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Identification and characterization of morphological diversity of Lemba (*Curculigo latifolia*) in East Kalimantan, Indonesia

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Abstract. *Raden I, Nugroho CC. Syahrani. 2017. Identification and characterization of morphological diversity of Lemba (*Curculigo latifolia*) in East Kalimantan, Indonesia. Biodiversitas 18: 1367-1376.* Lemba (*Curculigo latifolia*) is Kalimantan's land prospective for commercial cultivation because its leaf fiber has been traditionally utilized as fiber source for ulap doyo woven cloth; its fruit as sweetener; and its root as medicinal herb. To this days, only a few of research has been conducted on lemba in East Kalimantan or even in Indonesia, including studies on lemba plant phenotype suitable for weaving material. Thus, a research about identification and morphological characterization of lemba cultivars is necessary to identify and characterize lemba plant in East Kalimantan to reveal phenotypic variability in both quantitative and qualitative traits that can be utilized as the source of germplasm for the plant breeding program. This study was carried out in three Sub-districts, i.e.: Tenggarong Sub-district (Kutai Kartanegara District), Kota Bangun Sub-district (Kutai Kartanegara District), and Jempang Sub-district (West Kutai District). Data collection was done by observation, and measurement of quantitative and qualitative traits of lemba plant. Descriptive analysis was applied on the morphological traits data, while correlation analysis was performed to reveal relationship between the qualitative and quantitative morphological traits by using software Minitab v.14.12. Phenotypic variability was determined based on the standard deviation. Principal component analysis and cluster analysis of the data were performed by using software SPSS v.11.6. The variance value of the 33 observed lemba plant accessions from the three Sub-districts indicated that the phenotypic variability of the qualitative traits was narrow while that of the quantitative traits was broad. There are three principal components that account for the observed variability with a cumulative variance of 96% which is obtained from 19 observed traits. Cluster analysis at similarity 95% indicates that there are five lemba accessions groups based on only qualitative, only quantitative, or based on combined qualitative and quantitative traits.

Keywords: Cluster analysis, *Curculigo latifoliadoyo*, characterization, phenotypic variability

INTRODUCTION

East Kalimantan is rich with biodiversity, one of them is lemba (*Curculigo latifolia*). Lemba is an endemic plant of Kalimantan that so far only naturally grow in the wild and has not been cultivated. Besides in Kalimantan, various variants of the plant can also be found in Sumatra, Bangka, Papua, and Java. Moreover, the plant is reported to be distributed in the Western Africa (marasi or lemba), India, Burma (Myanmar), Thailand, Malaysia (Perak, Pahang, Sarawak, and Sabah), and the Philippines (Palawan, Balabac, and Samar). Lemba is a Kalimantan's landrace plant that is high potential for cultivation because of its high economic value and commercial prospect owing to its diverse purposes. A study by Kocyan (2007) reported that there are more than 20 species from the family of Hypoxidaceae, and among those species, *Curculigo* and *Hypoxis* were the most important genera of the family.

Genus *Curculigo* is distributed in the tropical Africa and rainforest of Asia, especially in Malaysia and Singapore. According to Ismail et al. (2010), there are four important species of the genus namely *C. latifolia*, *C. capitulations*, *C. racemes*, and *C. orchioides*. In Malaysia, *C. latifolia* Dryand is an important medicinal plant (Farzinebrahimi et al. 2013). There, the plant propagates by rhizome and abundantly found in highland areas with an altitude between 1500-2000 m asl., and generally grow in slope and forest area. In Kalimantan and Malaysia, fibers from lemba leaves are utilized for making fishing net, rope, and material for weaving doyo. Shaari (2005) stated that lemba leaves and flowers could be used to treat high fever, while lemba flower and rhizome potion has been used to treat stomachache and frequent urinating. Ahmad and Holdsworth (1994) reported that lemba rhizome as topical ointment to treat cut wound. Wiart (2000) reported that lemba rhizome extract was able to inhibit hepatitis B virus. Yamashita et al. (1990) identified and characterized curculin sweet proteins with taste-modifying activity from *C. latifolia*. These proteins are 500 times sweeter than sucrose (Kant 2005; Masuda and Kitabatake 2006) and can be used as a low-calories sweetener for diabetic and obese people (Ismail et al. 2010). In Eastern Kalimantan, lemba leaf fiber is used for traditional practice of weaving ulap doyo cloth. According to ulap doyo weavers, to produce one woven cloth with a length of about 1.5 m, it requires about two spools of yarn. A spool of yarn was made from about thirty *senik*, and a *senik* is produced from 30-36 lemba fresh leaves. Thus, it requires 1800-2160 lemba leaves to weave one sheet of cloth. The demand on lemba plant as raw material for ulap doyo woven cloth is high, but the availability of the material is low because no one is cultivating the plant. Generally, lemba plant used for

material for the weaving by people of Dayak Benuaq tribe are lemba biang and lemba pentih.

