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Morphological characterization and geographical mapping of mango (*Mangifera indica* L.) accessions

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Abstract A total of eighty mango accessions located in the orchard were mapped using ArcGIS software. However, only seventy-two of these are analyzed by the Shannon-Weaver Diversity Index due to some accessions being cut down or dead. The remaining mango accessions were characterized using the International Plant Genetic Resources Institute's (IPGRI) descriptor list, with a total of seventeen morphological traits, twelve of which are qualitative traits and five of which are quantitative traits. According to the Shannon-Weaver Diversity Index (H'), the general mean of mango characters has a diversity index of 0.73. For qualitative traits, the diversity index was 0.62, while the mean average for quantitative traits was 0.84. The majority of mango accessions had higher diversity in qualitative traits such as leaf texture (H'= 0.99), mature tree height (H'= 0.96), foliage density (H'= 0.81), and leaf fragrance (H'= 0.78). Meanwhile, all quantitative traits, such as trunk circumference (H'= 0.80), crown diameter (H'= 0.87), leaf blade length (H' = 0.86), leaf blade width (H' =0.88), and petiole length (H'= 0.80), showed greater diversity. This higher level of diversity of mango accessions located in the orchard should be maintained by using the map for easier monitoring, inventory, and access of a breeder or curators, particularly during varietal improvement.

Keywords: Accessions, Diversity analysis, Geographical mapping, Mango, Morphology

Introduction

Mango (*Mangifera indica* L.) also known as “manga” in the Philippines is considered the most prevalent horticultural crops in the tropical and subtropical regions around the world (Khan *et al.,* 2015).

Mango is a member of the Anacardiaceae family under Sapindales with a chromosome number of 2n=40. This genus is widespread throughout tropical Asia accounts for 70 species and is divided into two subgenera where mango belongs to the subgenus *Mangifera* (Shamili *et al.,* 2012). It is considered the

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most vital fruit among *Mangifera* due to its edible quality and industrial usage that contribute to economic growth. The Philippines is one of the countries in the Southeast Asian region where mango is observed (Dinesh *et al.,* 2011). There are 8 species found in the country. Because of great diversity, the cultivation of mango contributes to the socio-economic in the country where the production reached 94.92 thousand metric tons, of which the *carabao* variety shared the largest production with 77.25 thousand tons (Philippine Statistics Authority, 2019). Mango fruits account for 50% of exportable quality from the total crop harvested (Esguerra, 2002).

Despite the high demand and export value of mango, proper maintenance and conservation practices are commended to maintain its genetic makeup. The good quality taste and other potential traits present in mango accessions have to be tapped for further improvement for current and future purposes. For the conservation and improvement of mango cultivars, proper identification and mapping of genetic resources are important. Characterization is essential for documentation of the performance of the cultivars in a given environmental condition which provides aid to reveal, identify, select, and enhance existing mango varieties (Bora *et al.,* 2017). One of the primary tools in characterization is the use of the descriptor list. IPGRI now Bioversity International (2006), developed the descriptors list intended for mango species which focused on morphological characteristics. Hoogendijk and Williams (2001) recommended the use of morphological characters as the first stage in characterization. Its application is the simplest of the formal, homogenous, and replicated methods of evaluating crop genetic diversity (Bora *et al.,* 2017). Moreover, morphological characters may be associated with environmental features using GIS for selecting valuable germplasm accessions for crop development (Pederson *et al.,* 1996).

Geographic Information System (GIS) is a tool that provides spatial data in graphics form for exploration, and geographic patterns of biodiversity and to aid management in the genebank and present data in several forms. One of the effective functions of GIS in genebank is the inventory, conservation, and mapping of genetic resources. GIS is designed in creating maps to support the plant genetic resources and biodiversity of species based on the range of distribution (Hijmans *et al.,* 2002). Therefore, the genetic diversity of mangoes can be easily located and explored when it is linked to a system like GIS which gives easy access to the genebank curators and plant breeders.

Hence, the study aimed to assess the diversity of mango located in the orchard and specifically to characterize the mango accessions and create a map using GIS.

