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Clustering of 24 Lesser Yam (*Dioscorea esculenta* L.) Indonesian Local Accessions Based on Morphological Characteristics

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ABSTRACT

Background: Lesser yam (*Dioscoreacea esculenta* L.) is one of the potential sources of tubers crops as industrial raw materials for food, feed and other purposes. The objective of this study was to characterize and morphologically classify lesser yam originated from three provinces in Java island of Indonesia.

Methods: A total of 24 lesser yam accessions from Central Java, East Java and DIY were characterized for morphological characters in Malang in 2018 refers to the standard evaluation for *Dioscorea.*

Result: The results showed a diversity of morphological characteristics in leaves, stems and tubers. For quantitative traits, the variability is seen in stem length, stem diameter, internode length, spine length, leaf length, leaf width, tip length, petiole length, tuber length and tuber width. For qualitative characteristics, diversity is seen in stem color, petiole color, leaf density, roots on the tuber, tuber skin color and flesh color of tuber. Lesser yam accessions were divided into four groups with a dissimilarity value of 0.00-0.89. Group I consisted of 15 accessions with characteristic stem color brownish brown to dark brown, color spot at spine base purple, thorns on the stem quite a lot, tuber flesh color white. Group II consisted of 6 accessions with the characteristics of having slightly rounded, smaller leaves. Group III has one accession, the petiole is shorter, the tuber is small and has a yellow flesh color. Group IV consisted of two accessions that had smaller leaves than groups 1 and 2, few roots on the tuber surface and yellow tuber flesh.

Key words: Lesser yam, Local accessions, Morphological characters, Roots, Variability.

INTRODUCTION

Lesser yam (*Dioscoreacea esculenta* L.) is one of the tubers of the *Dioscoreacea* family. It is currently an important cultivated crop in Southeast Asia, particularly in New Guinea, Oceania, the Caribbean and China (Flach and Rumawas, 1996). In some areas of Indonesia, lesser yam is popular with local name kumbili in Papua island and gembili or gembolo in Java island (Sabda *et al.,* 2019).

Lesser yam tubers are an important food source of carbohydrates because they produce and store starch and as a producer of industrial raw materials for food, feed and other purposes. The tubers of *D. esculenta* contain crude protein (2.95-10.5%), crude fat 0.61-2.58%, ash 0.25-8.5% and starch 17.25-18.79% (Anwar *et al.,* 2019) (Obidiegwu *et al.,* 2020). lesser yam flour is also used in food products such as bakery, cookies, noodles, ice cream and confectionery (Retnowati *et al.,* 2019)(Herlina, 2019) (Herlina *et al.,* 2020). In addition, it also contains functional compounds in the form of dioscorin, diosgenin and glucomannan which is beneficial for health (Khasanah *et al.,* 2019; Andriani *et al.,* 2020 and Sareu *et al.,* 2021).

In some areas of Indonesia, lesser yam is an important carbohydrate food source because it produces and stores starch and as a producer of industrial raw materials for food, feed and other purposes of a traditional food ingredient. Lesser yam is not cultivated intensively. It begins to grow in the rainy season and could be harvested in the dry season. It grows around existing perennial plants and it is tolerant to 50% shading level (Lestari *et al.,* 2019) (Sawitri *et al.,* 2020). Lesser yam is still found in some areas, but because of the characteristics of the thorny roots, this plant has become rare. Ex-situ conservation is very important to save genetic resources from extinction and to ensure availability for their use. Conservation of tubers such as lesser yam in other institutes of Indonesia was carried out in the field and some were stored in vitro culture (Hidayatun *et al.,* 2018).

Characterization is an important step in germplasm management. Morphological characterization has been

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used for many commodities referring to descriptors as done by (Odongo *et al.,* 2023) on Bambara groundnut, (Rai *et al.,* 2024) on mungbean, and on other commodities. Exploration and characterization of lesser yam from several regions in Indonesia has been carried out by (Purnomo *et al.,* 2013)(Pertiwa *et al.,* 2018)(Maqfiroh *et al.,* 2018) and showed that there were variations in morphological characters, especially tubers. The objective of this study was to characterize and morphologically classify lesser yam originated from three provinces in Java island of Indonesia.

