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Full Length Research Paper

Morphological Characterization of Mango (*Mangiferaindica* L.) in Mexico

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The purpose of this current study was to morphologically characterize 37 accessions of mango taken from the germplasm bank at Rozariolzapa experimental station of the National Forestry, Crops and Livestock Research Institute (CERI-INIFAP) in Mexico, in order to support genetic improvement programs for mango. We used 49 varietal descriptors for this species. Characters were analyzed through Principal Component Analysis (PCA), Hierarchical Cluster Analysis (HCA), and Cladistics Analysis (CA). Principal Component Analysis (PCA) indicated that the first eight components generated 61.4% of total variation. The other 32 characters permitted to make a distinction amongst accessions and so we formed three groups via HCA: group I using material from Guatemala Rey Jorge and Suchitoto, group II with regional criollo material from Mexico Ataulfo andmanililla; and group III using Floridian-type materials. Cladistics Analysis (CA) allowed the formation of eight groups and eight materials being grouped alone, the distinction from the three groups was mainly determined by embryos (monembryony and polyembryony) also by their geographical origin and high heritability characters such as fruit skin color at physiological maturity, fruit skin color at maturity and ripeness, shape of left shoulder, skin thickness; core and fruit core depth. We determined the existence of a wider genetic diversity in the studied accessions of mango so it can be used for the genetic improvement program.

Keywords: *Mangiferaindica L.*, morphological characterization, germplasm bank, diversity in mango.

INTRODUCTION

Mango *Mangiferaindica* L. is a prominent species from the *Anacardiaceae* family because they're integrated by 64 genera, whereas *Mangiferaindica* L. (mango), *Anacardiumoccidentale* (cashew), *Pistaceavera* (pistachio),

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Spondiaspurpurea L. (jobo), and *S. mombin* L. (jobo or plum) (Mata, 1995) stand out for their economic importance. In Mexico, the cultivated land for mango is of 185,124 ha (SIAP, 2017) which are distributed within the tropic. Difference in climate conditions and the type of sexual reproduction this species present has generated a variation in its shape, size, color, flavor, and aroma.

Levels in variation amongst types of mangoare being studied via morphological characterization of qualitative and quantitative characters (Subedi *et al*., 2004; Bally, 2006); iso-enzymatic (Gálvez-López *et al*., 2007), and molecular by using different types of markers; e.g., RAPD´s (Ravishankar *et al*., 2004; Karihaloo *et al*., 2003; Anju *et al*., 2008); and microsatellites (Viruel *et al*., 2005; Xinhua *et al*., 2005). To carry out morphological characterization few characters have been added; that is, Bally (2006) employed fruit characters to differentiate main varieties in mango; and Subedi *et al*. (2004) utilized 19 characters of fruit and seed in which 11 were quantitative but 8 were qualitative. Differentiation between types of mango has been done by characters associated with yielding components; that is, fruit size and weight, flesh and fiber content (Rajan *et al*., 2009), and fruit shape-aroma (Sagar *et al*., 2009) as well. As the *Soconusco* region homes a vast diversity of mango, the National Forestry, Crops and Livestock Research Institute (hereafter referred to INIFAP) started to work on its genetic improvement program in 1975 in Mexico. By introducing different types of mango (Chávez *at al*., 2001), as part of this program, we have selected and evaluated materials like *Irwin, Edward* and *Diplomatico*, and have also registered a clone for *Ataulfodiamante* by taking into account some characters of interests related to tree growth and yielding components. Nonetheless, there's a lack of research regarding this fruit tree genetic diversity.

In the view of the foregoing, we determined to carry out a morphological characterization in 37 accessions that were taken from the mango germplasm bank to know about its genetic diversity and to strengthen the use of creole species by means of genetic improvement programs.

MATERIAL AND METHODS

From the INIFAP mango *Mangiferaindica* L. germplasm bank, we used 37 accessions as vegetative material in 25-30 year-old plants (Table 1). It is located in the experimental station *La Norteña,*92° 30' Wand 14° 30'-15° 00' N at an altitude of 14 m and has an annual temperature of 27.8 ºC (82.04 °F).

Morphological characterization was based on some mango descriptors suggested by IBPGR (1989) (Table 2). We assessed 49 descriptors, among which 39 are qualitative characters and 10 quantitative. Qualitative characters are visual parameters-based whilst color was determined through Pantone® color chart. To register quantitative characters, a ruler and a Mitutoyo, Model No. CD-6 CS electronic Vernier have been employed; in addition, we evaluated 20 repetitions per accession for each character as we consider one repetition for leave, another for fruit or seed, accordingly.

Data was being analyzed through principal components (PC), while proper values (eigen values), proper vectors (eigen vectors); and the Pearson correlation coefficient were interpreted by means Princomp procedure of SAS (1996) plus correlation matrix between original variables and principal components (Jonhson, 1998). Moreover, we set these components into graphics within a Cartesian plane to observe the distribution of the accessions being characterize.

