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Morphological Characterization of Native Mangos from Chiapas, Mexico

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ABSTRACT

Mango is a major fruit crop throughout sub-tropical and tropical areas of Mexico. In the state of Chiapas, Mexico, new phenotypes have been found. These individuals have originated directly from seeds and after grafting and used for mango plantations. The aim of this work was to characterize mango accessions native to southern Chiapas, Mexico, based on morphological traits. Fifty morphologic traits from leaves (9), inflorescences (6), flowers (10), fruits (10), and seeds (5) were measured during 2005 and 2006 in 41 local mango accessions collected from five locations (Huehuetán, Pijijiapan, Tuxtla Chico, Tapachula, Escuintla) in the state of Chiapas, Mexico. We found significant morphologic variability in mango accessions from Chiapas. Seven fruit traits (length, width, and weight of fruits; pulp thickness and weight; and fibre content and fibre length) and two leaf traits (length and width) were used to index mango morphology. Mango accessions locally named as 'Ataulfo' from Tapachula and 'Ajo' and 'Sin nombre-2' from Tuxtla Chico showed the highest fruit weight and pulp contents and the lowest fibre contents. Based on fruit morphology and growth at southern Chiapas, some mango accessions can be useful for further field evaluations and then propagated for future plantations.

Additional Index Words: Mangifera indica L., fruit quality, fruit yield, morphology, Soconusco region.

Mango (*Mangifera indica* L.) is a major crop in the state of Chiapas, México, where 26,000 ha are planted and 176,000 Mg were produced during 2008. The majority of mango production (≈95%) is located in the southern region known as 'Soconusco' which comprises 17 counties, and where Tapachula county produces nearly one third of the state's mango production (SIAP, 2009). A broad morphological and genetic diversity of mangos has emerged in southern Chiapas due to free sexual recombination and continuous grafting of outstanding plants produced from seeds of commercial cultivars grown and/or consumed in the state. For example, the cultivar 'Ataulfo' (Manila fruit type) was originated in the Soconusco region and was then dispersed throughout Mexico and other areas of the world (Gálvez-López et al., 2007a, b).

Several procedures for the identification and characterization of mango genotypes have been developed based on outstanding fruit morphological traits. However, those traits are visually evaluated in most cases and are thereby subjective morphological characteristics that can improve characterizations for defining the potential use of any genotype (Jaramillo and Baena, 2000). The International Plant Genetic Resources Institute (IPGRI) of Rome, Italy, has established a list of descriptors for mango that includes the morphological traits of plant, leaves, flowers, fruits and seeds and provides a universal format for the characterization of mango genetic resources (IBPGR, 1989; IPGRI, 2006). Mango cultivars from Mexico have been characterized based on fruit traits and isozyme patterns (Gálvez-López et al., 2007a, b). The objective of this work was to characterize mango accessions native to southern Chiapas, Mexico, based on their morphology.

MATERIALS AND METHODS

Forty-one mango accessions from the Soconusco region in southern Chiapas, México were located during 2005. Each accession has unknown genetic origin, making it unclear whether the accessions originated by planting of one seed of a cultivar grown at Chiapas, or whether it was obtained directly from local markets or from grafting of local mangos or cultivars planted through Soconusco region. The geographical locations and local names of each accession are shown in Table 1 and Fig. 1.

Accessions were characterized based on mango descriptors listed by IBPGR (1989) and IPGRI (2006). Fifty-three traits (35 qualitative and 18 quantitative) were measured per accession from November 2005 to April 2006 (Tables 2 and 3). Descriptive statistics (mean, amplitude, variance, standard deviation, and coefficient of variation) were calculated for each accession. Data were subjected to Principal Component Analysis (PCA) to identify traits that best explained mango morphologic variability. Then cluster analysis of mango accessions was performed based on most explicative morphologic traits derived from PCA, and a single dendrogram based on the Unweighted Paired-Grouping Method with Arithmetic Averages (UPGMA) algorithm was constructed (Hair et al., 1992). Statistical analysis was performed using Statistica® ver. 5.1 for Windows software (StatSoft Inc., Tulsa, OK, USA).

