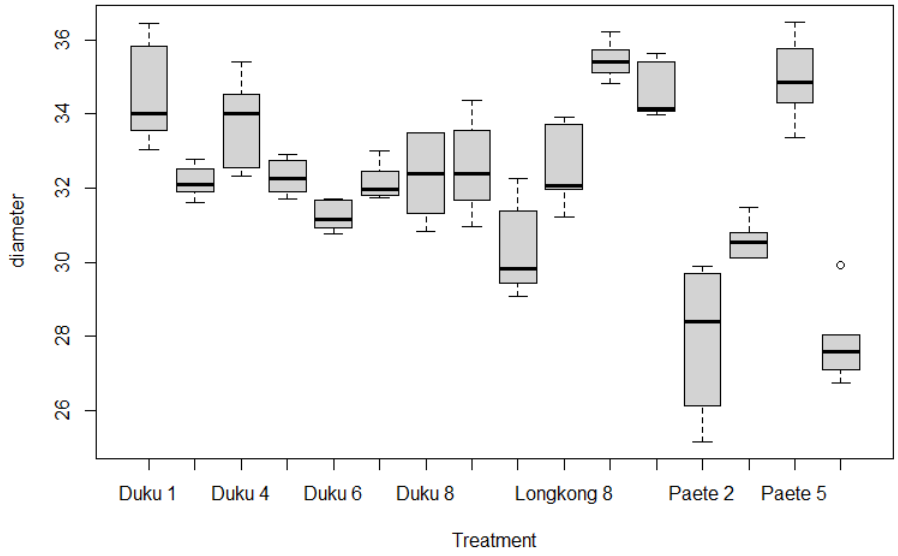

Figure 9. Fruit aril thickness on sixteen accessions was measured using a digital caliper

For the fruit weight, results revealed there's a significant difference in the fruit weight observed in the eight accessions. Both 'Mindanao 4' and 'Mindanao 5' had the highest weight with a mean of 28.8 g and 28.16 g and had a significant difference to fourteen accessions. It was followed by 'Duku 1' and 'Duku 4' with a mean of 25.66 g and 26.50 g and had significant differences compared to the remaining eleven accessions. Meanwhile, 'Paete 3' revealed the lowest fruit weight with only 11.63 grams. These findings indicated 'Mindanao' accessions

had more seeds as compared to 'Duku', 'Longkong', and 'Paete' accessions. In terms of the number of fruits, 'Mindanao' varieties showed the highest number of seeds per fruit 5-6 and this is why plant nurseries use 'Mindanao' varieties for seedlings as rootstocks for grafting purposes.

Discussion

Based on the results of the study, all twenty-nine accessions of lanzones exhibited verticillate and irregular in terms of branching patterns except for 'Longkong 3', 'Longkong 4' and 'Mindanao 1' which showed irregular and pyramidal branching patterns. Other results on qualitative characters were observed similarly on the twenty-nine accessions of lanzones. The shape of the leaflets was elliptic for all the varieties. The leaf tip and base were broadly acuminate and cuneate, respectively. On the other hand, variation in the sizes of the leaves was observed among the varieties. One factor that influences plant morphology is the environment where the plant is grown. Those environmental factors are soil type, water supply, light intensity, and exposure duration, growing space, and temperature. Furthermore, another adaptability of plants against limited water is changing their leaves from standard size to sharper and smaller (sword-shaped) to reduce transpiration (Sari *et al.*, 2015). Lanzones reported low light intensity for growing and over time required full-time light, also known as a semi-tolerant plant. Good growing space accompanied by sufficient carbohydrates will support canopy growth and cause leaf number and tree height to become genetic characteristics that positively affect tree development (Rochman and Hamida, 2017).