By conducting Proc clusterrocedure of SAS (1996), we were able to carry out both a Hierarchical Cluster Analysis (HCA) and an algorithm by accessions clustering to generate a dendogram that allowed to distinguish the groups formed by characterize accessions (Gonzáles, 2001). Furthermore, a cladistics analysis was conducted by comparing 37 accessions from *Mangiferaodorata Griff* species as an outer tax on that was managed by using parsimony algorithm from Nona program (Goloboff, 1993) alongside Win Clada program (Nixon, 2002). Finally, we obtained the following characteristics: heuristic scanning run by 1000 stepwise repetitions and TBR braches combined with Multipars activated; all characters were equally evaluated. Bootstrap values and Jackknife for nodes were calculated in 1000 repetitions, 1000 repetitions of scanning (mult*1000) combined with TBR; and 10000 as maximum number for clustering of trees.

RESULTS AND DISCUSSION

Principal component analyses (PCA)

These indicated that the first eight principal components (PC) generate 61.4% of the total variation. Principal component 1 (PC1) produce 11.5%, PC2 (9.7%), CP3 (8.1%), CP4(7.4%), CP5 (7.1%), CP6 (6.7%), CP7(6.7%); and CP8 (4.8%)of the total variation (Table 3).

Variables that significantly contributed in each of the first three principal components were: 1) PC1 with fruit width, fruit width/length ratio, peduncle diameter, fruit cross-section shape, skin color at physiological maturity; shape of left shoulder, core depth, juiciness, fiber content attached to the endocarp, fiber content attached to skin, and type of embryonic; 2) PC2withlenticels density, color contrasting between lenticels and skin; peduncle cavity, neck of fruit, shape of right shoulder, main color, and firmness on flesh; and 3) PC3 with leaf length, width leaf, leaf width/length ratio; base shape, apice shape, stalk

Table 1. Mango (*Mangifera indica* L.) accesions of Gene Bank to INIFAP, used in the study.

Código	Accesión	Origin	Embrionytype
RI 1	Rey Jorge[¶]	Cultivated	Monoembryonic
RI 2	Suchitoto[¶]	Cultivated	Monoembryonic
RI 3	Diplomático[¶¶]	Cultivated	Polyembryonic
RI 4	Pochota[¶¶]	Criollo	Polyembryonic
RI 5	Plátano[¶¶]	Criollo	Polyembryonic
RI 6	Manzana[¶¶]	Criollo	Polyembryonic
RI 7	Manila de Chiapas[¶¶]	Cultivated	Polyembryonic
RI 8	Papayo[¶¶]	Criollo	Polyembryonic
RI 9	Oro[¶¶]	Cultivated	Polyembryonic
RI 10	Ataulfo[¶¶]	Cultivated	Polyembryonic
RI 11	75-1[¶¶]	Criollo	Polyembryonic
RI 12	Quc[¶¶]	Criollo	Polyembryonic
RI 13	75-0[¶¶]	Criollo	Polyembryonic
RI 14	Manililla[¶¶]	Cultivated	Polyembryonic
RI 15	74-82[¶¶]	Criollo	Polyembryonic
RI 19	Zill[¶¶¶]	Cultivated	Monoembryonic
RI 20	Davies Haden[¶¶¶]	Cultivated	Monoembryonic
RI 22	Pope[¶¶¶]	Cultivated	Monoembryonic
RI 25	Irwin Rojo[¶¶¶]	Cultivated	Monoembryonic
RI 26	Cambodiana[¶¶¶]	Cultivated	Polyembryonic
RI 27	Kensington[¶¶¶]	Cultivated	Monoembryonic
RI 28	Sensation[¶¶¶]	Cultivated	Monoembryonic
RI 29	Fabián[¶¶¶]	Cultivated	Monoembryonic
RI 31	Lucio-2[¶¶¶]	Cultivated	Polyembryonic
RI 32	Florigón[¶¶¶]	Cultivated	Monoembryonic
RI 35	Vishis[¶¶¶]	Criollo	Polyembryonic
RI 37	Edward[¶¶¶]	Cultivated	Monoembryonic
RI 39	Carabao[¶¶¶]	Cultivated	Polyembryonic
RI 40	Joe Welch[¶¶¶]	Cultivated	Monoembryonic
RI 41	Tommy Atkins[¶¶¶]	Cultivated	Monoembryonic
RI 42	Brooks[¶¶¶]	Cultivated	Monoembryonic
RI 43	Irwin Morado[¶¶¶]	Cultivated	Monoembryonic
RI 44	Springfields[¶¶¶]	Cultivated	Monoembryonic
RI 45	Palmer[¶¶¶]	Cultivated	Monoembryonic
RI 46	Ataulfo Diamante+	Cultivated	Polyembryonic
RI 47	Ataulfo Clon 08+	Cultivated	Polyembryonic
RI 48	Ataulfo Elite+	Cultivated	Polyembryonic

[¶]:Origin of Guatemala;[¶¶]:Localaccesions;[¶¶¶]: Accesions of gene bank to Experimental StationCuliacán-INIFA. (+):Varietyimprovementin Experimental StationRosario Izapa,-INIFAP.