RESULTS

Four morphological traits from the 53 originally measured (flower nature of disc, number of fertile stamens, pistil, and fruit stalk insertion) were eliminated as they showed only one phenotypic class. Qualitative traits showed from two to eight phenotypic classes (Table 2), while quantitative traits with the highest CVs (>35%) were number of fertile stamens, pulp thickness, inflorescence length and fruit weight.

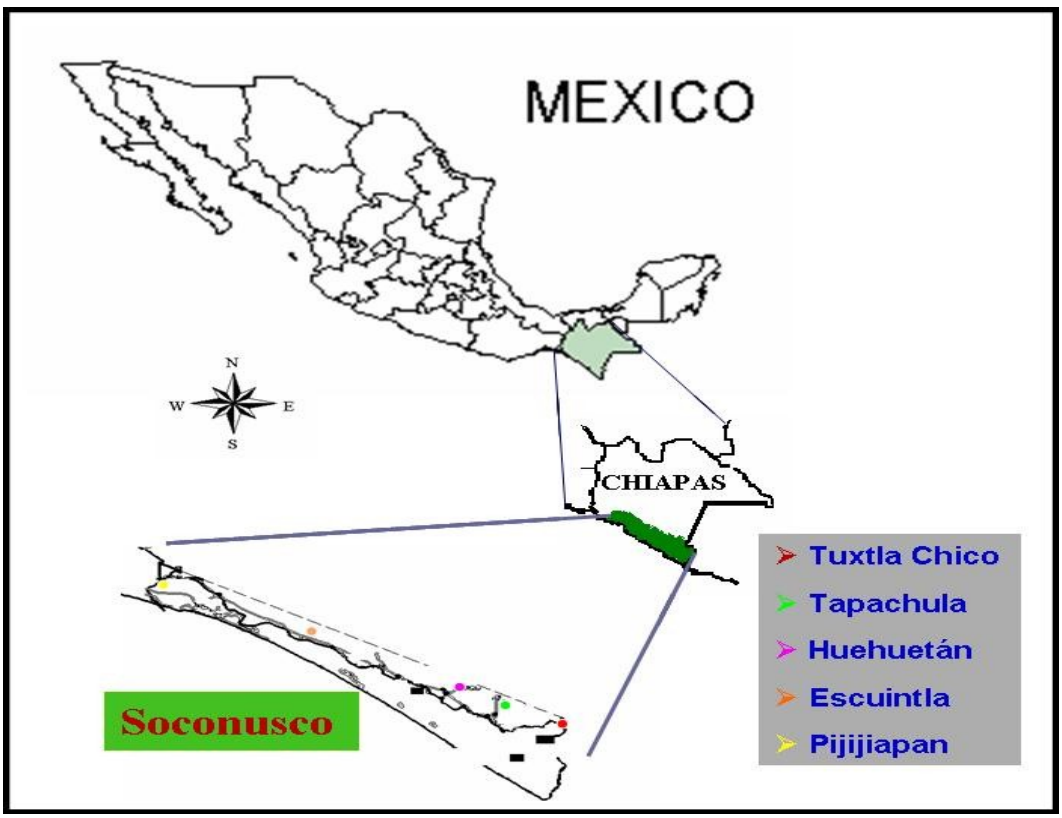

Fig. 1. Origins of mango landraces from Chiapas, Mexico.

Table 1. Mango accessions collected in Chiapas, Mexico and accessions obtained from the Mango Germplasm Bank of INIFAP.