Identification and characterization of lemba plant are necessary steps in developing new superior lemba varieties with high productivity and other important traits with a goal to increase plant quality and competitiveness (Carsono 2008; Barnum 2005; Sari 2013). Identification step aims to identify taxonomical characteristics of various individuals and to classify each into a particular taxon (Mayr and Ashlock, 1999; Litbang Pertanian 2004). Identification can be made using several approaches i.e. (i) identification based on morphological and agronomical characteristics; (ii) identification based on cytology; (iii) identification based on DNA or molecular pattern (Swasti 2007; Jamsari 2008).

Low diversity of vegetative-propagating lemba plant is one of the obstacles encountered in lemba plant breeding. Narrow genetic diversity hinders the selection process thereby resulting in a low selection efficiency (Sigrist et al. 2011). Conversely, wide genetic diversity in germplasm is a determining factor in developing a superior plant variety (breeding) (Pribadi 2009; Singh et al. 2012). Until now, only a few of research has been conducted on lemba in East Kalimantan or even in Indonesia, including studies on lemba plant phenotype suitable for weaving material. People in Kutai Kartanegara to these days have not cultivated lemba. Therefore, a study on identification and morphological characterization of lemba cultivars need to be done. This study aimed to identify and characterize lemba plant in East Kalimantan to reveal phenotypic variability in both quantitative and qualitative traits that can be utilized as the source of germplasm for the plant breeding program.

MATERIALS AND METHODS

Study area

The study was conducted in July - December 2016 in Tenggarong Sub-district and Kota Bangun Sub-district, Kutai Kartanegara District, East Kalimantan Province, Indonesia; and in Jempang Sub-district, West Kutai District, East Kalimantan Province, Indonesia (Figure 1). The area, altitude, and soil type in those study area are shown in Table 1.

Procedures

Data collection

Data collection was done by interview, exploration and direct measurement on quantitative and qualitative traits of lemba plant in three sub-districts i.e., Tenggarong (TGR), Kota Bangun (KOBA), and Jempang (JMP) (Cunningham 2001; Newing et al. 2011). An interview was carried out to gather information from the locals on the utilization of naturally occurring wild lemba as material for weaving. Direct observation and measurement of the object of the study were conducted to characterize lemba plant according to Developing Crop Descriptor Lists (BI 2007). The characterization included 12 qualitative and quantitative traits.

Observed variables

Variables observed and measured in lemba plant were qualitative and quantitative traits which are shown in Table 2. Observation and measurement of those traits were done on mature lemba plant. Data scoring system for each trait is provided in Table 2.

Data analysis

Data obtained in this study were accordingly subjected to descriptive analysis, correlation analysis, principal component analysis, and cluster analysis. Descriptive analysis was used to evaluate morphological characteristics. Correlation analysis was employed to examine the relationship between morphological characteristics in both quantitative and quantitative traits. Correlation analysis in this study was performed by using software Minitab version 14.12. Principal component analysis was used to highlight the diversity in the observed variables or technique to determine plant traits that have significantly contributed to a particular variation, thus pointing out the character diversity (Afuape et al. 2011). In this study, Principal Component Analysis was performed using software SPSS version 11.6. Cluster analysis was utilized to group objects based on their characteristics. The cluster analysis used Euclidean distance as the criterion and generated dendrogram that shows a relationship between germplasms. The analysis was a hierarchical clustering since the clustering was carried out structurally based on character similarity and the number of desired clusters was not known. The cluster analysis was performed using software SPSS 11.6.

RESULTS AND DISCUSSION

Morphological characteristics of lemba germplasm

The characterization used in this study employed an agronomical-morphological approach (Swasti 2007; Jamsari 2008); Bajracharya et al. 2006). Morphological characteristics observation on seven quantitative variables of 33 lemba accessions revealed that some lemba had a short leaf sheath and a short petiole (Figure 2a) while some others have a long leaf sheath and petiole (Figure 2b). Lemba accession possessing the shortest leaf sheath and the shortest petiole was TGR2 (25 mm) and JMP6 (52 mm), respectively. Meanwhile, accession with the longest leaf sheath and petiole was KOBA5 (298 mm) and TGR4 (510 mm), respectively. Leaf dimension analysis revealed that JMP12 accession has the shortest leaf length (775 mm), while KOBA11 has the longest leaf (1195 mm). Observation on lemba leaf fiber identified that the accessions with the lowest and the highest fiber length to width ratio was KOBA4 (810.67) and KOBA12 (1165.3), respectively.