MATERIALS AND METHODS

The field testing was carried out at the Indonesian Legumes and Tuber Crops Research Institute (ILETRI) in Malang, East Java, Indonesia from November 2017 to June 2018. All tubers were planted in 60 cm diameter concrete pots, with a distance of 1.5 m × 1.5 m between the pots and wrapped around the stems in the form of bamboo or poles. Plants were fertilized with 50 kg Urea + 75 kg SP36 + 50 kg KCl per hectare, which was given individually (per planting hole), all at the time of planting. Provision of water according to conditions in the field. Pests, diseases and weeds are intensively controlled with pesticides. Tuber are harvested after the plant is 8-10 months old which is marked by drying of the leaves. Harvesting is done by trimming the leaves and leaving a 30 cm long midrib or stem, then the plant is dismantled by digging the surrounding soil.

The lesser yam genotypes consisted of 24 accessions of lesser yam from the Indonesian Legumes and Tuber Crops Research Institute for (ILETRI) which were collected from several regencies in East Java, Central Java and DIY, Indonesia. Observations were made on 10 quantitative traits and 62 qualitative traits on three parts of the plant stems, leaves and tubers. Young stems were observed after 20 days of plant emergence after planting and mature stems were observed before aging. Meanwhile, the leaves were observed after 30 days when the plants appeared after planting and the tuber in the soil was observed at harvest. Morphological characterization refers to the standard evaluation for *Dioscorea* from the International Institute of Tropical Agriculture, Ibadan, Nigeria/International Plant Genetic Resources Institute, Rome, Italy (IPGRI/IITA, 1997).

Data were analyzed using SPSS 21 program for two step cluster, principle component analysis and PBSTAT-CL for grouping using Gower dissimilarity method and average linkage clustering method.

RESULTS AND DISCUSSION

Plant performance

Lesser yam is characterized by the direction of the twisting of the stem to the left clockwise, the stem is thorny, the leaves are simple, the stem is round and there are no aerial bulbil. There is a diversity of morphological characteristics in leaves, stems and tubers (Tables 1 and 2). For quantitative traits, the variability is seen in stem length, stem diameter, internode length, spine length, leaf length, leaf width, tip length, petiole length, tuber length and tuber width. For qualitative properties, diversity can be seen in stem height, stem color, color of spot at spine base, petiole color, leaf density, leaf color, tip color, petiole color, place of roots on the tuber, wrinkles on tuber surface, tuber skin color (beneath the bark), hardness of tuber, skin color at head of the tuber, flesh color at central transverse cross-section, flesh color of lower part of tuber, uniformity of flesh color in cross-section, texture of flesh, time for flesh oxidation after cutting (Table 2).

The shape of the lesser yam tubers is almost the same, namely regular, round to elongated. The surface of the tuber is smooth and some is slightly rough and has root fibers. The diversity is seen in the size of the tubers and the color of the tubers. The color of the tuber skin is brown, gray-brown. The color of the tuber is white, yellowish white or pale white, yellow and orange. The size of the tubers is small to large with a tuber length of 3-26 cm and a tuber width of 2.8-27 cm (Table 1). The number of tuber per plant is 1-5, some even have more than 5 tubers.

In general, “gembili” lesser yam (D. *esculenta* var. fasciculata) is almost the same as “gembolo” lesser yam (*D. esculenta* var. spinosa). Some differences are seen in the fibers in the tubers, spines on the roots and the size of the tubers. *D. esculenta* var. fasciculata has finer tubers, more tubers, fewer spines and tastes better. The plant appearance of *D. esculenta* var. spinosa is not much different from *D. esculenta* var. fasciculata, by which some accessions have wider and rounder leaves. Significant differences between fasciculata and spinosa can be seen in the number and size of tubers per plant and the fiber in the tubers. Spinosa generally has less tubers and larger in size.