Materials and methods

The study was conducted at the Institute of Crop Science-Mango Orchard, College of Agriculture and Food Sciences, University of the Philippines, Los Banos Laguna, Philippines from August to December 2019. All mango accessions present in the orchard were manually measured from (latitude 14° 9'50.2"; longitude 121°14'48") of the first mango accession up to the last mango accessions located in the area. Through using the compass, laser, and GPS, the bearing, location, and distance between mango accessions were gathered and set to the ArcGIS software. The existing map from the geographic information system (GIS) was used to plot the geo-reference points of mango accessions using the layer menu of the software. ArcGIS software was used to assess the spatial distribution and map the data collected in the location site of mango.

A total of seventy-two mango accessions were used to characterize using the descriptor list of mangoes (*Mangifera indica* L.) from the International Plant Genetic Resources Institute (IPGRI, 2006). The qualitative data characterized are the following: tree type, crown shape, tree growth habit, foliage density, leaf blade shape, leaf altitude in relation to branch, the thickness of pelvinus, angle of secondary veins to the midrib, curvature of secondary veins, leaf shape, leaf texture, leaf apex shape, leaf base shape, leaf margin, the color of young leaf, color of fully developed leaf and leaf fragrance. The following quantitative data were collected: tree height, trunk circumference, crown diameter. Each accession was randomly selected at least 10 samples for leaf blade length and leaf blade width and petiole length. The mango accessions were recorded based on the existing name tags found in the trees. However, some mango accessions have no accession number and this was recorded using simple numerical numbers.

The data were analyzed to determine the phenotypic diversity by using the formula of the Shannon-Weaver Diversity Index (H') (Jain *et al.,* 1975):

Where:

$$H' = \frac{-\sum_{i=1} P_i (\log_2 P_i)}{\log_2 n}$$

p=proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N).

log= natural log

Σ= sum of the calculations

s= number of species

The diversity index criteria of Eticha *et al.* (2006) and Jamago and Cortes (2012) will be followed.

$H2 \geq 0.67$= high
$0.34 \leq H' \leq 0.66$ = intermediate
$0.01 \leq H' \leq 0.33$= low

Results

Mapping

The mango orchard was located at the Institute of Crop Science, University of the Philippines, Los Banos, Laguna (Latitude 14°09'49.9' Longitude 121 °14'48.3"). The map shows the accessions of mangoes planted in the orchard. The mango was captured using the ArcGis program capable of creating map by inputting the latitude and longitude data taken individually from mango accessions. There are 80 mango accessions that were mapped in the orchard but some of these trees were down due to abiotic and biotic stresses. The triangular shape represents the 80 mango accessions (Figure 1).

A total of seventy-two mango accessions were characterized using the descriptor list of the International Plant Genetic Resources Institute. A wide range of variability was observed for 17 morphological descriptors among the 73 mango accessions (Table 1). As evidenced by the Shannon-Weaver Diversity Index (H') there are 0.73 diversity index as the general mean among mango characters. The qualitative traits recorded 0.62 diversity index while 0.84 for the quantitative traits as the mean average (Table 1).

Discussion

Mapping

The use of coordinates in each mango accession is a useful way to create an accurate map. The exact coordinates of the mango provide an actual position of mango trees in the orchard. In fact, the mapping of mango in the orchard is the first attempt to develop an effective inventory and monitoring of live mango accessions. According to Kumar *et al.* (2013), mapping using geographic information systems is important effectively in the documentation, diversity analysis, identifying gaps in the collection, assessment of loss of diversity, developing new strategies for conservation, and sustainable utilization, particularly in the wake of recent international developments related to food and nutritional security. Furthermore, Sunil *et al.* (2008) was able to determine the diversity of *J. curcas* accessions and notice the gaps in collection and diversity richness of India's collection through geographical mapping. Shabanimofrad *et al*. (2011), also utilize GIS and found the highest diversity of physic nut (*Jatropha curcas*) in terms of oil content in different parts of Malaysia.