This morphological characterization is beneficial to highlight the variations and identify germplasms for plant breeding purpose. Morphological character variations of germplasm are particularly important for plant breeding (Tresniawati and Randriani 2011; Swasti 2007). The result of quantitative observation on the seven traits of lemba plant is shown in Table 4.

Figure 1. Study location in East Kalimantan Province, Indonesia. 1. Tenggarong Sub-district, Kutai Kartanegara, 2. Kota Bangun Sub-district, Kutai Kartanegara, 3. Jempang Sub-district, West Kutai.

Table 1. Area, altitude, and soil type in the study locations

Sub-district	District	Area (km^2)	Altitude (m asl.)	Soil type
Tenggarong	Kutai Kartanegara	398.10	10	Organosol glei humus
Kota Bangun	Kutai Kartanegara	1.143.74	9	Organosol glei humus
Jempang	Kutai Barat	744.47	10	Organosol glei humus

Note: Bappeda Kukar (2007); Suryadi (2014); BPS Kubar (2015); BPS Kukar (2016)

Table 2. Data scoring system for lemba plant qualitative and quantitative traits

Variables	Score	Characteristic
Qualitative traits		
Leaf sheath shape	3	Flat and short
	5	Flat and open
	7	Wide and open
Leaf sheath color	1	Green yellow
	2	Yellow green
	3	Green
	4	Bluish green
	5	Dark green
Leaf sheath arrangement	1	Alternate (only one leaf emerges from each stem node)
	2	Opposite (a pair of leaves emerge is situated opposite to each other in the same node ring)
	3	Sub-opposite (leaves from the neighboring node that are not far apart are arranged in opposite direction)
	4	Verticillate (there are more than two leaves arranged in the same stem node)
Petiole color	1	Green
	2	Yellow
	3	Brown
	4	Bluish green
Leaf surface	1	Glabrous
	2	Pubescent
	3	Rugose
	4	Tomentose
Leaf blade color	1	Green yellow
	2	Yellow green
	3	Green
	4	Bluish green
	5	Dark green
Leaf margin	1	Entire
	2	Serrate
	3	Doubly serrate
	4	Dentate
	5	Crenate
	6	Repand
Leaf base	1	Accuminate
	2	Acute
	3	Cuneate
	4	Obtuse
	5	Rounded
	6	Truncate
Leaf tip	1	Accuminate
	2	Acute
	3	Obtuse
	4	Rounded
	5	Truncate
	6	Retuse
	7	Mucronate
Stem surface	1	Glabrous
	2	Costale
	3	Sulcate
	4	Winged
	5	Pubescent
	6	Spiny
	7	Showing the remaining of leaves
Stem color	1	Green
	2	Greyish green
	3	Dark Green
	4	Yellowish brown
	5	Redish brown
	6	Grey
Leaf fiber	1	Very fine
	3	Fine
	5	Intermediate
	7	Rough
	9	Very rough
Quantitative traits		
Leaf sheath length	1	Very short (< 5cm)
	3	Short (6-10 cm)
	5	Intermediate (11-13 cm)
	7	Long (14-16 cm)
	9	Very long (> 16 cm)
Petiole length	1	Very short (≤ 10 cm)
	3	Short (10-20 cm)
	5	Intermediate (21-30 cm)
	7	Long (31-40 cm)
	9	Very long (> 40 cm)
Leaf blade length	1	Short (< 75 cm)
	3	Intermediate (75-85 cm)
	5	Long (86-100 cm)
	7	Very long (> 100 cm)
Leaf blade width	1	Short (< 5 cm)
	3	Intermediate (6-10 cm)
	5	Long (11-15 cm)
	7	Very long (> 15 cm)
Stem Diameter	1	Small (< 2 cm)
	3	Medium (2-4 cm)
	5	Large (> 4 cm)
Plant height	3	Short (< 50 cm)
	5	Intermediate (50-100 cm)
	7	Long (> 100 cm)
Leaf fiber length to diameter ratio	0	< 1000
	1	> 1000

Note: BI (2007) (Data scoring in this study was modified according to the necessity)

Figure 2. Lemba leaf sheath and petiole traits. Plant with (A) short and (B) long leaf sheath and petiole