The difference between var. fasciculata and var. spinosa has been reported by (Antonio and Buot, 2021). *D. esculenta* var. spinosa has many spines on the anchor roots, large and numerous tubers with various shapes and long stolons in which the tubers hang are cultivated, have flowers, larger leaf sizes, feathers on upper and lower leaves while the cultivated *D. esculenta* var. fasciculata has sparsely absent spines at anchor roots, smaller leaves and very short stolons, allowing the small tubers to be close together or directly clustered at the base of the stem.

Based on the characteristics of leaves, stems and tubers, there are several characters that have a major contribution to diversity and grouping. The sequence of characters that contributed the most to the diversity of stems was the color of spot at spine base, stem height, stem color and young stem color and young stem length (Fig 1). The main differentiator on the leaves is the color of the petiole from green to purplish (all green with purple base, all green with purple leaf junction and all green with purple at both ends) (Fig 2). Several variables that have a

Table 1: Morphological characters of leaves, stems and tubers of lesser yam.

Accession number	Stem colour	Leaf length (cm)	Leaf width (cm)	Petiole colour	Tuber length (cm)	Tuber width (cm)	Roots on the tuber surface	Flesh colour at central transverse cross-section
MLG-0006	Brownish green	11.5	11.5	Green	13.0	6.0	Few	White
MLG-0008	Dark brown	9.0	8.0	Green	17.0	13.0	Many	White
MLG-0009	Dark brown	14.5	13.5	Green	12.0	5.0	Many	White
MLG-0011	Dark brown	9.5	9.0	Green	11.0	7.0	Few	Orange
MLG-0035	Brownish green	10.0	10.5	Green	19.0	5.3	Many	White
MLG-0184	Purplish green	13.5	14.0	Green	16.0	5.2	Many	Yellowish white or off-white
MLG-0235	Brownish green	8.0	7.0	Green	21.5	7.5	Many	Yellowish white or off-white
MLG-0249	Purple	12.5	12.0	Green	14.0	12.0	Many	White
MLG-0257	Green	14.0	8.5	Green	4.0	4.4	Few	Yellow
MLG-0258	Purple	11.7	11.5	Green	16.0	4.5	Few	White
MLG-0259	Purple	13.2	12.1	Green	26.0	13.0	Many	White
MLG-0263	Purple	10.0	8.5	Green	13.5	5.0	Few	White
MLG-0264	Purplish green	13.5	12.5	Green	11.4	4.0	Few	White
MLG-0268	Purplish green	12.5	11.5	All green with purple base	12.6	3.4	Many	White
MLG-0269	Purplish green	11.0	9.5	Green	13.3	5.0	Many	Yellowish white or off-white
MLG-0271	Purple	14.0	15.5	All green with purple leaf junction	13.0	7.0	Many	White
MLG-0272	Purple	14.0	14.0	All green with purple leaf junction	16.0	4.5	Many	White
MLG-0274	Purple	11.5	11.5	All green with purple leaf junction	10.4	4.5	Many	White
MLG-0284	Purple	9.0	7.5	Green	6.5	6.0	Many	Yellowish white or off-white
MLG-0285	Brownish green	15.0	16.0	Green	13.0	8.0	Many	Yellowish white or off-white
MLG-0290	Purple	12.0	10.0	All green with purple leaf junction	17.0	9.0	Many	White
MLG-0294	Purplish green	11.0	10.0	Green	17.0	9.0	Many	Yellowish white or off-white
MLG-0296	Brownish green	13.0	12.5	Green	13.0	8.0	Few	White
MLG-0297	Purplish green	11.5	11.5	Green	12.0	9.0	Few	White

major contribution as a differentiator in lesser yam tubers include the color of the tuber, the color of the skin of the main tuber, the texture of the flesh tuber and wrinkles on the tuber surface (Fig 3).