Number	Local name/origin	Number	Local name/origin
	Tuxtla Chico, Chiapas		
TCH01	Agua	TCH08	Platano
TCH02	Sin nombre 1	TCH09	Sin nombre 3
TCH03	Sin nombre 2	TCH10	Piña
TCH04	Oro	TCH11	Manzana
TCH05	Coche	TCH12	Piña
TCH06	Amatillo	TCH13	Cachetio
TCH07	Alcanforado	TCH14	Ajo
	Escuintla, Chiapas		
ESC01	Piña	ESC09	Manzana Grande
ESC02	Amatillo	ESC10	Viejita
ESC03	Coche	ESC11	Oro
ESC04	Pomarrosa	ESC12	Tecolote
ESC05	Canela	ESC13	Pepino
ESC06	Tapanero	ESC14	Pija
ESC07	Manzana Chico	ESC15	Melon
ESC08	Manilon		
	Huehuetan, Chiapas		
HUE01	Tecolote	HUE03	Alcanfor
HUE02	Manililla	HUE04	Amate
	Pijijiapan, Chiapas		
PIJ01	Papaya	PIJ03	Cuero
PIJ02	Piña	PIJ04	Agua
	Tapachula, Chiapas		
TAP01	Ataulfo1 (70)	TAP03	Ataulfo3 (50)
TAP02	Ataulfo2 (70)	TAP04	Ataulfo4 (30)

Traits with CV > 10% were disc diameter, flower diameter, and number of sepal and petal (Table 3). The PCA of quantitative data explained more than 50% of total variation into the three former Principal Components (PC) (Table 4). Nine traits were significant, two qualitative (fibre content and fibre length) and seven quantitative (leaf width, petiole length, fruit length, fruit thickness, fruit weight and pulp thickness). The most significant traits were fruit characteristics, and all significant morphological traits were positively associated with morphological variability in mango germplasm (Table 5).

Dispersion of accessions based on the two major PC from PCA divided genotypes into four quadrants. Quadrant III included accessions with high means for fruit weight, thickness and length. Pulp content as well as low fibre contents for outstanding 'Ataulfo' from Tapachula (TAP01, TAP02, TAP03, TAP04) and 'Ajo' (TCH14) and 'Sin Nombre 2' (TCH03) landraces from Tuxtla Chico were also included.

Table 2. Summary of qualitative morphologic traits measured in mango landraces from Chiapas, México.

Trait [a]	Phenotypic classes [b]
Leaf	
Shape	Oblong-lanceolate (6), lanceolate (31), elliptic-oblong (4)
Colour of young leaf	Light green (20), light green with brownish tinge (5), light brick red (7), reddish brown (8), deep coppery tan (1)
Texture	Coriaceous (2),Thinly coriaceous (8), Thickly coriaceous (31)
Tip	Obtuse (7), Acute (18),Acuminate (16)
Margin	Flat (16), Wavy (22), Folded (3)
Inflorescence	
Position	Terminal (23), Axillary (9), Both terminal and axillary (3)
Shape	Conical (18), Pyramidal (8), Broadly pyramidal (9)
Flower density	Densely flowered (35)
Colour	Light green (5), green with red patches (17), light red (4), dark red (9)
Hairiness	Absent (21), Puberulous (9), Pubescent (5)
Flower	
Type of flower	Pentamerous (25), pentamerous and tetramerous (4), hexamerous (4), pentamerous and hexamerous (2), tetramerous, pentamerous and hexamerous (1)
Nature of disc	Disc swollen, lobed, broader tan ovary (36)
Number of fertile stamens	5, 1 fertile (36)
Pistil	Present (36)
Fruit	
Shape	Oblong (15), elliptic (6), roundish (15)
Colour of skin of mature fruit	Red (1), yellow (20), green-yellow (5), Green (3), orange (1), red-yellow (4), yellow with red spots (1), yellow with green spots (1)
Thickness of fruit skin	Thin (8), medium thick (23), thick (5)
Skin texture	Smooth (32), rough (4)
Pulp texture	Firm (13), soft (10), juicy (13)
Adherence of skin to pulp	Absent (free) (6), present (adhering) (30)
Fibre in pulp	Absent (8), present (28)
Quantity of fibre	Scarce (18), abundant (18)
Length of fibres	Short (10), medium (17), long (9)
Stalk insertion	Vertical (36)
Beak type	Absent (15), point (11), prominent (7), mammiform (3)
Sinus	Absent (11), present (25)
Sinus type	Absent (12), shallow (20), deep (4)
Groove	Absent (34), present (2)
Shoulders	Level (16), dorsal higher than ventral (8), ventral higher than dorsal (12)
Slope of shoulders	Sloping abruptly (7), ending in a long curve (15), rising and then rounded (14)
Apex	Acute (32), obtuse or rounded (4)
Basal cavity	Absent (9), present (27)
Seed	
Veins	Level with surface (3), depressed (30), elevated (3)
Pattern of venation	Parallel (28), forked (6), both parallel and forked (2)
Fibre	Absent (2), present (34)