Table 4. Quantitative traits of 33 lemba accessions

Accession	Leaf sheath length (mm)	Petiole length (mm)	Leaf blade length (mm)	Leaf blade width (mm)	Stem diam. (mm)	Plant height (mm)	Fiber length to diameter ratio
TGR1	30	100	780	100	29.5	988	1001.00
TGR2	25	98	880	92	26.3	1100	1026.60
TGR3	28	100	820	98	28.2	930	1033.00
TGR4	160	510	1040	140	50.1	1732	813.00
TGR5	140	491	1030	132	45.6	1701	946.60
TGR6	133	131	880	107	33.1	1241	1108.00
TGR7	135	129	875	105	33.1	1241	1118.67
TGR8	50	182	1030	117	29.1	1312	1145.30
TGR9	55	191	1040	117	29.3	1331	1161.30
KOBA1	140	483	1020	130	44.8	1643	894.67
KOBA2	132	130	870	106	32.5	1212	1104.00
KOBA3	50	180	1010	115	28.4	1270	1125.30
KOBA4	220	252	845	113	24.2	1347	810.67
KOBA5	298	390	921	110	39.1	1641	884.00
KOBA6	199	285	962	131	33.2	1481	881.33
KOBA7	63	128	856	111	18.1	1067	1030.67
KOBA8	72	78	782	64	19.1	924	1002.67
KOBA9	122	252	1050	110	41.1	1453	885.33
KOBA10	60	154	921	101	26.8	1163	1028.00
KOBA11	129	240	1195	150	32.7	1606	934.67
KOBA12	96	196	991	74	17.6	1307	1165.30
JMP1	104	213	902	123	44.3	1243	868.00
JMP2	103	164	898	121	44.6	1192	1038.67
JMP3	72	98	782	124	39.8	953	1014.60
JMP4	72	174	892	164	45.7	1162	1041.30
JMP5	78	174	894	141	34.4	1168	1064.00
JMP6	77	52	779	108	30.4	897	1001.30
JMP7	112	298	862	94	31.5	1298	677.30
JMP8	52	472	936	93	31.8	1498	937.30
JMP9	42	351	878	81	42.5	1300	845.33
JMP10	141	453	936	93	44.1	1561	921.33
JMP11	62	84	908	98	31.9	886	1173.33
JMP12	103	208	775	84	25.3	1105	766.67
Mean	101.7	225.5	916.4	110.5	33.6	1271.3	983.3

Note: TGR = accession found in Tenggarong, KOBA = accession found in Kota Bangun, JMP = accession found in Jempang

Correlation analysis

Correlation analysis of the quantitative data revealed that there was a highly significant positive correlation between the leaf sheath length and the petiole length (0,476) and plant height (0.617). Furthermore, the analysis indicated another significant positive correlation between the petiole length and the leaf blade length (0.491), stem diameter (0.563), and the plant height (0.886). Other significant positive correlations were shown between the leaf blade length and the width (0.452) and the plant height (0.743); between the leaf blade width and the stem diameter (0.551); and between the stem diameter and the plant height (0.500). The leaf width also exhibited a positive correlation with the plant height (0.361). Whereas significant negative correlations were shown between the leaf fiber length to width ratio and the petiole length (-0.562), the leaf sheath length (-0.428) and the plant height (-0.399) (Table 5).

Two characters are positively correlated when one character increases quantitatively as the other character increases, or one character decrease when the other decreases. Positive correlations between the leaf sheath length and the petiole and between the leaf sheath length and the plant height meant that the longer the leaf sheath, the longer the petiole length and the plant height. Similarly, the longer the petiole, the longer the leaf blade, the wider the stem diameter and the higher the plant. Accordingly, the positive correlation between the stem diameter and the plant height, and between the stem diameter. Conversely, a negative correlation such as those between the leaf fiber length to diameter ratio and the leaf sheath length, the leaf width and the plant height, respectively, meant that the higher the ratio, the shorter the sheath, the narrower the width and the shorter the plant.

Analysis of phenotype variance

Determination of phenotypic variability criteria was done by comparing the phenotypic variance with the standard deviation. A Phenotypic variability is wide if the phenotypic variance is bigger than or equal to 2 times the standard deviation (σ2f ≥ 2 Sd σ2f). A phenotypic variability is considered narrow if the phenotypic variance is smaller than 2 times the standard deviation (σ2f < 2 Sd σ2f) (Anderson dan Bancroft, 1952). Phenotype variability is a multiplication between genotypic and phenotypic variability (Allard 1960; Falconer and Mackey 1996). A higher genotypic variability allows a better chance for improvement through breeding method.

Variances in qualitative and quantitative traits of observed lemba plants from the three Sub-districts showed a narrow phenotypic variability in the qualitative traits and a wide phenotypic variability in the quantitative traits (Table 6). Quantitative traits are highly influenced by environment and multiple genes (Acquaah 2007; Makmur, 1992). Furthermore, Mangoendidjojo (2003) stated that different in environmental condition raise the chance of the emergence of variation that determines plant appearance. The apparent variation is not necessarily passed down to next progeny. Nevertheless, a broad phenotypic variability is an essential requirement for an effective selection program as it provides an array of genotype/accession options to be utilized as germplasm source. The variability of lemba plant qualitative traits was considered narrow. Crowder (1993) stated that qualitative traits are discreet and to an inconsiderable degree influenced by environment.