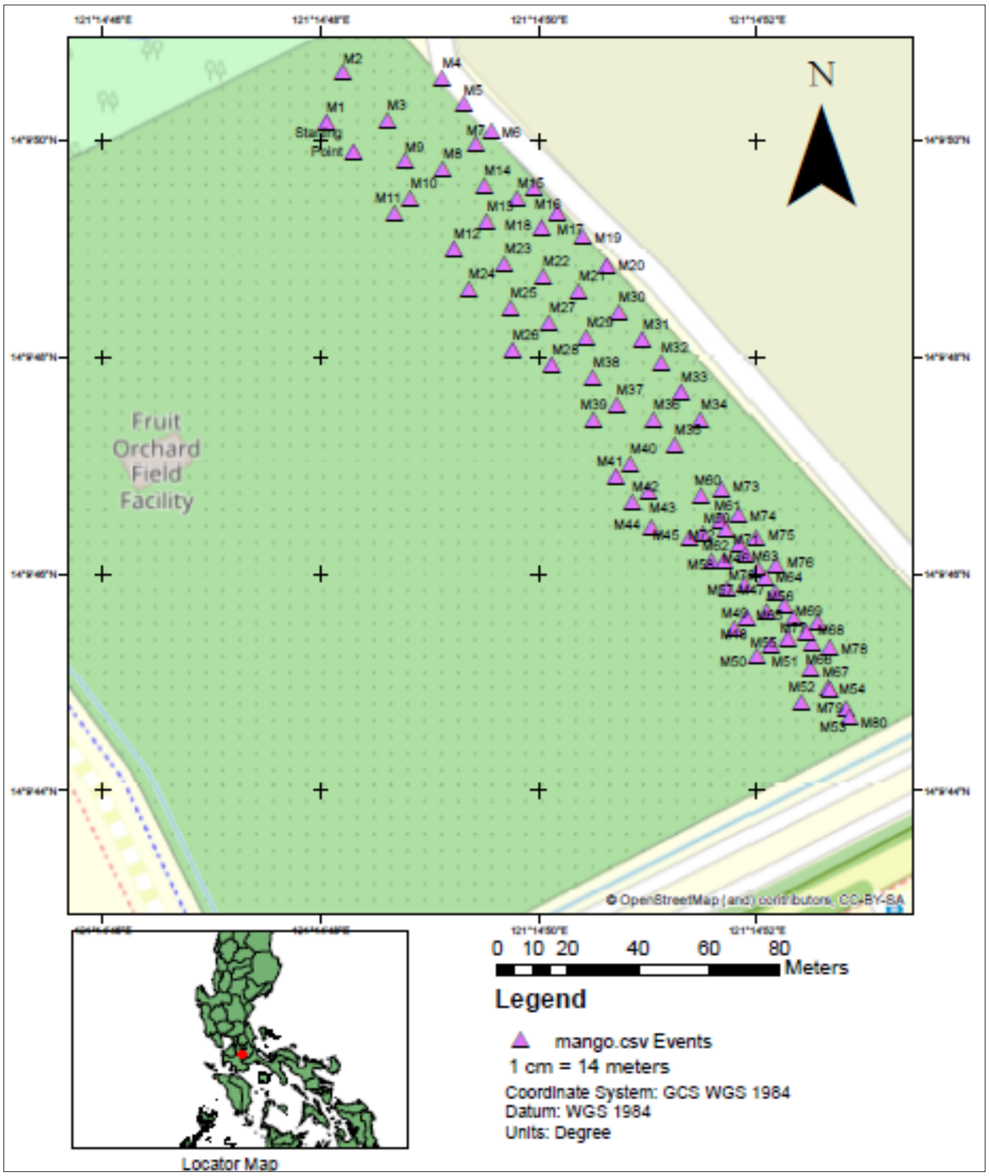

Figure 1. Showing the distribution of mango accessions in the orchard area of the Institute of Crop Science

Table 1. Computed diversity indices of 17 morphological traits

	Qualitative Traits			Quantitative Traits	
	Traits	**H'**		**Traits**	**H'**
Tree	Height of mature tree	0.96	**Tree**	Trunk circumference (cm)	0.80
	Crown shape	0.43		Crown diameter(m)	0.87
	Tree growth habit	0.94			
Leaf	Foliage density	0.81	**Leaf**	Leaf blade length (cm)	0.86
	Leaf blade shape	0.31		Leaf blade width(cm)	0.88
	Thickness of pelvinus	0.58		Petiole length (cm)	0.80
	Angle of secondary veins to the midrib	0.18			
	Leaf texture	0.99			
	Leaf apex Shape	0.36			
	Leaf base shape	0.50			
	Color of fully developed leaf	0.62			
	Leaf fragrance	0.78			
	Mean	**0.62**		**Mean**	**0.84**
		General Mean: H'= 0.73			

Tree descriptors (Qualitative traits)

Heights of mature trees obtained a high diversity index (H' 0.96) which varied from short (15.07% accessions), medium (32.88% accessions), tall (34.25% accessions) and very tall mango trees recorded 17.81% accessions. On the other hand, tree growth habit also shows high diversity index of 0.94 in which 64.38% of mango accessions have spreading growth habit while the remaining 35.62% have erect growth. This is comparable to the results conducted by Toili *et al.* (2016) reported that 65.1% of the mango trees have spread growth habit out of 98 accessions in different regions of eastern Kenya.