Several studies show the diversity of morphological characteristics of lesser yam in Indonesia (Purnomo *et al.,* 2017) (Pesireron *et al.,* 2021). The preferred tubers are tubers with large size, easy to harvest, regular tuber shape, delicious when steamed, white or yellowish tuber flesh color, smooth texture and not brittle when eaten (Hapsari and Trimanto, 2015)(Honfozo *et al.,* 2021). Flour obtained from white tubers is highly preferred, can be a promising raw material for the manufacture of bakery, cookies, noodles and confectioneries (Retnowati *et al.,* 2019).

Grouping of accession

Principal component analysis (PCA) and cluster analysis are two multivariate analysis approaches that are critical for quantifying and categorizing the diversity in germplasm. From several important characters that contribute, grouping is done using Gower dissimilarity and average linkage clustering method. The two main components (PC1 and PC2) accounted for 56.1% of the total variance and accession positions in the distributed scatter diagram in the four groups presented in Fig 2. Some accessions were located around the center point, others were widely distributed along both PC axes. Some accessions were overlap within the group, suggesting a possible similarity (Fig 4). The use of multivariate analysis to group accessions based on many characters is also carried out for many commodities, such as melon (Ghorbani *et al.,* 2020), chickpea (Kumar *et al.,* 2022) and other commodities.

The grouping results showed a high diversity of lesser yam, with a dissimilarity value of 0.00-0.89. Lesser yam accessions were divided into four groups (Fig 5). Group 1 consisted of 15 accessions with characteristic stem color of brownish brown to dark brown, color spot at spine base purple, leaf heart shape, thorns on stem quite a lot, inner tuber is white flesh color. Accessions included in group I are: The accessions are MLG-0009, MLG-0006, MLG-0035, MLG-0249, MLG-0258, MLG-0259, MLG-0263, MLG-0264, MLG-0268, MLG-0271 , MLG-0272, MLG-0274, MLG-0290, MLG-0296, MLG-0297.

The second group consisted of 6 accessions with the characteristics of having slightly rounded leaves, smaller than group I and yellowish white or off-white tuber color. The six accessions are: MLG-0184, MLG-0235, MLG-0269, MLG-0284, MLG-0285 and MLG-0294. The third group has one accession, namely MLG-0257, shorter leaf stalks,

Table 2: Coding characters based on descriptor of *Dioscorea* (IPGRI).

Morphological characters	Coding characters and number accessions
Young stem colour	Green (3)*; Purplish green (6); Brownish green (1); Dark brown (4); Purple (10)
Stem height	<2 m (15); 2-10 m (9)
Stem colour	Green (1); Purplish green (6); Brownish green (5); Dark brown (3); Purple (9)
Colour of spot at spine base	Red (18); Purple (6)
Petiole colour	All green with purple base (2); All green with purple leaf junction (5); All
green with purple at both	ends (17)
Leaf density	Low (4); Intermediate (7); High (13)
Leaf colour	Yellowish (3); Pale green (10); Dark green (11)
Tip colour	Light green (3); Dark green (10); Purple green (11)
Petiole colour	All green with purple base (1); All green with purple leaf junction (4); Green (19)
Roots on the tuber surface	Few (8); Many (16)
Place of roots on the tuber	Lower (3); Middle (2); Upper (3); Entire tuber (16)
Wrinkles on tuber surface	Few (2); Many (22)
Tuber skin colour (beneath the bark)	Light maroon (17); Dark maroon (4); Greyish (3)
Hardness of tuber	Hard (4); Easy (20)
Skin colour at head of the tuber	White (15); Yellowish white or off-white (7); Yellow (1); Orange (1)
Flesh colour at central transverse cross-section	White (16); Yellowish white or off-white (6), Yellow (1); Orange (1)
Flesh colour of lower part of tuber	White (15); Yellowish white or off-white (6); Yellow (1); Orange (1); Light purple (1)
Uniformity of flesh colour in cross-section	No (1); Yes 23)
Texture of flesh	Smooth (22); Grainy (2)
Time for flesh oxidation after cutting	<1 min (2); 1-2 min (3); >2 min (19)

*within the bracket states the number.