Table 6. Variability of qualitative and quantitative traits

Trait	σ^2 ± SD	Criterion
Qualitative		
Leaf sheath shape	0	Narrow
Leaf sheath color	0.27 ± 0.52	Narrow
Leaf sheath arrangement	0	Narrow
Petiole color	0	Narrow
Leaf surface	0	Narrow
Leaf color	1.96 ± 1.4	Narrow
Leaf margin	0	Narrow
Leaf base	0	Narrow
Leaf tip	0	Narrow
Stem surface	0.33 ± 0.57	Narrow
Stem color	1.27 ± 1.13	Narrow
Leaf fiber fineness	0.98 ± 0.99	Narrow
Quantitative		
Leaf sheath length (mm)	3419.1 ± 58.473	Wide
Petiole length (mm)	17483 ± 132.22	Wide
Leaf length (mm)	9214.8 ± 95.994	Wide
Leaf width (mm)	452.19 ± 21.265	Wide
Stem diameter (mm)	70.821 ± 8.4156	Wide
Plant height (mm)	56442 ± 237.57	Wide
Leaf fiber length to diameter ratio	15102 ± 122.89	Wide

Note: σ^2 = variance; SD = standard deviation

Table 5. Correlation analysis among quantitative characteristics of 33 lemba accession

Variable	LSL	PL	LL	LW	SD	PH	FR
LSL	1.000	0.476**	0.205^{ns}	0.242^{ns}	0.293^{ns}	0.617**	-0.428*
PL	-	1.000	0.491**	0.193^{ns}	0.563**	0.886**	-0.562**
LL	-	-	1.000	0.452**	0.286^{ns}	0.743**	0.060^{ns}
LW	-	-	-	1.000	0.551**	0.361*	-0.010^{ns}
SD	-	-	-	-	1.000	0.500**	-0.311^{ns}
PH	-	-	-	-	-	1.000	-0.399*
FR	-	-	-	-	-	-	1.000

Note: LSL = Leaf sheath length, PL = petiole length,LL = leaf length, LW = leaf width,SD = stem diameter,PH = plant height,FR = leaf fiber length to diameter ratio, ** = significantly different α = 1%, * = significantly different α = 5%,ns = not significant.