Table 2. Descriptors used for the morphological characterization of the accessions of the Mango germplasm bank (*Mangiferaindica* L.) of INIFAP.

Code	**Quantitative characters**	**Code**	**Qualitativecharacters**
LL	LeafLenght (cm)	IAP	Intensity of anthocyanin pigmentation(5 state)
LW	Leaf wide (cm)	SL	Shape leaf (3 state)
R L/W	Relationship lenght/wide	LC	Leaf color (4 estados)
SBR	Spacebetweentheribs(cm)	TOR	Torsión (2 state)
PL	Peduncle Length (cm)	LR	Limbo Ripple (3 state)
FL	Fruitlength(cm)	SB	Shape of the base (3 state)
FW	Fruitwide(cm)	AS	Apiceshape (3 state)
R L/W	Relationship length/wide	PRS	Position in relation to the shoot (5 state)
DP	Pedunclediameter (cm)	SCC	Shape of cross-section (3 state)
TS	Thickness of the shell(cm)	SC	Shell color (7 state)
Code	**Qualitative characters**	DL	Density of lenticels (3 state)
FP	Firmness of the pulp (3 state)	CCBLS	Color contrast between lenticels and shell(3 state)
JUI	Juice (3 state)	SL	Size of lenticels (3 state)
TP	Texture of the pulp (3 state)	SR	Surface roughness(2 state)
AFAE	Amount of fiber attached to the endocarp (4 state)	PC	Pedunculararcavity(2 state)
AFAS	Amount of fiber attached to the shell (4 state)	NF	Neck of thefruit(2 state)
TF	Turpentine flavor (2 state)	NL	Necklength(3 state)
RSE	Relief of the surface of the endocarp(3 state)	SLS	Shape of theleftshoulder(5 state)
SPS	Side perspective shape(2 state)	SRS	Shape of the right shoulder (5 state)
EMB	Embryonic (2 state)	LSG	Length of shoulder Groove (3state)
SPE	Scar point estilar(2 state)	DGLS	Depth of groove on left shoulder (3 state)
SC	Shell color (10 state)	LLS	Lump in the left shoulder (2 state)
SS	Speckle of the shell(4 state)	BF	Breast of the fruit (2 state)
ASP	Adherence of the shell to the pulp	DB	Depth of breast (3 state)
PCP	Principal color of the pulp (3 state)	PPSS	Protuberance proximal to the stylusscar (3 state)

Table 3. Eigen values and variances explained by principal components (PC), based on 39 morphological characters and 10 quantitative characters in 37 mango accessions.

PC	Eigen values	Proportion of variance	Cumulative total variance
PC1	5.44	0.115	0.115
PC2	4.57	0.097	0.213
PC3	3.82	0.081	0.294
PC4	3.51	0.074	0.369
PC5	3.35	0.071	0.440
PC6	3.15	0.067	0.507
PC7	2.70	0.067	0.567
PC8	2.29	0.048	0.614

Table 4. Eigenvectors and Pearson correlation coefficients (R^2) among morphological variables in 37 Mango accessions.