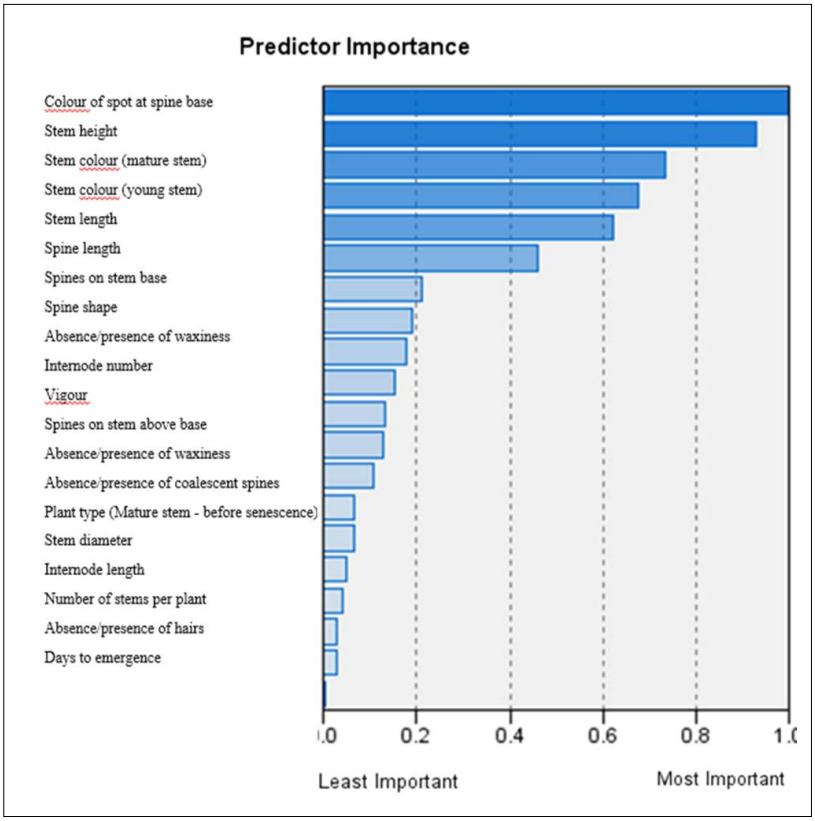

Fig 1: Prediction of characters contribution on stem.