[a] Traits according to IBPGR (1989) and IPGRI (2006).

[b] Numbers in brackets indicate the number of accessions per class.

Table 3. Basic statistic parameters of quantitative traits measured in mango landraces from Chiapas, México.

Trait	Parameter				
	Mean	Amplitude	Variance	Standard Deviation	Coefficient of Variation
Leaf length (cm)	25.6	24.9	33.0	5.7	22.4
Leaf width (cm)	5.8	5.2	0.8	0.9	15.7
Petiole length (cm)	4.1	4.2	1.0	1.0	24.1
Number of nerves	23.5	24.5	14.0	3.7	15.9
Inflorescence length (cm)	32.8	45.0	145.8	12.1	36.9
Flower diameter (mm)	6.6	3.0	0.4	0.6	9.7
Number of anthers	1.1	1.0	0.1	0.2	21.6
Number of stamens	2.9	4.0	1.7	1.3	46.0
Disc diameter (mm)	2.6	1.4	0.1	0.3	12.2
Number of petals	5.1	1.5	0.2	0.4	7.7
Number of sepals	5.1	1.5	0.2	0.4	7.7
Fruit length (cm)	10.2	6.3	3.2	1.8	17.5
Fruit width (cm)	6.9	3. 9	1.0	1.0	14.7
Fruit thickness (cm)	6.0	3.3	0.6	0.8	13.3
Fruit weight (g)	251	362.2	8533.3	92.4	36.9
Pulp thickness (cm)	2.1	4.2	0.7	0.8	40.6
Seed length (cm)	8.4	4.3	1.5	1.2	14.7
Seed weight (g)	20.2	19. 6	28.2	5.3	26.3

Quadrant I included accessions with small fruit size and pulp contents, while quadrant II included germplasm with large fruits and high pulp and fibre contents. Finally, quadrant IV included mangos with low fibre contents in fruits but small fruits and low pulp content (Fig. 2).

Using data from the more explicative traits derived from PCA a dendrogram of mango accessions was constructed that showed three major groups of genotypes. Group I included three genotypes with outstanding morphological traits (TCH03, TCH14 and TAP01), and group II showed genotypes collected from all five locations of Chiapas and 'Ataulfo' accessions (TAP02, TAP03, TAP04). Group III included three accessions from Escuintla (ESC06, ESC08, ESC15), one from Tuxtla Chico (TCH09) and other from Pijijiapan (PIJ03). The last genotypes were different from the others because some of the morphological traits were not completely measured due to delayed or absent fructification (Fig. 3). When we constructed dendrograms with all 53 traits, or only nine of the most explicative morphological traits we found similar topologies (data not shown).

DISCUSSION

Broad morphologic diversity was found in native mango from Chiapas. We assumed that optimal conditions for free recombination among mangos introduced from other countries were common for farmers in Chiapas. Recombination is high since novel morphological traits, unreported in formal mango descriptors (IBPGR, 1989; IPGRI, 2006), were found in native mango germplasm. For example, some accessions showed hexamerous flowers and others exhibiting both hexamerous and pentamerous flowers. Other accessions included tetra, penta and hexamerous flowers in the same tree. IPGRI descriptors reported only tetra- or pentamerous flowers in mangos. Kostermans and Bompard (1993) found significant variation in flower morphology in some *Mangifera* species.