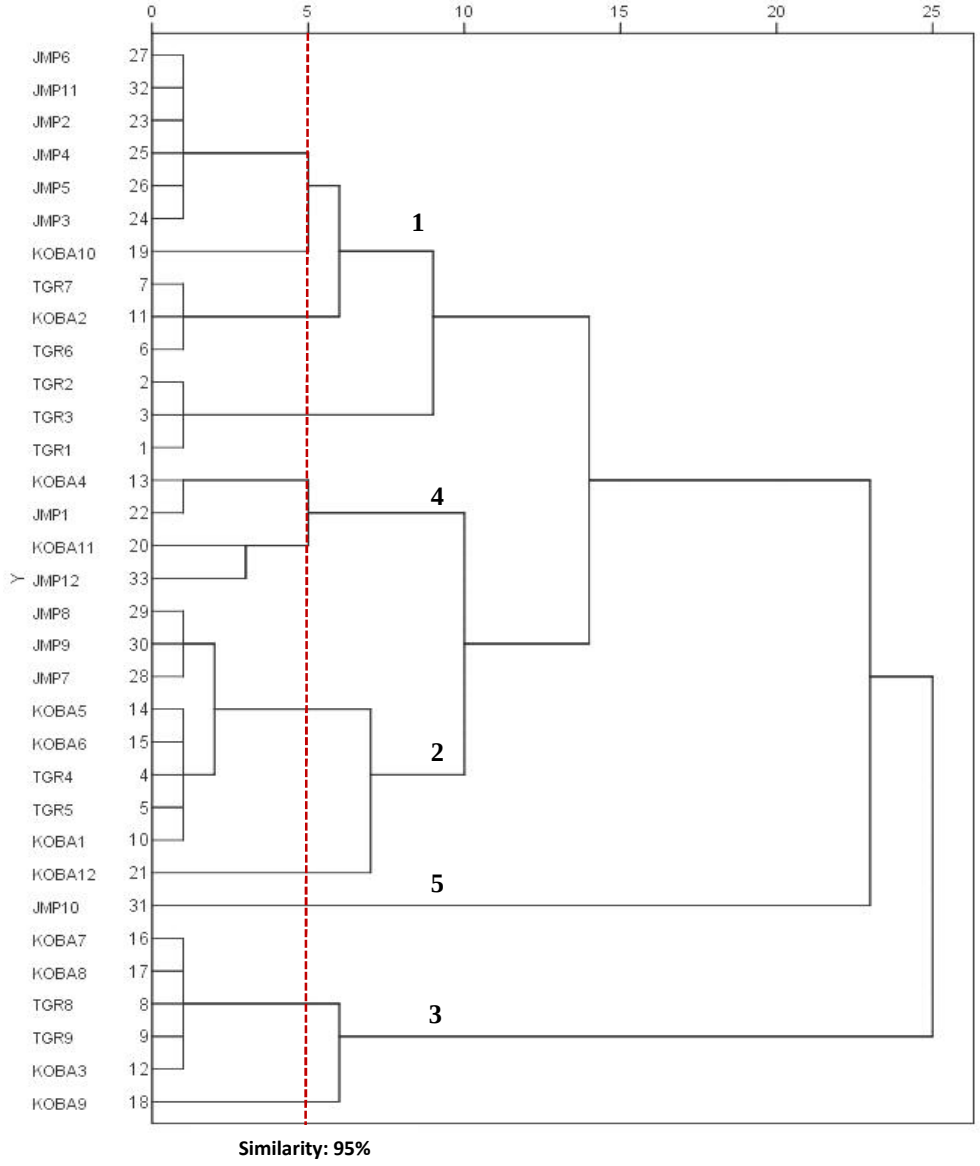

Figure 3. Dendrogram of 33 lemba accessions based on their qualitative traits

Principal Component Analysis

In this study, three principal components that account for the variability were identified. The cumulative variance was 96% which is obtained from 19 observed traits. A principal component was determined based on total initial eigenvalue (Mattjik and Sumertawijaya 2011; Tresniawati and Randriani 2011). Principal component analysis result showed that morphological traits in principal component 1 that affect the variability the most are leaf color, leaf fiber fineness, leaf sheath length, petiole length, leaf blade length, leaf blade width, stem diameter, and plant height. Morphological traits that have the most impact on principal component 2 are leaf sheath color, stem surface, and stem color. Meanwhile, traits that are highly affecting in the principal component 3 are leaf sheath shape, leaf sheath arrangement, petiole color, leaf surface, leaf margin, leaf base, leaf tip, and leaf fiber length to diameter ratio (Table 7).

Cluster analysis

Cluster analysis in this study used Euclidean distance and generated dendrograms that showed phylogenetic relationship between lemba germplasms. Classification based on morphological characteristics is important in plant breeding, especially to highlight variations and the relationship between germplasm accessions (Tresniawati and Randriani 2011). Accessions that share many similarities means that those accessions have a close relationship. Conversely, accessions that have many dissimilarities or differences are indicative of distant kinship (Jan et al. 2012).

Table 7. Observation on three principal components of lemba accessions at a cumulative variance of 96%.

Principal component	Observed character
KU1	Leaf blade color (LC),Leaf fiber fineness (LF),Leaf sheath length (LSL),petiole length (PL), leaf length (LL),leaf width (LW),stem diameter (SD),and plant height (PH).
KU2	Leaf sheath color (LSC), stem surface (SS), and stem color (SC).
KU3	Leaf sheath shape (LSS),Leaf sheath arrangement (LSA),petiole color (PC),leaf surface (LS),leaf margin (LM),leaf base (LB),leaf tip (LT),leaf fiber length to diameter ration (LFR).