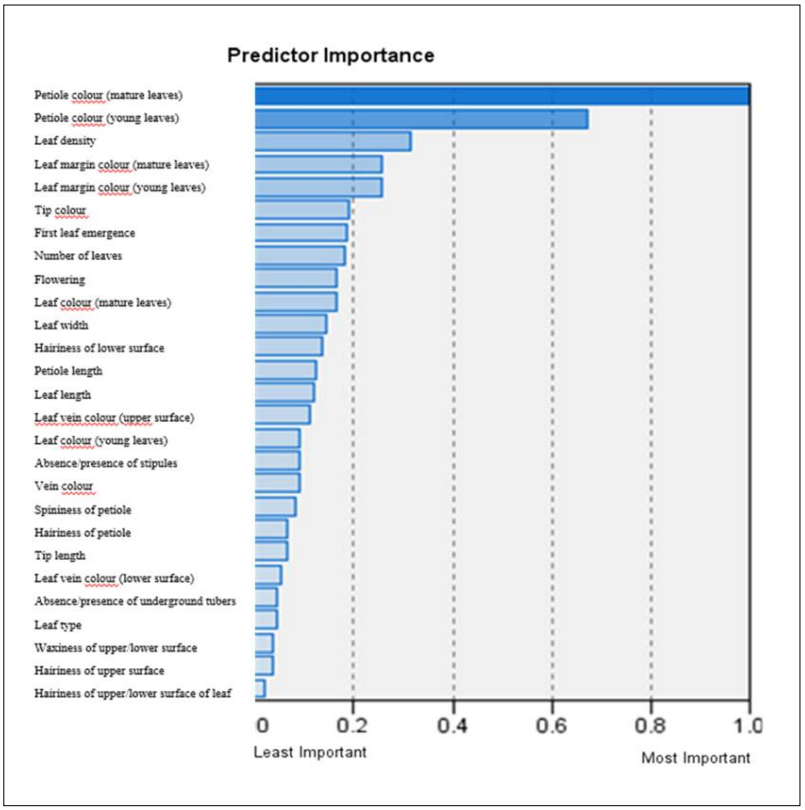

Fig 2: Prediction of characters contribution on leave.

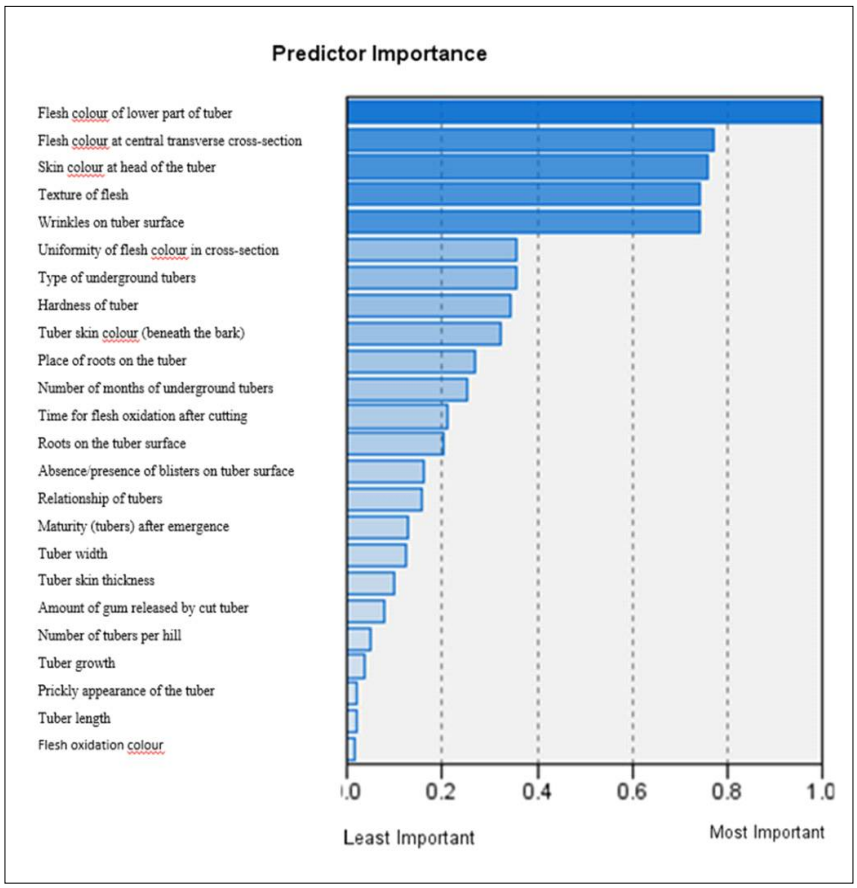

Fig 3: Prediction of characters contribution on tuber.