Foliage density has a 0.84 diversity index where most of the accessions have intermediate foliage (60.27%), 30.14% of accessions have sparse while 9.59% of accession have dense foliage density. The high diversity of foliage density may be caused by pest infestation, leaves rejuvenation and different timing of maturity. However, crown shapes have a medium diversity index (H' 0.49) in which 80.82% of mango accessions dominantly have semi-circular crown shape while oblong (12.33%), broadly pyramidal (5.48%) and spherical (1.38%).

Tree descriptors (Quantitative traits)

The quantitative traits of mango trees show higher diversity among accessions. Trunk circumference and crown diameter obtained 0.80 and 0.87

diversity index. The average trunk circumference of 73 mango accessions ranges from 63.78cm to 292.71cm due to different collecting and planting dates. The crown diameter of mango accessions ranged from 3.46 m to 15.77m. The high diversity of some of the traits may be influenced by environmental factors and even cultural management (Diaz-Matallana *et al.,* 2009).

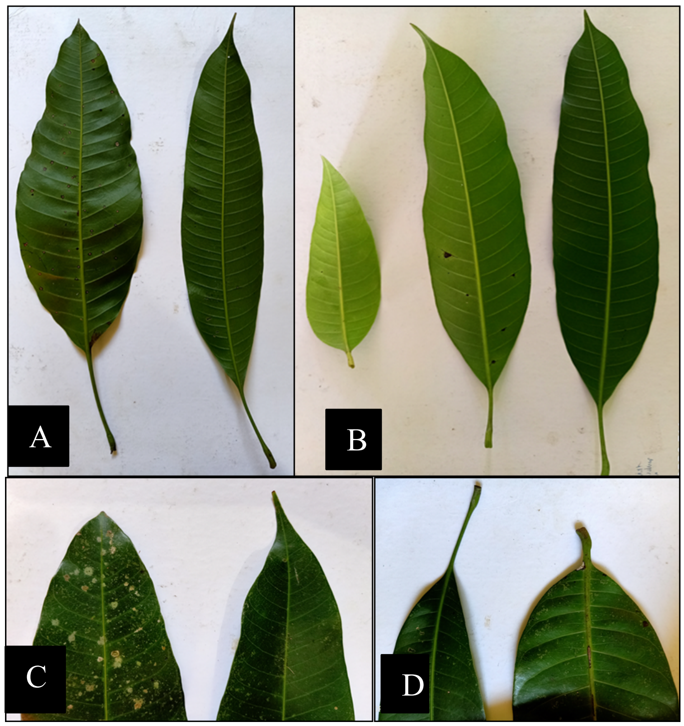

Figure 2. A. Shapes, B. color of leaves, C. Leaf apex, D. leaf base and thickness of pelvinus

Leaf descriptor (Qualitative traits)

Wide variation was observed in leaf texture (H' 0.99) and leaf fragrance (H' 0.78) among 72 mango accessions (Table 1). The leaf texture was distributed dominantly in 56.16% of accessions of mango observed with chartaceous while 43.83% of accessions have coriaceous leaf texture. Most of the accessions (53.42%) have mild leaf fragrance followed by 41.10% of accessions with no fragrance and the strong fragrance has the least accessions with 5.48% only. The variation in leaf texture is caused by weather, cultural management, and growth stage (Bally *et al.,* 2009). Moderate diversity was observed in the thickness of pelvinus (H' 0.58), leaf base shape (H' 0.50) and color of leaf (H'0.62) among the 73 mango accessions. Most of the mango accessions have a thick and tapering type of pelvinus that accounts 86.30% of the total accessions while the remaining 13.70% of accessions have thin pelvinus. In the same manner, leaf base shapes were dominantly obtuse which is 94.52% of accessions have this type of leaf base shape while 5.48% of accessions have acute (Figure 2D). The fully developed leaf of mango accession had pale green (2.74%), dark green (24.66%) and mostly green color (72.60%). The color shown above (Figure 2B) is not the actual color of accessions, but it was used only as a basis to classify the pale, green and dark colors. According to Bally *et al.* (2009) mango leaves are diverse in size, shape and leaf color. The leaf blade shape, leaf apex shape and angle of secondary vein show low diversity index among mango accessions (Table 1). Out of 72 mango accessions, 94.52% was observed with oblong while 5.48% of accession has lanceolate leaf blade shape (Figure 2A). Leaf apex shape (H' 0.36) has dominantly acuminate (86.30%) while acute (13.70%) (Figure 2C). Angles of secondary veins have low diversity index (H'0.18) out of 17 characters among the mango accessions, 97.26% observed with medium angles and the remaining is narrow with 2.74% accessions. This is the same with the results of Aguoru *et al*. (2016) reported that mango has low variation among cultivars which do not display significant variation in leaf morphological characters. No diversity has been observed among mango accessions in the leaf margin, leaf pubescence, curvature of secondary veins and leaf altitude in relation to branch.