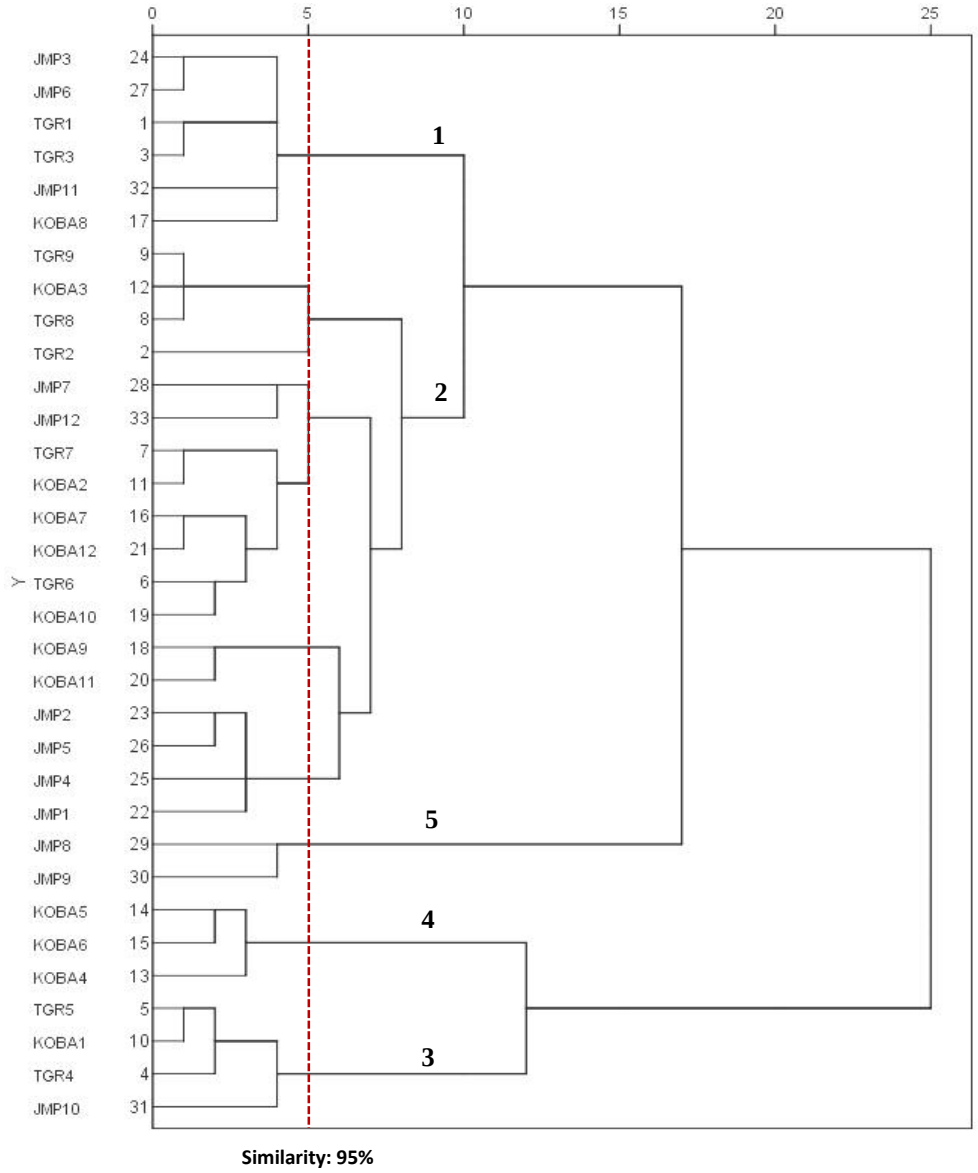

Figure 4. Dendrogram of 33 lemba accessions based on their quantitative traits

Cluster analysis result based on qualitative traits at 95% similarity revealed that there are five lemba accession groups. Group 1 consists of TGR1, TGR2, TGR3, TGR6, TGR7, KOBA2, KOBA10, JMP2, JMP3, JMP4, JMP5, JMP6, and JMP11 accessions; group 2 consists of TGR4, TGR5, KOBA1, KOBA5, KOBA6, KOBA12, JMP7, JMP8, and JMP9 accessions; group 3 which consists of TGR8, TGR9, KOBA3, KOBA7, KOBA8, and KOBA9 accessions; group 4 includes KOBA4, KOBA11, JMP1, and JMP12 accessions; and group 5 which consists of JMP10 accession (Figure 3).