Variables	**Principal Components**			**Pearson Correlation**		
	PC1	**PC2**	**PC3**	**PC1**	**PC2**	**PC3**
Leaf length	0.067	0.159	0.213	0.157	0.340	**0.415**
Leafwide	0.050	0.071	0.368	0.117	0.152	**0.719**
Ratelenght/wide	0.036	0.082	-0.212	0.084	0.176	**-0.415**
Base shape	-0.035	-0.060	0.380	-0.082	-0.129	**0.742**
Apex shape	0.155	0.089	-0.207	0.361	0.190	**-0.404**
Petiole length	0.026	0.010	0.194	0.060	0.021	**0.379**
Position in relation to the shoot	-0.095	-0.035	0.353	-0.223	-0.074	**0.690**
Fruit length	-0.056	0.142	0.024	-0.131	0.305	0.047
Fruit wide	-0.328	0.102	-0.121	**-0.765**	0.219	-0.237
Relationship lenggth/wide	0.213	-0.002	0.018	**0.497**	-0.005	0.035
Peduncle diameter	-0.205	-0.033	-0.020	**-0.478**	-0.071	-0.039
Shape of cross-section	-0.226	0.041	-0.123	**-0.529**	0.087	-0.241
Shell color	0.171	0.014	-0.147	**0.399**	0.031	-0.287
Density of lenticels	0.003	0.310	0.172	0.006	**0.663**	0.337
Color contrast between lenticels and shell	-0.003	0.201	0.197	-0.008	**0.431**	0.384
Pedunculararcavity	-0.169	-0.253	0.006	-0.394	**-0.541**	0.012
Neck of thefruit	0.178	0.197	-0.059	0.416	**0.421**	-0.115
Shape of the left shoulder	0.246	0.264	-0.089	**0.574**	0.565	-0.174
Shape of the right shoulder	0.072	0.326	0.083	0.167	**0.698**	0.163
Depth of breast	0.254	-0.089	0.109	**0.594**	-0.191	0.213
Speckle of the shell	-0.105	0.151	-0.180	-0.246	0.323	**-0.353**
Principal color of the pulp	0.071	0.197	0.115	0.166	**0.422**	0.224
Firmness of the pulp	0.132	-0.289	-0.025	0.308	**-0.619**	-0.048
Juice	-0.240	0.089	0.076	**-0.560**	0.191	0.149
Fiberbonded to the endocarp	-0.157	0.123	-0.168	**-0.367**	0.264	-0.329
Amount of fiber stuck to theshell	-0.176	0.152	-0.183	**-0.411**	0.325	-0.357
Embryony	0.245	-0.205	-0.020	**0.571**	-0.439	-0.040

length, stalk location in relation to shoot and dotted skin (Table 4).

Dispersion of accessions from the four quadrants was conducted in regards to qualitative and quantitative descriptors used in samples with a high morphological

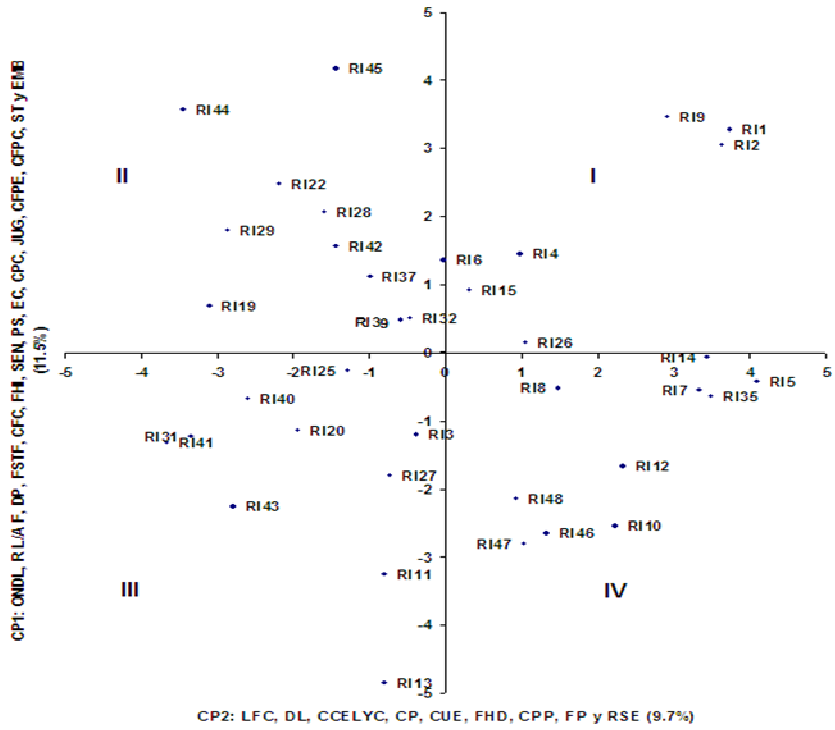

Figure 1. Dispersion of 37 Mango accessions (Mangifera indica L.) based on components PC1 and PC2.

variation from the accessions located inside INIFAP mango germplasm bank (Figure 1).

Hierarchical Cluster Analysis

With a semi-partial R^2 distance of 0.06, we could determine three groups. Group II was divided in IIa and IIb, whilst group III in IIIa, IIIb, IIIc; and IIId (Figure 2). Group I is formed by Rey Jorge and Suchitoto accessions that come from Guatemala. Fruits from this group are distinguished by being monoembryonic, they share similar sizes and shapes; possess orange-colored skins, and lenticels medium density with a color-medium contrast around these and skin. Also, they present some roughness presence on skin, light orange-colored fleshes with skin medium-adherence, high in juiciness and medium-textured with turpentine flavor; low amount of fiber attached to the endocarp, and medium quantity of fiber attached to skin.