Leaf descriptors (Quantitative traits)

Wide diversity was observed in leaf blade length (H' 0.86), width (H' 0.88), and petiole length (H' 0.80). This indicates that there were large variations among sampled trees from 72 accessions. This also states that mango accessions consist of mixed cultivars and typical traditional varieties located in the orchards. These results coincide with the report of Zenab and Tagelsir (2015) that mangoes have significant differences in terms of petiole length between genotypes but not within the cultivars. Fivaz (2008) also reported that leaf length, leaf width, and petiole length have great variation depending on cultivar, climate and cultural practices. A similar report to Sonibare *et al.* (2004), stated that *Ficus* Linn has significant variation in terms of leaf length and leaf width. Furthermore, morphological characterization is measured visually according to actual characters present during the characterization period. The characterization of germplasm is essential to record the important traits that are highly heritable and expressed in the environment. Likewise, geographic maps of germplasm are also important to determine the wide distribution as well as to monitor the diversity. The mango accessions located in the orchard showed high diversity in quantitative traits while qualitative traits also showed high diversity. The level of diversity (H'=0.73) among 72 mango accessions based on the Shannon-

Weaver Diversity Index indicated that these accessions could be very useful in enriching the mango germplasm and utilizing these diverse accessions for varietal improvement under different mango breeding programs. The high diversity of mango in the orchard may be due to varying responses to environmental conditions during the characterization. Some of the accessions have started to rejuvenate their leaves and some are matured. But most of the accessions may vary on morphological characters because of their genetic makeup that is represented by different alleles. The geographical mapping of the high diversity of mangoes located in the orchard provides support to monitor the accessions, inventory, and easy access for curators and breeders to locate their desired traits. Therefore, the linking of morphological data with geographical distribution maps is vital in field gene banking. The high value of mango made this crop one of the important fruit trees around the world. Hence, proper management and conservation practices must be applied by monitoring the diversity using maps and gathering morphological data. Furthermore, a continuation of this study to fulfill the whole morphological characteristics is recommended especially at the flowering, fruit, and seed stages. It is also important to include the response of mango to various biotic stresses and even at the molecular level.

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References

Aguoru, C. U., Okoli, B. E. and Olasan, J. O. (2016). Taxonomic investigation of four cultivars of mangifera using micro-anatomical features. International Research Journal of Natural Sciences, 3:21-32.

Bally, I. S. E., Lu, P. and Johnson, P. R. (2009). Breeding plantation tree crops. New York: Springer New York. pp.53.

Bora, L., Singh, A. K. and Singh, C. P. (2017). Characterization of mango (*Mangifera indica* L.) genotypes based on physico-chemical quality attributes. Journal of Applied and Natural Science, 9:2199-2204.

Diaz-Matallana, M., Schuler-Garcia, I., Ruiz-Garcia, M., and Hodson De Jaramillo, E. (2009). Analysis of diversity among six populations of Colombian mango (*Mangifera indica* L. c var. Hilacha) using RAPDs markers. Electronic Journal of Biotechnology, Retrieved from: http://www.ejbiotechnology.info/ index.php/ejbiotechnology/article/view/v12n3-10/715

Dinesh, M. R., Hemanth, K. N. V., Ravishankar, K. V., Thangadurai, D., Narayanaswamy, P., Ali, Q. and Basha, S. M. (2011). *Mangifera.* Wild Crop Relatives: Genomic and Breeding Resources, pp.61-74.