Common flowers in *M. laurina* are pentamerous, tetramerous and pentamerous in *M. casturi* and

Table 4. Eigenvalues for five principal components from the PCA of morphological data measured in mango accessions from Chiapas, Mexico.

Principal component	Eigenvalue	Total variance (%)	Accumulated variance (%)
1	4.82	32.2	32.2
2	2.35	15.7	47.9
3	1.84	12.3	60.2
4	1.36	9.1	69.3
5	1.24	8.3	77.6

Table 5. Eigenvectors of the most descriptive morphologic traits measured in mango germplasm from Chiapas, Mexico.

Trait	Principal component [a]		
	1	2	3
Leaf length	0.09	0.06	0.17
Leaf width	0.08	0.01	0.74*
Petiole length	0.02	0.09	0.89*
Inflorescence length	-0.22	-0.67	-0.30
Flower diameter	0.11	0.04	-0.02
Disc diameter	0.04	0.07	0.42
Fruit length	0.77*	0.15	0.12
Fruit width	0.89*	-0.02	-0.09
Fruit thickness	0.75*	0.14	0.09
Fruit weight	0.92*	0.19	0.04
Pulp thickness	0.81*	-0.22	0.09
Quantity of fibre	-0.15	0.84*	-0.28
Length of fibre	-0.02	0.72*	0.24
Seed length	0.57	0.28	0.22
Seed weight	0.44	0.34	-0.07
Eigenvalues	4.82	2.35	1.84
Total variance (%)	32.2	15.7	12.3

[a] Values with asterisk indicate the most descriptive traits.

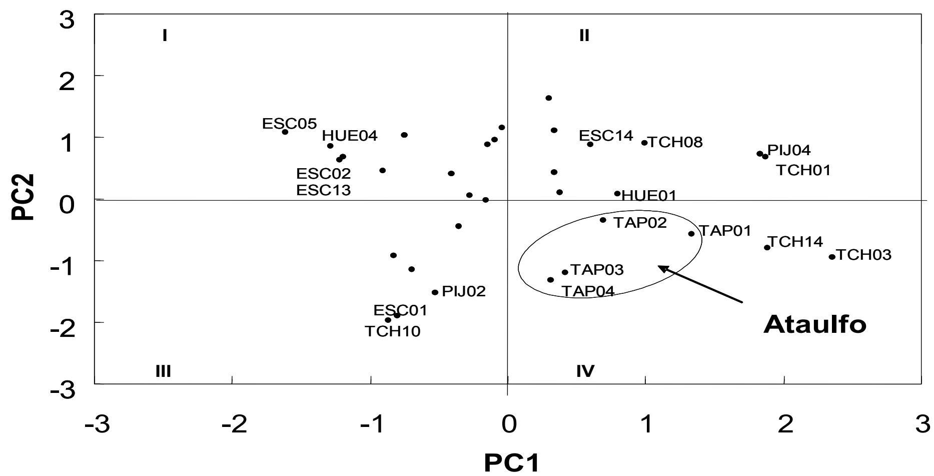

Fig. 2. Dispersion of mango landraces from Chiapas, Mexico based on PCA analysis of morphological data.