On the other hand, group II brought together 16 accessions integrated by Mexican regional creole materials that stand out for being polyembryony. Among this group, sub-group IIa was formed by 8 accessions; i.e., diplomatico, manzana, vishis, manila de Chiapas, oro, pochota; and 74-82. From these, the first three presented thick-skins with marked mottling, light orange-colored fleshes, thick-textured without turpentine flavor; higher amount of fiber attached to the endocarp and medium amount of fiber attached to skin with medium-adherence from skin to flesh. The other 5 share similarities in fruit shape, have yellow-orange skins, strong-density of lenticels with a color-heavy contrast around these and skin; fruits present core, light orange-colored fleshes with thick-textured and turpentine flavor. Likewise they present high quantity of fiber attached to endocarp but low amount of fiber attached to skin.

We got from sub-group IIb: Ataulfo, Ataulfo Diamante, Ataulfo Elite, Ataulfo 08, Papayo, Plátano, Quc and 75-1. Fruits from the four Ataulfo genotypes are similar in shape and size, and present medium-density of lenticels with a color-weak contrast around these and skin. However, due to lenticels presence, they have zero skin roughness and skin medium-adherence to flesh medium-juiciness. They're light orange-colored, firm, and fine-textured; possess medium-juiciness without turpentine flavor and low amount of fiber attached to endocarp and lower amount of fiber attached to skin as well. Provided the other 4 accessions are identical in size and shape, they're thick-skinned and their fruits present core, medium-density of lenticels with a color-medium contrast between lenticels and skin. There's a lack or weaker lack of mottling on skin and medium-adherence from skin to flesh; they're medium-firmness/textured, juiciness with turpentine flavor. Another

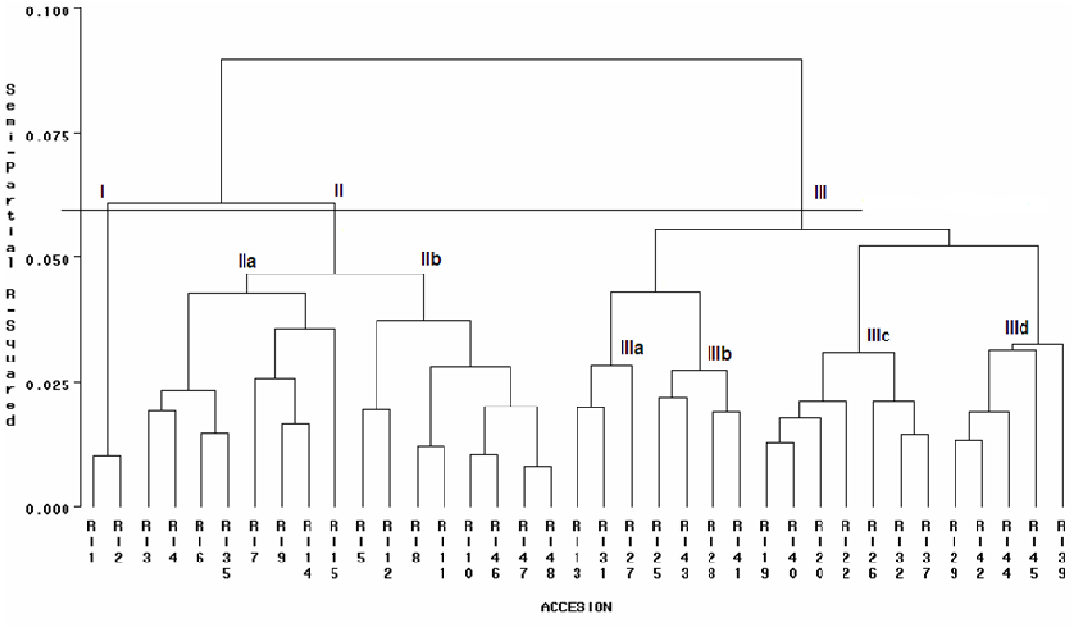

Figura 2. Dendrogram of 37 accessions of Mango (Mangifera indica L.) from 49 morphological characters.

thing is they have high quantity of fiber attached to endocarp but medium amount of fiber attached to skin. For the fresh market, mangoes are preferred to have low contents and low length in fiber just as higher length, width, thickness, weight and flesh content in fruit (Ramos, 2003). In this study, *Ataulfo* type-materials meet these quality parameters. Group III brought together 19 accessions that were classified as Floridian-type materials whose characterization made them being monoembryonic in which 4 sub-groups were obtained simultaneously: sub-group IIIa that was formed by Kensington, Lucio-2, and 75-0 distinguished themselves for showing weak-density of lenticels on fruits, absence of skin roughness, fruits have core, and medium-adherence from skin to yellow-colored flesh with medium-firmness/textured. They're thick-skinned, present high in juiciness with turpentine flavor, higher amount of fiber attached to endocarp but medium quantity of fiber attached to skin. Fruits from the latter two have green-colored skins at maturity. However, sub-group IIIb was made up by 4 accessions *purple Irwin*, *red Irwin*, *Sensation*; and *Tommy Atkins*. In these, lenticels show medium-density, a color-medium contrast (strong mottling on skin) and thick-skinned with strong adherence to flesh; high in juiciness and flesh medium-textured. Possess high amount of fiber attached to endocarp but low quantity of fiber attached to skin.