In general, the 'Longkong' variety showed the best performance in terms of mean chlorophyll content as it has two accessions with the highest mean values among the 20 accessions from the four varieties. Studies suggest chlorophyll is a photosynthetic pigment in a plant that absorbs red, blue, and purple lights and reflects green light as its characteristic color. The higher the chlorophyll content in the leaf, the higher productivity, and index of a plant will be. Leaf possessing high chlorophyll content is expected to be more efficient in absorbing energy from sunlight for the photosynthesis process (Larekeng *et al*., 2019). In addition, chlorophyll content directly regulates the photosynthesis process and eventually controls plant growth and development (Long *et al*., 2006). Moreover, the mechanism of chlorophyll in increasing the quality and production of the plant begins when chlorophyll actively converts CO2 and H2O into carbohydrates ($C_6H_{12}O_6$) and oxygen with the help of sunlight. The produced energy is then utilized by the plant in growth processes and the formed carbohydrates become dry ingredients that accumulate nutrients in the form of proteins and other

substances in the plant. High chlorophyll content will increase the rate of photosynthesis, and finally, it improves the quality and production of dry ingredients (Li *et al.*, 2006).

For fruit morphology characters, 'Duku' had the highest bunch weight ranges from 164.75 – 191.35 g followed by 'Longkong' accessions. Meanwhile, 'Longkong' accessions produce distinct compact bunch weights compared to the other three varieties. Results on taste of aril supported the findings done by Yee and Rao (2013). They observed the arils of 'Langsat' or 'Paete' were sweet to sour whereas those of 'Duku' were mainly sweet. The seeds of both varieties were oblong and covered by a thin seed coat to which the aril was attached. Furthermore, Techavuthiporn (2018) described the 'Paete' or 'Langsat' fruit as oval, ovoid-oblong, or nearly round, and the fruit peel is thin (11.5 mm). Variations were observed between the accessions on other fruit morphological characters. Singh *et al.* (1999) observed variations of morphology displayed by organisms were the result of interaction between genetic factors and the environment in which the organism was alive. Moreover, Verheij and Coronel (1997) state *Lansium domesticum* is a complex and varied species with wild varieties and cultivation. This is partly due to the occurrence of parthenocarpy events, apomixis, and natural crosses so that the taxonomic status of 'Duku, 'Kokosan', and 'Langsat' has become increasingly complex.

The four lanzones varieties demonstrated generally similar vegetative morphological traits, including branching pattern, stem surface texture, and various leaf characteristics such as color, shape, tip, base, surface, and variation. Despite these similarities, notable differences were found in several quantitative traits. These included leaflet length and width, overall leaf area, and chlorophyll content as measured by SPAD readings. Significant variation was also observed in fruit-related characteristics such as total soluble solids (TSS), individual fruit and bunch weight, fruit dimensions (length and width), peel thickness, aril weight and thickness, as well as the number of seeds per fruit. Additionally, the varieties differed in their percent success rate for cleft grafting.

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Conflict of interest

The authors declare no conflict of interest.

References

Coronel, R. E. (1983). Promising fruits of the Philippines (No. 634.6/C822).

Corner, E. J. H. (1988). Wayside Trees of Malaya. Malayan Nature Society. *Kuala Lumpur, Malaysia*.

De Mendiburu, F. (2020). Agricolae: Statistical Procedure for Agricultural Research. Retried from https:/CRAN.R-project.org/package=agricolae.

Efendi, D., Sari, H. P., Suwarno, W. B. and Matra, D. D. (2022). Genetic diversity of *Lansium parasiticum* (Osbeck) KC Sahni & Bennet accessions based on vegetative morphological characters and simple sequence repeat markers. Genetic Resources and Crop Evolution, 69:1707-1716. Retrieved from https://doi.org/10.1007/s10722-021-01336-9

Hanum, L., Kasiamdari, R. S., Santosa, S. and Rugayah, R. (2013). The phylogenetic relationship among varieties of Lansium domesticum Correa based on ITS rDNA sequences. Indonesian Journal of Biotechnology, 18:123-132.