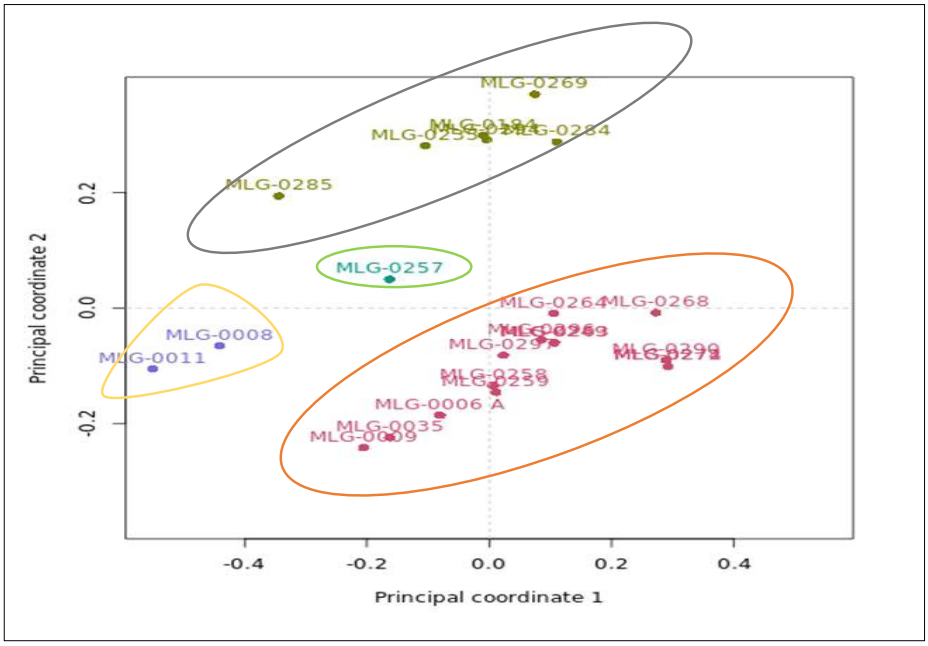

Fig 4: Distribution of 24 lesser yam accessions based on main component scores.

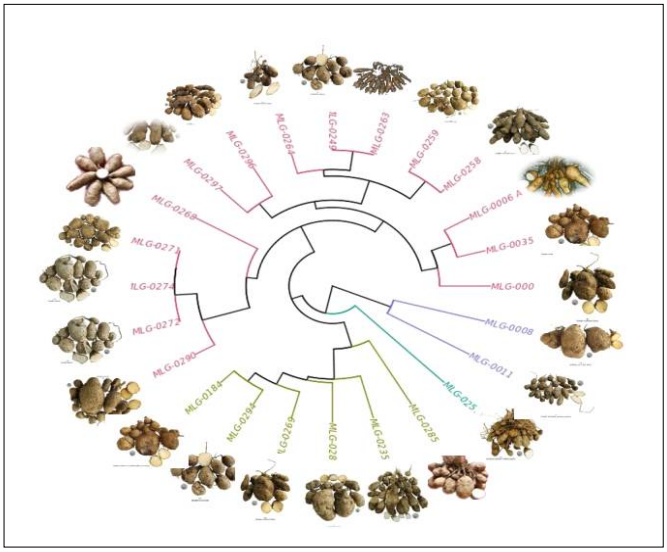

Fig 5: Clustering 24 lesser yam accessions based on morphological characteristics.

small tubers and roots at the top of the tubers and has a yellow flesh color. Group IV consisted of two accessions, namely: MLG-0008 and MLG-0011 which had leaves smaller than groups 1 and 2, long petioles, few roots on the tuber (rarely root on the tuber surface) and yellow flesh color (yellow tuber flesh).

CONCLUSION

Lesser yam accessions showed high diversity for qualitative and quantitative traits in leaves, stems and tubers with dissimilarity values of 0.00-0.89. Most accessions had white tuber flesh color, green petiole color and purplish green stem color. Lesser yam accessions were divided into four groups. Group 1 consisted of 15 accessions with characteristic stem color of brownish brown to dark brown, color spot at spine base purple, leaf heart shape, thorns on stem quite a lot, inner tuber color white. white flesh color. The second group consisted of 6 accessions with the characteristics of having slightly rounded leaves, smaller than group I and yellowish white or off-white tuber color. The third group has one accession, the petiole is shorter, the tuber is small and the root is at the top of the tuber and has a yellow flesh color. Group IV consisted of two accessions, which had smaller leaves than groups 1 and 2, long petioles, few roots on the tuber surface and yellow tuber flesh.

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Data availability

The data used to support the findings of this study are available from the corresponding author upon request.

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Conflict of interest

The authors declare no conflicts of interest regarding the publication of this study.

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