Sub-group IIIcbrough together 7 accessions Cambodiana, Davies Haden, Edward, Florigón, Joe Welch, Pope; and Zill that stand out since they present fruits with higher density of lenticels with color-heavy contrast among these (strong mottling on skin), and some presence of roughness due to lenticels on skin. Fruits have core, medium-adherence from skin to flesh, and high in juiciness; they're light orange-colored, soft and medium-textured without turpentine flavor, and have medium amount of fiber attached to endocarp and skin.

Moreover, sub-group IIId was integrated by 5 accessions Brooks, Carabao, Fabián, Palmer and Spring fields. All these materials except for Carabao, possess bigger fruits, ticker skins with high-density of lenticels and color-strong contrast around these and skin. There's a lack or weaker lack of mottling on skin, but they have heavy-adherence from skin to flesh, high in juiciness; they're thick-textured without turpentine flavor but with greater amount of fiber attached to endocarp; and medium quantity of fiber attached to skin.

Cladistics Analysis (CA)

The grouping of 37 characterized accessions and its comparison with *M. odorata Griff* species was done through the product of 10 most parsimony trees which length(L) was 407, retention index(RI) of 65, and consistency index (CI) of 28. (Figure 3).

By using cladistics analysis, we were able to determine the character and its condition being grouped in each accession and a more prompt distinction between accessions. In figure 3, there's an appreciation of 8 groups

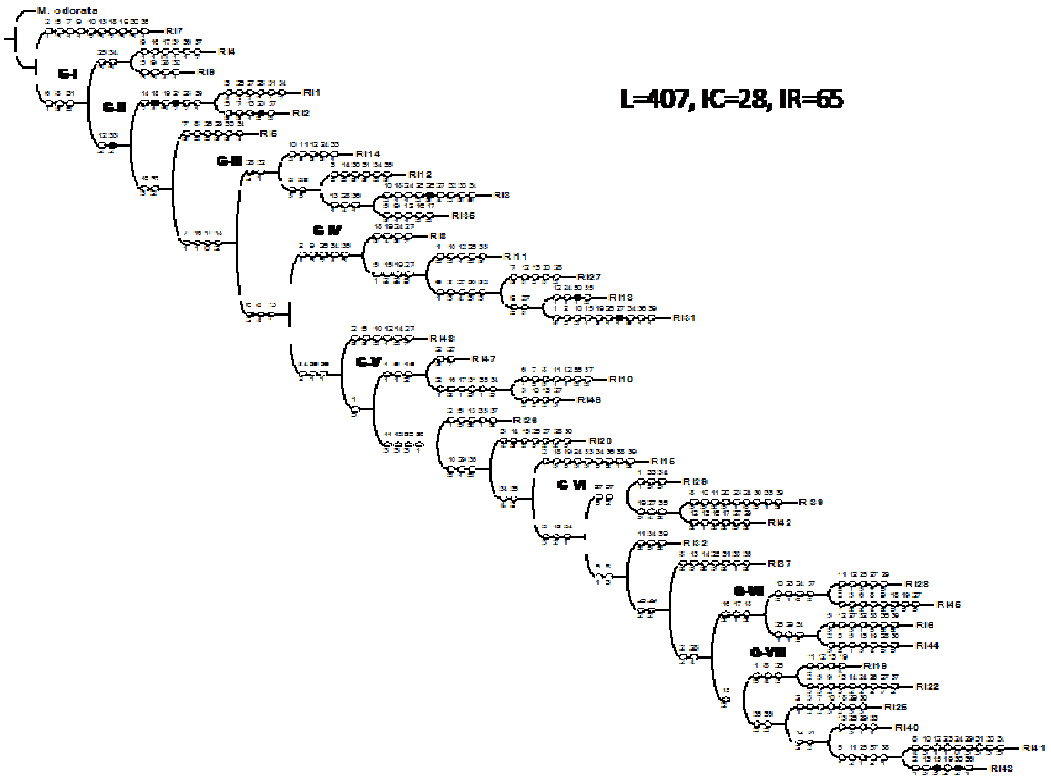

Figura 3. Strict consensus tree for 37 Mango accessions (*Mangifera indica* L.) from the INIFAP Mango genebank. IC: Consistency index; IR: Retentionrate.

and 8 accessions that were grouped alone (RI 7, RI 6, RI 48, RI 26, RI 20, RI 15, RI 32; and RI 37).

Group I characterized itself by showing fruit elliptical shape, turpentine flavor, and an absence of neck(RI 4); a strong undulation on leaves edges, heavy mottling on skin, and circulate-shaped fruit.