[IPGRI] Plant Genetic Resources Institute. (2002) Descriptors for Litchi *(Litchi chinensis*). International Plant Genetic Resources Institute authors, Rome, Italy.

Khushi, G. A., Sarker, M. D. T., Islam, M. D. S. and Shahriar, A. S. (2019). Effect of grafting time on the success and survivability of different varieties of mango. Biodiversity International Journal, 3:209-217. Retrieved from DOI: 10.15406/bij.2019.03.00147

Larekeng, S. H., Restu, M. and Arsyad, M. A. (2019). Observation of morphological and physiological characteristics of Abangares Mahogany (*Swietenia macrophylla* King.) In South Sulawesi. In *IOP Conference Series: Earth and Environmental Science* 270:012-022.

Li, R. H., Guo, P. G., Michael, B., Stefania, G. and Salvatore, C. (2006). Evaluation of chlorophyll content and fluorescence parameters as indicators of drought tolerance in barley. Agricultural Sciences in China, 5:751-757.

Lim, T. K. and Lim, T. K. (2012). *Lansium domesticum* 'Langsat-Lonkong Group'. Edible Medicinal And Non Medicinal Plants, 3:269-277.

Long, S. P., ZHU, X. G., Naidu, S. L. and Ort, D. R. (2006). Can improvement in photosynthesis increase crop yields?. Plant, cell & environment, 29:315-330.

Lutatenekwa, D. L., Mtengeti, E. J. and Msalya, G. M. (2020). A review of plant characterization: First step towards sustainable forage production in challenging environments. African Journal of Plant Science, 14:350-357. Retrieved from https://doi.org/10.5897/AJPS2020.2041

Philippine Statistic Authority (2017). Republic of the Philippines.

Ridley, H. N. (1922). The Flora of the Malay Peninsula: Polypetalae (Vol. 1). L. Reeve & Company, Limited.

Rochman, F. and Hamida, R. (2017). Keragaan karakter morfologi, stomata, dan klorofil enam varietas tembakau lokal Tulungagung. Buletin Tanaman Tembakau, Serat dan Minyak Industri, 9.

Sari, L., Purwito, A., Sopandie, D., Purnamaningsih, R. and Sudarmonowati, E. (2015). Characterization of some morphology, anatomy, and physiology of the wheat mutant (*Triticum aestivum* L.) Dewata and Selayar in tropical lowland. Widyariset, 1:21-30.

Sayekti, T. W. D. A., Syukur, M., Hidayat, S. H. and Maharijaya, A. (2021). Morphological response and genetic variability of four species of chili pepper (*Capsicum* spp.) under infection of pepper yellow leaf curl virus. Biodiversitas Journal of Biological Diversity, 22(11). Retrieved from DOI: 10.13057/biodiv/d221107

Singh, H. P., Batish, D. R. and Kohli, R. K. (1999). Autotoxicity: concept, organisms, and ecological significance. Critical Reviews in Plant Sciences, 18:757-772.

Techavuthiporn, C. (2018). Langsat- *Lansium domesticum*. Exotic fruits: 279-283. Retrieved from https://doi.org/10.1016/B978-0-12-803138-4.00036-8

Verheij, E. W. M. and Coronel, R. E. (1997). Buah-buahan yang Dapat Dimakan. Prosea. Sumber Daya Nabati Asia Tenggara 2. Gramedia Pustaka Utama. Jakarta.

Yaacob, O. and Bamroongrugsa, N. (1991). *Lansium domesticum* Correa *In*: Verheij, E.W.M. and Coronel, R.E. (Editors). Plant Resources of South-East Asia No. 2: Edible fruits and nuts. Pudoc, Wageningen, The Netherlands. pp.186-190.

Yee, T. F. and Rao, A. N. (2013). Comparative Anatomy of Duku and Langsat-*Lansium domesticum*. Journal of Tropical Medicinal Plants, 14.

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