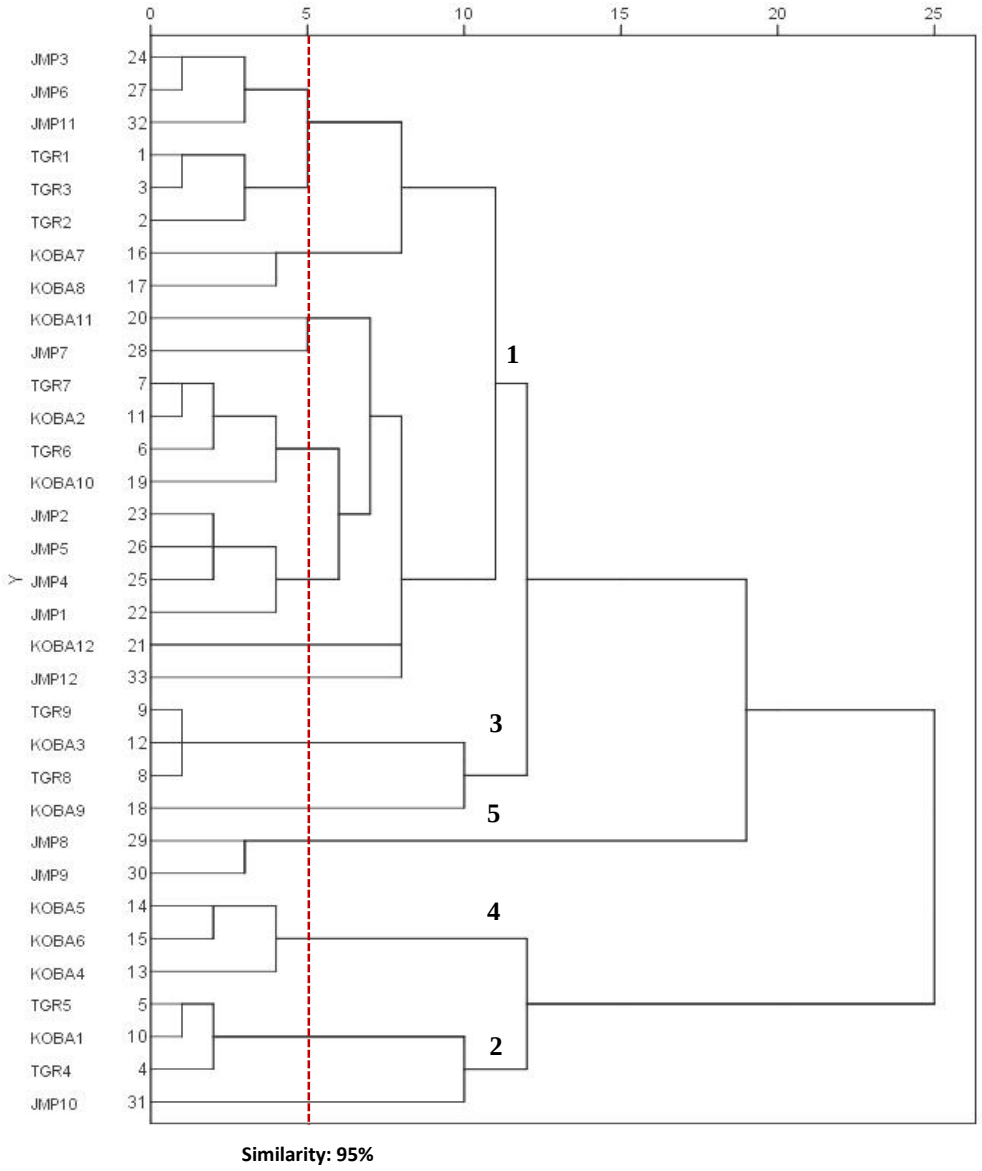

Figure 5. Dendrogram of 33 lemba accessions based on their combined qualitative and quantitative traits

Cluster analysis result based on quantitative traits at 95% similarity indicated five lemba plant accession groups. Group 1 consists of TGR1, TGR3, KOBA, JMP3, JMP6, and JMP11; group 2 consists of TGR2, TGR6, TGR7, TGR8, TGR9, KOBA2, KOBA3, KOBA7, KOBA9, KOBA10, KOBA11, KOBA12, JMP1, JMP2, JMP4, JMP5, JMP7 and JMP12 accessions; group 3 consists of TGR4, TGR5, KOBA1, and JMP10 accessions; group 4 consists of KOBA4, KOBA5, and KOBA6 accessions; and group 5 consists of JMP8 and JMP9 accessions (Figure 4).

Cluster analysis result based on combined qualitative and quantitative traits at 95% similarity indicated that there are five lemba plant accession groups. Group 1 consists of TGR1, TGR2, TGR3, TGR6, TGR7, KOBA2, KOBA7, KOBA8, KOBA10, KOBA11, KOBA12, JMP1, JMP2, JMP3, JMP4, JMP5, JMP6, JMP7, JMP11 and JMP12 accessions; group 2 consists of TGR4, TGR5, KOBA1, and JMP10 accessions; group 3 consists of TGR83 TGR9, KOBA3, and KOBA9 accessions; group 4 consists of KOBA4, KOBA5, and KOBA6 accessions; and group 5 consists of JMP8 and JMP9 accessions (Figure 5). According to Maji and Shaibu (2012), variables or observed traits that are tightly linked to the same group allows accessions to be divided into several existing relationships, and this interrelation is necessary to understand the behavior of complex traits of plant and allows the future development of the plant breeding program.

As a conclusion, the variance value of the 33 observed lemba plant accessions from the three Sub-districts points out that the phenotypic variability of qualitative traits was narrow while the that of the quantitative traits was broad. There are three principal components that account for the observed variability with a cumulative variance 0f 96%

which is obtained from 19 observed traits. Cluster analysis at similarity 95% indicates that there are five lemba accessions groups based on only qualitative, only quantitative, or based on combined qualitative and quantitative traits.

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