On the other hand, group II distinguished itself for displaying dottling on medium-style scar, medium-mottling on skin, and fiber attached to endocarp (RI 1), just like lenticels small size, and smooth relief on endocarp surface (RI 2). Group III, moreover, was characterized by the green-colored on fruit skin at maturity, heavy-density of lenticels, and flesh fine-textured (RI 14) with roughness caused by lenticels, low amount of fiber attached to endocarp (RI 12); and flesh thick-textured as well as high amount of fiber attached to endocarp (RI 3). Fruits are elliptical-shaped with neck presence (RI 35). In addition, group IV was notable for its fruit in-depth core and skin dominant orange-colored (RI 8); weak intensity because of anthocyan in pigmentation on young leaves and flesh thick-textured(RI 11); furrow's longer length on left shoulder and weak mottling on skin (RI 27). In some cases, there was shallow core and low quantity of fiber attached to skin (RI 13) with a greater amount of fiber attached to endocarp and lacking of turpentine flavor (RI 31). In contrast to group IV, group V integrated Ataulfo (RI 47, RI 10, and RI 46) types that were differentiated by a weak color-contrast between lenticels and skin, low amount of fiber attached to skin, dominant orange-colored at maturity; and smooth relief on endocarp surface. Group VI was characterized by showing flesh thick-textured and higher quantity of fiber attached to endocarp (RI 29); flesh fine-textured and polyembryony (RI 39); from neck and for monoembryonic presence (RI 42). However, group VII showed a strong adherence from skin to flesh (RI 28); elliptical-shaped fruits and right shoulder shape falling abruptly (RI 45); low in juiciness, flesh thick-textured, presence of turpentine flavor and polyembryony (RI 6), and lenticels bigger size (RI 44). On the other hand, group VIII was differentiated by its medium-density and lenticels small size (RI 19), roughness presence caused by lenticels (RI 22), left shoulder horizontal round-shaped and strong adherence from skin to flesh (RI 25); weak adherence from skin to flesh; and flesh fine-textured (RI 40), lacking of core (RI 41) and absence of turpentine flavor (RI 43).

DISCUSSION

Leaf characteristics (size and shape) and fruits (size, shape, color, flesh, fiber; and type of embryony) allowed to separate and make a distinction among mangoes' accessions. On that subject, Galvez-López *et al*. (2010) state that fruits' characteristics had the most significant characters to study morphological variability on mangoes' germplasm native from Chiapas, Mexico. In this context, Galvez-López *et al*. (2007) the study of creole mangoes' morphological diversity with fruits characteristics permitted to make a distinction and to register the characters with the highest coefficient of variation, i.e., mesocarp width and fruit weight. On another note, Subedi *et al*. (2004) found out quantitative and qualitative characters of seed, fruit, and leaf allowed the identification as well as the determination of variation level on mango varieties in Nepal. When Cumare and Avilán (1994) utilized 75 morph-agronomic descriptors to describe nine varieties of mango in Venezuela, they reported fruits characteristics, especially flesh's, can be ideal for promising material selection in genetic improvement.

The most broaden morphological variability observed in the 37 accessions of mango is due to germplasm origin (creole or cultivated) and eco-geographical. Different studies have proved that the type of embryony and geographic origin contribute to mango varieties distinction (Karihaloo *et al*., 2003; Viruel *et al*., 2005; Ravishankar *et al*., 2004; Anju *et al*., 2008). In Mexico, diversity studies on mango with iso-enzymes, (Galvez-López *et al*., 2007) and AFLP´s (Galvez-López *et al*.,2010) separated creoles types from the ones cultivated within the Soconusco region in Chiapas; they also divided Mexican criollo mangoes from the ones cultivated in United States and other countries (Australia and Spain). The differentiation amongst mangoes from Chiapas and materials brought from other countries depended on an empirical selection and on fruit most preferred among local consumers.

With the use of cladistics and hierarchical cluster analyses, the groups found in this study, were based on fruits geographical origin and characteristics of mango accessions. Mexican varieties differentiate themselves for being polyembryony, while varieties from other countries aremonoembryonic and clearly distinguishing for their fruit shape and size. Having the knowledge of these differentiated characters by mango accessions allowed to conduct a better usage on germplasm for its preservation and yield in genetic improvement. This must be focused on the needs markets and consumers have; Ramos (2003) mentions that for the fresh market, mangoes are preferred to have low contents and low length in fiber just like higher length, width, thickness, weight and flesh content. For the Asian market, red-yellow colored mangoes are favored (Human & Rheeder, 2004); whilst in Europe and United States they prefer yellow or red mangoes, but in Mexico, they favor yellowed mangoes (Ramos, 2003).

CONCLUSION

Distinction between mangoes groups was mainly determined by embryony type, geographical origin and if they are creoles or cultivated. Leaf and fruits characters contributed to groups' difference, particularly, color characters and fruit shape result to be valuable for mango genetic improvement strategies, left shoulder shape, skin thickness, core and core deepness. In Mexico, we found a large morphological diversity among the studied accessions are going to be of great benefit for any genetic improvement on mango.