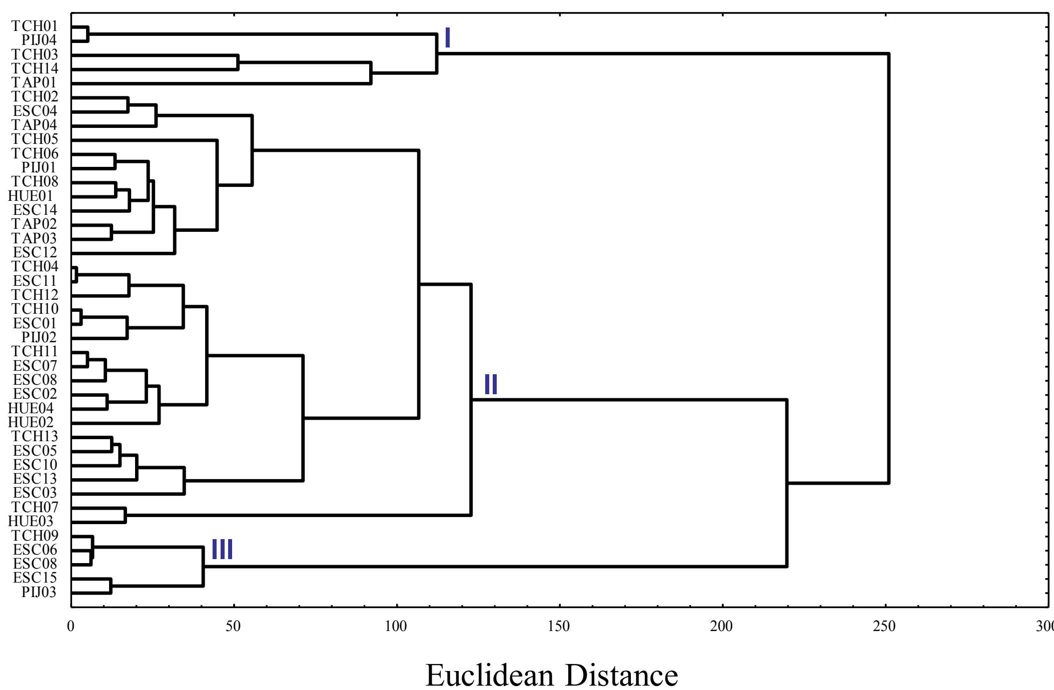

Fig. 3. Dendrogram of mango accessions from Chiapas, Mexico based on morphological data.

tetramerous in *M. torquenda* and *M. quadrifida*. In addition, we found three flower types in the same tree. In the same vein, four new fruit skin colors were found (orange, red-yellow, yellow with red spots, yellow with green spots) that were not reported previously (IBPGR, 1989; IPGRI, 2006). Some mango landraces ('Agua,' 'Sin nombre-2,' 'Coche,' 'Amatillo,' 'Ajo,' 'Tecolote' and 'Ataulfo') showed fruit weights similar to those reported by Chávez et al. (2001) in breed cultivars growing in Michoacán, México.

Seven flower traits and two leaf traits were positively associated with morphological variability in mango germplasm. We suggest that the use of only fruit traits can give a good perspective about mango diversity, and expensive and laborious work to obtain more than 50 morphological descriptors can be avoided without losing efficiency and effectiveness in classification of mango germplasm. Mangos for commercial exploitation should exhibit low fibre content in fruits with short fibres; high length, width, thickness and weight of fruits; and high contents of pulp (Human and Rheeder, 2004). Mango cultivars 'Ataulfo' from Tapachula as well as 'Ajo' and 'Sin Nombre-2' from Tuxtla Chico show the highest number of traits mentioned above and can be useful for mango breeding in southern Chiapas.

Although information remains unclear, mangos were probably introduced from Asia to the Caribbean in the 18th century and to Mexico in the 18th and 19th centuries, and were well adapted to climatic conditions of the country at the time of introduction. Mango plants were then dispersed to other countries, and bred mainly in Florida and Hawaii, USA (Duval et al., 2006). Bred cultivars have been introduced to Mexico (Chávez et al., 2001). In southern Chiapas common practices by mango growers consist of allowing mango fruits to germinate and produce sexual plants that are derived from natural and random recombinations. When recombinants show good phenotypic traits, trees are selected and then planted in the orchard. It is therefore common to see small orchards that include a broad range of mango phenotypes (López-Valenzuela et al., 1997).

Our results suggest that native mango populations from Chiapas show genetic differences based on geographical origin and their known history, but the genetic exchange remains. Bred mangos from USA are mono-embryonic while Mexican mangos are commonly poly-embryonic. Close genetic relations among Ataulfo, Manila and Carabao suggest that later cultivars may be parents of Ataulfo, a genotype that originated in Cordoba, Veracruz where Manila was first introduced (Chávez et al., 2001; SAGAR-INIFAP -PRODUCE, 2000).

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