Esguerra, E. B. (2002). Year-end Report: Postharvest system improvement for 'Carabao' mango. Report submitted to PCARRD, Los Baños, Laguna, July 2002.

Eticha, F., Belay, G. and Bekele, E. (2006). Species diversity in wheat landrace populations from two regions of Ethiopia. Genetic Resources and Crop Evolution, 53:387-393.

Fivaz, J. (2008). Botanical aspects. In: de Villiers, E, A. and Joubert, P. H. (ed). The cultivation of mango. ARC. Institute for Tropical and Subtropical Crops. pp.9-20.

Hijmans, R J., Guarino L. and Rojas E. (2002). DIVA-GIS a geographic information system for the analysis of biodiversity data. Manual. International Potato Center, Lima, Peru.

Hoogendijk, M. and Williams, D. (2001). Characterizing the genetic diversity of home garden Crops: Some examples from Americas. 2nd International Home gardens workshop, 17-19 July 2001, Witzenhausen, Federal Republic of Germany. pp.34-40.

International Plant Genetic Resources Institute (2006). Descriptors for mango (*Mangifera indica* L). International Plant Genetic Resources Institute, Rome

Jain, S K., Qualset, C O., Bhatt, G M. and Wu, K K. (1975). Geographical patterns of phenotypic diversity in a world collection of durum wheat. Crop Science 15:700-704.

Jamago, J. M. and Cortes, R. V. (2012). Seed diversity and utilization of the upland rice landraces and traditional varieties from selected areas in Bukidnon, Philippines. IAMURE International Journal of Ecological Conservation, 4:112-130

Khan, A. S., Ali, S. and Khan, I. A. (2015). Morphological and molecular characterization and evaluation of mango germplasm: An overview. Scientia Horticulturae, 194:353-366.

Kumar, G., Sivaraj, N., Kamala, V., Gangopadhyay, K K., Pandey, S.,Tiwari, S.K., Panwar, N.S., Meena, B.L. and Dutta, M. (2013). Diversity analysis in eggplant germplasm in India using DIVA-GIS approach. Indian Journal of Horticulture, 70:519-52.

Pederson, G. A., Fairbrother, T. E. and Greene, S. L. (1996). Cyanogenesis and climate relationships in U.S. white clover germplasm collection and core subset. Crop Science, 36:427-433

Philippine Statistics Authority (2019). Major Fruit Crops Quarterly Bulletin, January-March 2019. Date retrieved August 09, 2019.

Shabanimofrad, M., Yusop, M. R., Saad, M. S., Wahab, P. E. M., Biabanikhanehkahdani, A. and Latif, M. A. (2011). Diversity of Physic Nut (*Jatropha curcas*) in Malaysia: Application of DIVA-Geographic Information System and Cluster Analysis. Australian Journal of Crop Science, 5::361-368.

Shamili, M., Fatahi, R. and Hormaza, J. I. (2012). Characterization and evaluation of genetic diversity of Iranian mango (*Mangifera indica* L., Anacardiaceae) genotype using microsatellites. Scientia Horticulturae, 148:230-234.

Sunil, N., Sivaraj, N., Anitha, K., Abraham, B., Kumar, V., Sudhir, E. and Varaprasad, K. S. (2008). Analysis of diversity and distribution of *Jatropha curcas* L. germplasm using Geographic Information System (DIVA-GIS). Genetic Resources and Crop Evolution, 56:115-119.

Sonibare, M. A., Jayeola, A. A. and Egunyomi, A. (2004). A Morphometric analysis of the genus *Ficus* Linn. (Moraceae). African Journal of Biotechnology, 3:229-235.

Toili, M. E. M., Rimberia, F. K., Nyende, A. B. and Sila, D. (2016). Morphological diversity of mango germplasm from the upper athi river region of eastern Kenya: an analysis based on non- fruit descriptors. African Journal of Food, Agriculture, Nutrition and Development, 16: DOI: 10.18697/ajfand.74.13755

Zenab, M. A. M. and Tagelsir, H. M. A. (2015). Diversity of Mango (*Mangifera indica* L.) Cultivars in Shendi Area: Morphological Leaf Characterization. International Journal of Research in Agricultural Sciences, 2:2348-3997.

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