BIBLIOGRAPHY

Anju BS, Navin S, Rajan RC (2008). Genetic diversity and discrimination of mango accessions using RAPD and ISSR markers. Indian J. Hort. *65(4)*: 377-382.

Bally ISE (2006). *Mangiferaindica* (mango), ver. 3.1.In: Elevitch, C.R. (ed.). Species Profiles for Pacific Island Agroforestry. Permanent Agriculture Resources (PAR), Hōlualoa, Hawai'i. <http://www.traditionaltree.org>.

Chavez CX, Vega A, Tapia LM, Miranda S (2001). Mango, su manejo y producción en el trópico seco de México. Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias. México. pp. 17-25.

Cumare SJA, Avilán R (1994). Descripción y caracterización de nueve variedades de mango para ser usados como patrones. I: Descripción. Agronomía Tropical 44(3): 373-391.

Gálvez-López D, Adriano-Anaya ML, Villarreal-Treviño C, Mayek-Pérez N, Salvador-Figueroa M (2007). Diversidad isoenzimática de mangos criollos de Chiapas, México. Rev. Chapingo. SerieHorticultura13(1): 71-76.

Goloboff PA (1993). Nona Ver. 1.5.1.American Museum of Natural History, New York.EEUU. s/p.

Gonzáles AF, Pita VJM (2001). Conservación y Caracterización de Recursos Fitogenéticos. Ed. Escuela Universitaria de Ingeniería Técnica Agrícola Madrid. 279 p.

Hair JF, Anderson RE, Tanthan LR, Black WC (1992). Multivariate data analysis. MacMillan Publ. Co. Nueva York. 544 p.

Human CF, Rheeder S (2004). Mango breeding: results and successes. Acta Hort. *(ISHS) 645*:331-335.

IBPGR (1989). Descriptors for mango. International Board for plant Genetic Resources. Roma. 22 p.

Johnson DE (1998). Métodos Multivariados Aplicados al Análisis de Datos. Thomson editores, México, D.F. pp. 93-143, 217-286.

Karihaloo JL, Dwivedi SYK, Gaikwad AB (2003). Analysis of genetic diversity of Indian mango cultivars using RAPD Markers. J. Hort. Sci. & Biot. 78 *(3)*:285-289.

Mata BI (1995). La producción de Mango en México. Limusa. México. 59 p.

Nixon KC (2002). Winclada Ver. 1.00.08. Publicado por el autor. Ithaca, New York. EEUU.s/p.

Rajan S, Yadava LP, Ram K, Saxena SK (2009). Genetic divergence in mango varieties and possible use in breeding.*Indian J. Hort. 66(1):*7-12.

Ramos NJ (2003). Perspectivas de la red Mango para el 2003. FIRA-Banco de México. México. pp. 2-12.

Ravisahnkar KV, Chandrashekara SP, Sreedhara MRA, Dinesh L, Anand GV, Saiprasad S (2004). Diverse genetic bases of Indian polyembryonic and monoembryonic mango (*Mangiferaindica* L) cultivars. Current Sci. *87(7):*870-871.

Sagar SP, Chidley HG, Kulkarni RS, Pujari KH, Giri AP, Gupta VS (2009). Cultivar relationships in mango based on fruit volatile profiles. Food Chem. 114(1):363-372.

SAS(1996). Statistical Analysis System.SAS system for Windows version 6.12.SAS Institute Inc. Cary NC 27513, USA.

SIAP-SAGARPA (2017). Anuarios Estadísticos de la Producción Agrícola en México, Mexico D.F. 2009. http://www.siap.gob.mx

Subedi A, Bajravharya J, Joshi BK, Regmi HN, Gupta SR, Hari BKC (2004). Characterization and genetic diversity of mango (*Mangiferaindica* L.) in Nepal. In: On-farm Conservation of Agricultural Biodiversity in Nepal.Volume I. Assessing the Amount and Distribution of Genetic Diversity on-farm.B.R. Sthapit MP. z Upadhyay, P.K. Shrestha, D.I. Jarvis (Eds.). IPGRI. *Proceedings of the Second National Workshop.Nagarkot, Nepal.* 191 p.

Viruel MA, Escribano P, Barbieri M, Ferri M, Hormaza JI (2005). Fingerprinting, embryo type and geographic differentiation in mango (*Mangiferaindica* L., Anacardiaceae) with microsatellites. *Mol. Breed. 15:* 383-393.

Xinhua H, Yangrui L, Yongze G, Zhipeng T, Rongbai L (2005). Genetic Analysis of 23 Mango Cultivar Collection in Guangxi Province Revealed by ISSR. *Mol. Plant Breed. 3(6):* 829-834.